DESIGN AND CONSTRUCTION OF A DIGITAL ZENER DIODE TESTER

BY

AUWAL ABUBAKAR G.

2004/18457EE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT,

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA,

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DEDICATION

In the name of ALLAH, the most gracious the most merciful peace and blessing of ALLAH be upon our noble prophet MUHAMMAD (S.A.W) and his companions and all those who follows the right path. This project work is earnestly dedicated to my father ALH ABUBAKAR G. UMAR and his brother ALH SANI M. GWARZO and their entire families for all their support throughout my academic life. May ALLAH (SWT) reward and help them here and thereafter. Also my special tribute and last respect goes to my late father ALH AUWAL MOH'D MAI TAYA. I pray Allah grand his soul mercy and bless him with Jannatul Firdausi, Ameen.

DECLARATION

I, *AUWAL ABUBAKAR* declare that this work was done by me and has never been presented elsewhere for the award of degree. I also hereby relinquish the copyright to the Federal University of Technology Minna, under the supervision of *DR Y.A ADEDIRAN.*

....	21—12—09
AUWAL ABUBAKAR G.	SIGN AND DATE
(Project student)	
....	21/12/09
DR Y.A ADEDIRAN	SIGN AND DATE
(Project supervisor)	
....	May 6, 2010
DR. Y.A ADEDIRAN	SIGN AND DATE
(H.O.D)	
....	09/03/10
EXTERNAL SUPERVISOR	SIGN AND DATE

ACKNOWLEDGEMENT

I would like to give thanks to almighty (ALLAH) Ta'ala, the Alpha, the Omega, the Omnipotent, the Omniscient, who cherishes and sustains the whole universe without whose guidance and support no means, device, plan, trick, scheme, wisdom, power will be achieved.

Secondly, I wish to express my endless profound gratitude to my learned and able supervisor in person of DR Y.A ADEDIRAN for his innumerable guidance, contribution and advice to the success of this work. May Allah reward and increase his knowledge.

Finally, am saying thank you to all my friends and loved ones, I pray ALLAH reward everybody including the unmentioned names that have contributed in one way or the other or have intention of contributing but something prevented.

ABSTRACT

This project is concerned with the design and construction of a versatile digital zener diode tester, it was designed to verify the specified breakdown voltages and tolerances values and in addition, it can check the dynamic impedance of zener diodes. The dynamic impedance characteristics of a zener diode determines how well the zener diode regulates its own breakdown voltage. The tester can be used in conjunction with an ordinary digital multimeter to measure the operating voltage of any zener diode and also give an idea of the efficiency of the component under test. This circuit is capable of testing zener diodes of breakdown voltage ratings of up to 220V and wattage ratings of 250mW, 400mW, 500mW, and 1W. The circuit can be deployed in quick test mode and also in quality test mode one can perform a rough check of zener diodes breakdown voltage up to 47volts. In quality test mode, one can check dynamic impedance characteristic for zener diodes from 1V to 200V. A multisim electronics work bench was used to simulate the circuit and some adjustment were made in order to get better results. The workability of the tester and results expected were satisfactory.

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CHAPTER I

INTRODUCTION

In this chapter the following sub-headings will be discussed. These include:

1.1 General introduction

1.2 Motivation

1.3 Aims and objective

1.4 Types of zener diode tester

1.5. Principle of operation

1.1 GENERAL INTRODUCTION.

The impact of numerous discoveries and invention in the field of electronics is a matter of record. Electronics has traditionally included the problem of developing and manufacturing electronic circuits and system. This project is concerned with the design and construction of a digital zener diode tester. The tester will be used to verify and check mainly the tolerance values. This can be achieved with the aid of digital multi-meter and digital ammeter to measure the operating voltage of any zener diode and also give an idea of the efficiency of the component under test. The complete circuit diagram gives the bulk of the circuitry used to generate the source-voltage up to 230V/9VDC. The block diagram for the versatile digital zener diode tester consists of four major units. Namely power unit I, power unit II, Control unit and the display unit.

- **POWER SUPPLY UNIT:**

The power supply units are probably the single most common functional unit in all electronics. Almost every piece of apparatus contains one or more of that. The first stage of the power unit steps down the 230V A.C to 9V A.C while the second stage of the power unit is 9V, current rating of 500mA.

- **CONTROL UNIT:**

This is the unit which controls the variable D.C voltage sources and computing the voltage across each resistor in series combination in one step. The circuit can also be used as a buffer unit, to serve as a power amplifier which increases the current being generated. However, the current limiting resistor was introduced to limit the current across the transistor as well as the milliammeter M_1 for protection from the reverse voltage in order not to destroy the meter. Therefore a power supply unit is the circuit inside electronics equipment that converts the AC input voltage to almost perfect D.C output voltage.

- **VISUAL DISPLAY UNIT:**

This unit consists of milliammeter as well as the multimetre which display a parameter of component under test, and the test current required for each component.

1.2 MOTIVATION.

The various applications of versatile digital zener diode testers are usually employed and appreciated by students of electronics and electrical engineering for its wide applications and unique features. A tester that can be easily constructed by students to investigate the different applications of zener diode.

1.3 AIMS AND OBJECTIVES

The major aim of this project is to develop an experimental module for the demonstration of some applications of the versatile zener diode tester.

The Objectives are as follows:

- The tester presented here will enable one to verify the specified tolerance values.

- The circuit can be used to compare the characteristics of zener diodes and categorize them accordingly.
- The tester is capable of testing zener diodes of break down voltage rating of up to 200 volts and wattages rating of 250mW, 400mw and 1W respectively.
- The tester can also enable one to check the dynamic impedance of zener diodes.
- The circuit can also be deployed both in quick and quality test modes of operations. In quick test mode one can perform a rough check of zener diodes breakdown voltages up to 47 volts while in quality test mode; one can check dynamic impedance and characteristics of zener diodes from 1_V to 200_V respectively.

1.4 TYPES OF ZENER DIODE TESTERS

The following are some of the relevant zener diode testers such as: -

(a) ZENER DIODE TESTER

Using two transistors as oscillators with voltmeter but without power transformer. One of the disadvantages of this arrangement is that the capacitor must gain sufficient charge during the load current process. The more constant the capacitor maintains the voltage, the shorter is conductor period of the diode.

(b) ZENER DIODE TESTER USING A SINGLE IC 555 TIMER

The circuit can test zener diodes of voltage rating up 50V D.C. The 555 timer is used in the astable mode, the output at pin 3 drives a small audio transformer such as the LT 700. This has a primary impedance of 8ohms, the unloaded AC voltage is around 120volts. This is rectified by IN4004 diode and smoothed by the 2.2uf capacitor which must be 150VD.C. The zener under test is measured with a multimetre set to DC volts. The load current switch enables the zener diode to be tested at 1 or 2mA D.C. The rectified D.C voltage and a good zener diode should maintain the reading on the voltmeter.

(e) HANDY ZENER DIODE TESTER

A handy zener diode tester is capable of testing zener diodes with breakdown voltages extending up to 120 volts. The main advantage of the circuit is that it works with a voltage as low as 6VD.C and consumes less than 8mA current.

The circuit can be fitted in a 9volts battery box. Two- thirds of box may be used for 1.5 volt battery and the remaining one- third sufficient for accommodating the circuit. In the circuit a commonly available transformer with 230V.A.c primary to 9-0.9V, 500mA secondary is used in reverse to achieve higher A.C voltage across 230V terminals, Transistor T_1 of (BC547) is configured as oscillator and drives to obtain required A.C voltage across transformer's 230VA.C terminals. This A.C voltage is converted to D.C, a diode D_1 and filter capacitor C_2 is used to test the zener diodes, resistor R_3 is used in series as a current limiting resistor. After assembling the circuit, check D.C voltage across terminal points A and B without connecting any zener diode, then switch ON S_1 the D.C voltage across point A and B which should vary from 10V to 120V by adjusting photometer VR_1 (10k), if everything is all right, the circuit is ready for use. For testing a zener diode of unknown value, connect it across A and B. Note down the zener value corresponding DC voltage reading on the digital millimeter. When testing zener diode of value less than 3.3V, the meter shows less voltage instead of the actual zener above 5.8 with a tolerance of 10 percent.

(d) THE VERSATILE ZENER DIODE TESTER The circuit was initially designed to test zener diodes rating between the range of 3.3 to 120V with the aid of analogue ammeter and digital voltmeter respectively. However, the following modification was introduced in this new project, these include:-

(1) The circuit is now capable of testing zener diodes rating from 1V – 200V.

(2) The analogue ammeter has been replaced with digital ammeter.

(3) The astable circuit using **IC555 timer** was also introduced with light emitting diode (LED'S) indicators in order to indicate which operation between quick and quality test is being performed during tests.

1.5 PRINCIPLE OF OPERATION

As shown in fig 3.1a, to test zener diodes a variable voltage (0 to above 120V) and current 1mA to 150mA, supply source is required. Designing this type of power supply is quite complicated and is prone to damage if excess current is drawn accidentally. The zener diode tester circuit has been designed considering the above factors. Because it is capable of testing zener diode of breakdown voltage rating of up to 200V and voltage ratings of 250mW, 500mW and 1W. The circuit can be deployed in quick test mode as also in quality test mode of operation. In quick test mode one can perform a rough check of zener diodes breakdown voltage up to 47 volts. In quality test mode, one can check dynamic impedance, characteristic for zener diodes from 1V to 200V. The 220V D.C voltage approximately across c_1 selects to test 220V D.C voltage. The advantage of using this high voltage circuit is that the current gets restricted to a low value. It delivers only 3mA (approx) when testing higher zener diodes values e.g. 200V while testing diodes of low breakdown values such as 1V, it deliver a current slightly above 20mA. Before using the circuit, check D.C voltage across test terminals without connecting any zener diode and then flip toggle switch S2 to quick-test position. D.C voltage available across terminals A and B will be around 200V D.C. Now put toggle switch to quality-test position. D.C voltage, it can now be adjusted from 6V D.C to 200V D.C (approx.) with the help of potentiometer VR_1. After these preliminary checks, the circuit is ready for operation. To test zener diode by quick-test method, connect zener diode across terminals A & B and flip switch S1 to ON position, note down D.C voltage in digital milliammeter M_2 which is the rough breakdown voltage. In quick test method one can test zener diode values, if zener diode presents a short, digital mili-ameter M_2 will read "O" volts To perform quality test on the same zener diode, turn switch S1 'off' and remove Zener diode from across terminals A and B. Now turn switch S_1 'on' and adjust potentiometer VR_1 to obtain D.C voltage (on digital multi-metre) across terminals A and B equal to the one found during quick test method. Now keeping potentiometer VR_2 in mid position and connect zener diode across terminals A and B. Test current I min and maximum test current (I max) required for various zener diode values, depending upon their wattage rating.) The meter and the zener diode are connected in series and the breakdown current is recorded at the digital meter M_2. However, when comparing zener diodes of the same values, the zener showing less voltage deviation would regulate better.

CHAPTER TWO

LITERATURE REVIEW.

2.1 INTRODUCTION

An attempt could be made in this chapter to review some related literatures on electronic zener diode testers, their advantages and disadvantages including this particular project. There have been significant changes in the design and construction of electronics zener diode testers, from simple to complex, old and new methods requirement of each system, a simple zener diode tester may be required to test a fixed zener diode voltage and current, while other complicated zener diode testers may be required to test several variable zener voltages and current. From the previous research many engineers used different methods and different components for example, some have used a combination of single transformer, single transistor and few resistors and capacitors in designing zener diode testers. While other zener diode tester requires complex circuit consisting of many transistors, resistors, capacitors and transformers.

2.2 THRORITICAL BACKGROUND.

A **Zener diode** is a type of diode that permits current to flow in the forward direction like a normal diode, but also in the reverse direction if the voltage is larger than the breakdown voltage known as "Zener knee voltage" or "Zener voltage". A conventional solid-state diode will not let significant current flow if it is reverse-biased below its reverse breakdown voltage. When the reverse bias breakdown voltage is exceeded, a conventional diode is subject to high current flow due to avalanche breakdown. Unless the current is limited by external circuitry, the diode will be permanently damaged. In case of large forward bias (current flow in the direction of the arrow), the diode exhibits a voltage drop due to its junction built-in voltage and internal resistance.

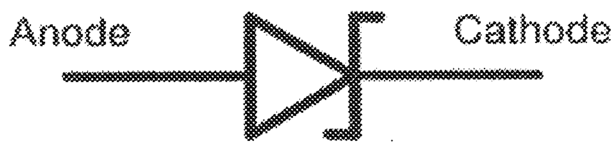


Fig 2.1 A Zener diode schematic symbol

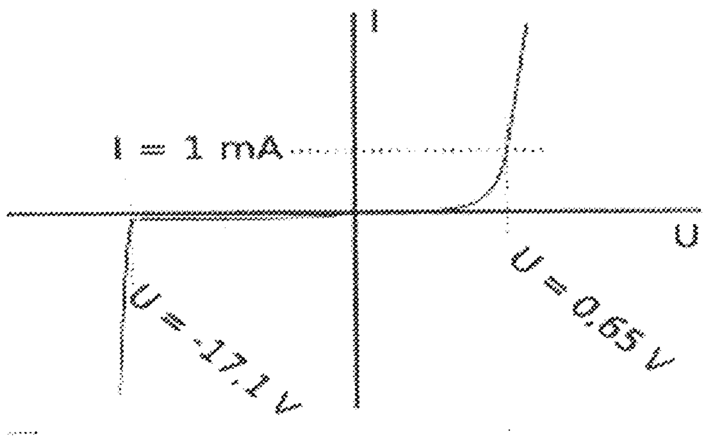


Fig 2.2 Current voltage characteristics of a zener diode.

The amount of the voltage drop depends on the semiconductor material and the doping concentration .A **Zener diode** exhibits almost the same properties, except the device is specially designed so as to have a greatly reduced breakdown voltage. A reverse-biased Zener diode will exhibit a controlled breakdown and let the current flow to keep the voltage across the Zener diode at the Zener voltage. For example, a diode with a Zener breakdown voltage of 3.2V will exhibit a voltage drop of 3.2V if reverse biased voltage applied across it is more than its Zener voltage. However, the current is not unlimited, so the Zener diode is used to generate a reference voltage for an amplifier stage, or as a voltage stabilizer for low-current applications.

The breakdown voltage can be controlled quite accurately in the doping process. While tolerances within 0.05% are available, the most widely used tolerances are 5 % and 10%.

2.3 APPLICATIONS OF ZENER DIODE

Zener diodes find numerous applications in transistor circuitry some of their common applications are:

(1) As a power supply regulators:

Zener diodes are widely used to regulate the voltage across a circuit. When connected in parallel with a variable voltage source so that it is reverse biased, a zener diode conducts when the voltage reaches the diode's reverse breakdown voltage. From that point it keeps the voltage at that value.

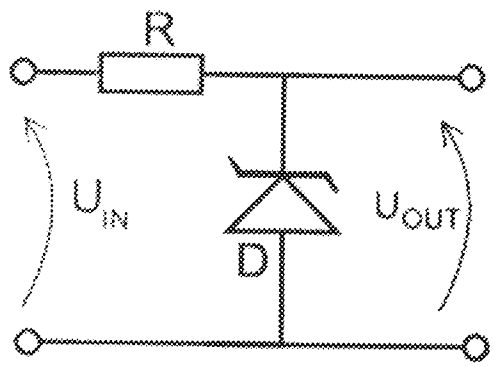


Fig 2.3 Zener diode voltage regulator

In the circuit shown fig 2.3, resistor R provides the voltage drop between U_{IN} and U_{OUT}. The value of *R* must satisfy two conditions:

(a) R must be small enough that the current through D keeps D in reverse breakdown. The value of this current is given in the data sheet for D. For example, the common BZX79C5V6 device, a 5.6V 0.5W zener diode, has a recommended reverse current of 5mA. If insufficient current flows through D, then U_{OUT} will be unregulated, and less than the nominal breakdown voltage (this differs to voltage regulator tubes where the output voltage will be higher than nominal and could rise as high as U_{IN}.) When calculating R, allowance must be made for any current flowing through the external load, connected across U_{OUT}.

(b) R must be large enough that the current through D does not destroy the device. If the current through D is I_D, its breakdown voltage V_B and its maximum power dissipation P_{MAX}, then $I_D V_B < P_{MAX}$. A zener diode used in this way is known as a shunt voltage regulator.

(2) As a fixed reference voltage in a network.

Zener diodes are used to maintain a fixed voltage. They are designed to 'breakdown' in a reliable and non-destructive way so that they can be used **in reverse** to maintain a fixed voltage across their terminals. The diagram shows how they are connected, with a resistor in series to limit the current. Zener diodes can be distinguished from ordinary diodes by their code and breakdown voltage which are printed on them. Zener diode codes begin BZX... or BZY... Their breakdown voltage is printed with V in place of a decimal point i.e 4V7 means 4.7V for example. Zener diodes are rated by their breakdown voltage and maximum power: The minimum voltage available is 2.7V and Power ratings of 400mW and 1.3W are common.

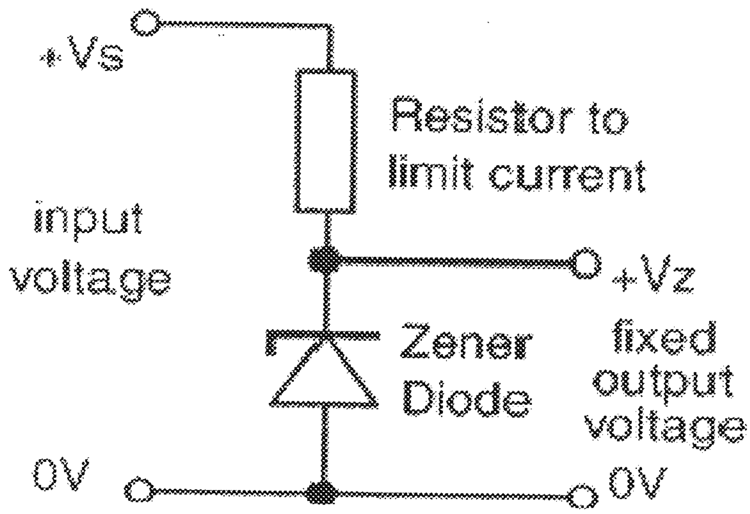


Fig 2.3 Zener Diodes as a Fixed Reference Voltage

(3) Zener Clamps as voltages dropping coupling elements. Often, it is necessary to apply a clamp to prevent an AC voltage from exceeding a specified value.

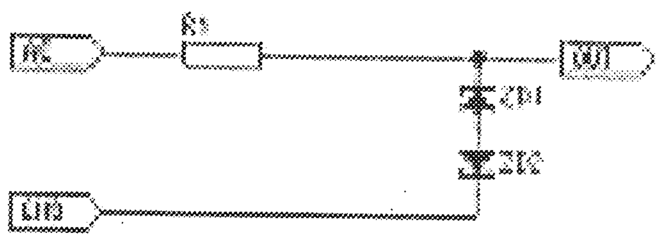


Fig 2.4 Zener Diode Clamp

The actual clamped voltage will be 0.65V higher than the zener voltage because of the series diode. 12V zeners will therefore clamp at around 12.65V, R1 is designed to limit the current to a safe value for the zeners, as described in fig 2.4.

2.6 REVIEWS OF OTHER ZENER DIODE TESTERS

The following are some reviews of the relevant zener diode testers:-

ZENER DIODE TESTER:- Using two transistors as oscillators with voltmeter but without power transformer, one of the disadvantage of this arrangement is that the capacitor must gain sufficient charge during the load current for the remaining time, the more the capacitor maintains the voltage, the shorter the conduction period of the diode.

The complete circuit diagram of this type of zener tester is as shown fig 2.5

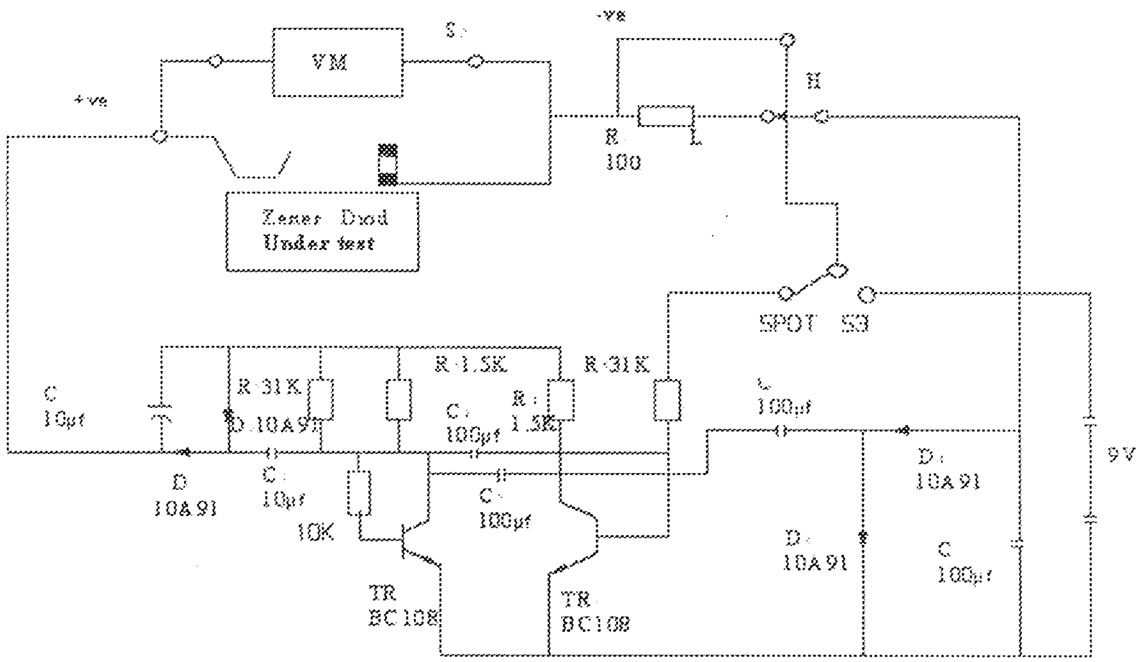


Fig 2.5 Zener Diode Tester without Transformer Circuit Diagram

THE CIRCUIT OPERATION

S_1 and S_2 as shown in fig 3.1a above are connected to a multimetre, with S_1 to the – ve terminal and S_2 to +ve terminal of the voltmeter. They consist of short lead fitted with a wander plug at one end and a crocodile clip at the other a similar set of leads are used to connect the zener under test to a tester, but these leads are terminated in a single 3.5mm jack socket rather than a wander plugs. The multimeter should be switched to 50VD.C range, which will gradually drop and the better will need to be replaced, that is when the reading on meter falls below 27volts. As battery ages, this reading will gradually drop and the better will need to be replaced. In order to test a zener diode it is necessary to connect the component across the test leads to read the operating voltage on the meter. That is cathode connected to the +ve output and the cathode is usually identified by a colour band around the end of the component. An idea of the efficiency of the zener diode can be obtained by switching S_1 to the high (H) position. This should result in the meter reading unaltered or increasing very slight. If large increase is noticed in the meter it signifies that the zener diode under test is inefficient.

ZENER DIODE TESTER USING A SINGLE LC 555 TIMER

Zener diode tester using a single IC 555 timer, this will test zener diodes of voltage rating up 50V D.C. The 555 timer is used in the astable mode. The output at pin 3 drives a small audio transformer such as the LT 700. It has a primary impedance of 8 ohms used in reverse the unloaded AC voltage is around 120volts AC. This is rectified by IN4004 diode and smoothed by the 2.2uf capacitor which must be 150VD.C. The zener under test is measured with a multimetre set to DC volts. The load current switch enable the zener to be tested at 1 or 2mA D.C. The rectified D.C load, but a good zener should maintain the reading on the voltmeter.

HANDY ZENER DIODE TESTER

A handy zener diode tester is capable of testing zener diodes with breakdown voltages extending up to 120volts. The main advantage of this teeter is that it works with a voltage as low as 6VD.C and consumes less than 8mA current.

The tester can be fitted in a 9volts battery box. Two- third of box may be used for 1.5 volt battery and the remains of one- third is sufficient for accommodating the tester. In this tester a commonly available transformer with 230V.A.C primary to 9-0.9V, 500mA secondary is used in reverse to achieve higher A.C voltage across 230V terminals, transistor T_1 is of (BC547) is configured as oscillator and drives to obtain required A.C voltage across transformer's 230VA.C terminals This A.C voltage is converted to D.C by diode D_1 and filter capacitor C_2 is used to test the zener diodes, resistor R_3 is used in series as a current limiting resistor. After assembling the circuit, check D.C voltage across terminal points A and B without connecting any zener diode, now switch on S_1 the D.C voltage across point A and B should vary from 10V to 120V by adjusting photometer VR_1 (10k) if everything is all right, the circuit is ready for use. For testing a zener diode of unknown value, connect it across A and B. Note down the zener value corresponding DC voltage reading on the digital millimeter. When testing zener diode of value less than 3.3V the meter shows less voltage instead of the actual zener above 5.8 with a tolerance of 10 percent.

2.7 ZENER BIASING

For proper working of a zener diode in any circuit it is essential that the diode must:

- Be reverse biased.
- Have voltage across it greater than V_z.
- Be in a circuit where current is less that I_z-max.

2.8 ZENER DIODE IDENTIFICATION

Physically a zener diode look like any other diode and it recognized by its in number such as IN4001, IN4007 (high power) etc.

CHAPTER THREE

DESIGN AND ANALYSIS

3.1 INTRODUCTION

This chapter deals with the design and analysis of the digital zener diode tester. The tester has four major units namely: the power supply unit I and II, the timing and control unit, the display unit and other associated components.

3.2 THE POWER SUPPLY

The power supply unit is a circuit which is designed to convert high voltage A.C mains electricity to a suitable low voltage supply for electronics circuits and other devices. The functions of the power supply is to provide necessary D.C voltage and current as specified with low level of A.C ripple and with a good stability and regulation against change in the mains input and load current output another important function is that, it should be able to limit, if possible the available output current and voltage in the case of over-load or short circuit. It also provides isolation of equipment from the A.C mains.

The block diagram of a regulated power supply system for this project is shown in fig 3.1.

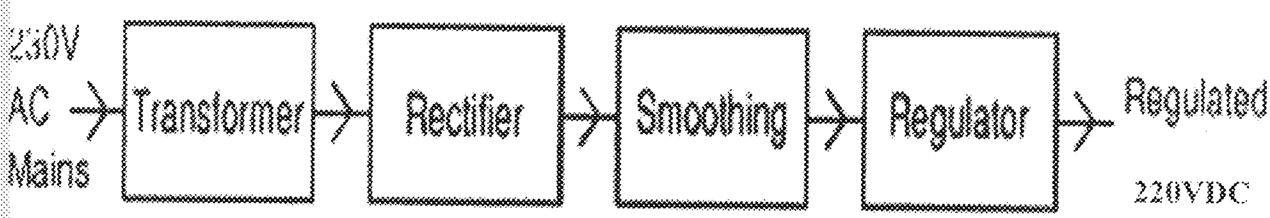


Fig 3.1 Block Diagram of a Regulated Power Supplies System

(i) Transformer- steps down high voltage A.C mains to low voltage A.C

(ii) Rectifier- converts A.C to D.C, but the D.C output is varying.

(iii) Smoothing smooth the D.C from varying greatly to a small ripple.

(iv) Regulator eliminates ripple by setting D.C output to a fixed voltage.

The element of the power supply unit consists of the following:-

(1) Transformer x_1 and transformer x_2

(2) Light Emitting Diode (LED1)

(3) Current Limiting Resistor (R_1)

(4) Rectifier

(5) Filter capacitor (C_1)

A 230V/9V, 50HZ, 500mA step down transformer $x_{1\ \text{and}}$ x_2 are connected back to back and use to provide an A.C high voltage of 230v to the rectifier, the output D.C voltage is fed into the fetile capacitor C_1, for final and better smoothening 220V D.C

For the operation of zener-diode tester. The complete circuit diagram for power supply unit is shown in fig below.

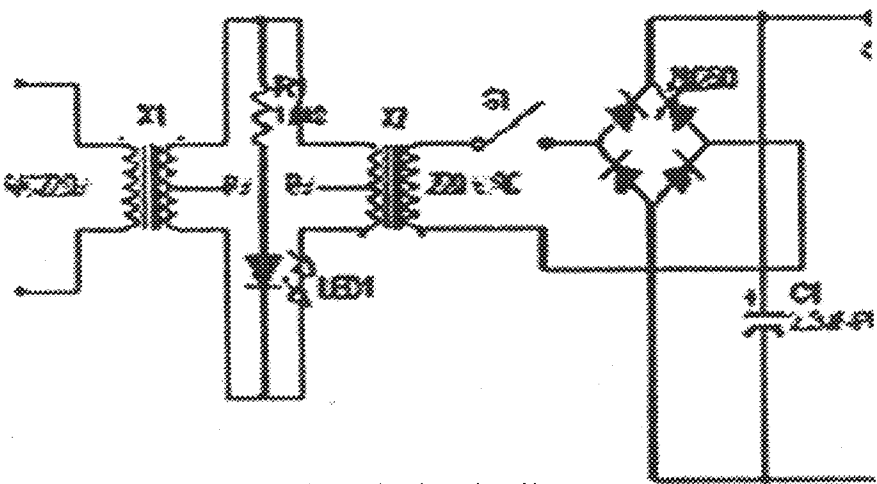


Fig 3.2 the power supply unit circuits diagram

3.3 TRANSFORMERS X_1 AND X_2 The transformers are step-down types to reduce AC voltage from mains supply 230V to a safer low voltage (9V) for the requirement of this project.

A step-down transformer has a large number of turns on their primaries (input) Coils are connected to the high voltages mains supply and a small number of turns on their secondaries (output) coils to give a low out put voltages. The following design specifications and assumptions were made to satisfy the designer requirement.

Turns ratio Vp, Np,Vs and Ns...(3.1.1)

And power out = power in

$V_s \, xI_s = V_p \, xI_p$ ....(3.1.2)

Where:-

V_p = primary input voltage (220V)

N_p = number of turns on primary coil (1800 tunes)

I_p = primary input current?

V_s = secondary output voltage (9v)

N_s = number of turns on secondary coil ?

Is = secondary output current (0.5A)

H_Z = Out frequency ($50H_Z$).

To calculate turns ration

$$\frac{NP}{NS} = \frac{IP}{IS} \qquad (3.1.4)$$

$$NS = \frac{NPIS}{IP} \qquad (3.1.5)$$

$$NS = \frac{1800x0.5}{12.22}$$

:. = 74 turns

$$\frac{NP}{NS} = \frac{EP}{ES} = \frac{IP}{IS} \qquad (3.1.6)$$

$$\frac{EP}{ES} = \frac{IP}{IS} \text{..} (3.1.7)$$

$$\therefore IP = \frac{EPxIS}{ES} \text{..} (3.1.8)$$

$$IP = \frac{9x0.5}{220}$$

IP = 0.020454545

:. IP = 20.45mA

From the results of the above analysis, the expected values for both current, voltages and turns ratios of the transformers were obtained accordingly.

3.4 R_1 and LED1

The R1 and LED1 form the visual indicator for the power supply unit when switch S_1 is ON R_1 is used here as a current limiting resistor, it is required that a forward current (If) of about 7mA should follow through the LED at our A.C voltage of 9V, the value of R_1 can now be calculated by the use of this equation:

$$R_1 = \frac{VS - Vd}{IF} \text{..} (3.1.9)$$

Where:-

R_1 = is the current limiting resistor

V_s = is the supply voltage (9V A.C)

V_d = is the forward voltage drop of the LED (9-7 = 2V)

I_f = is the forward current following through the LED1.

$$\Rightarrow R_1 = \frac{9 - 2}{7x10^{-3}} = 1000\Omega$$

∴ R_1 = 1K ± 5%.

3.5 THE RECTIFIER.

There are several ways of connecting diodes to make a rectifier to convert Ac to Dc. The bridge rectifier is the most important one. And it can be made using four individual diodes, but also available in special packages containing the four diodes required.

It is called a full- wave rectifies because it uses all the A.C wave (both positive and negative section) 1.4V is used 0.7V when conducting and there are always two diodes conducting as shown in fig 3.3 below the diagram shows the

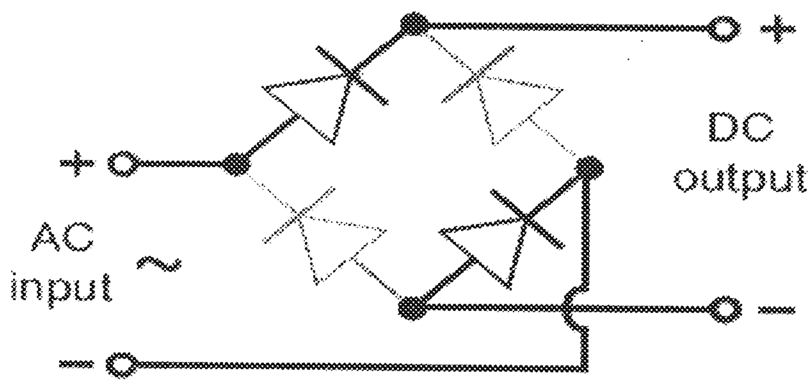


Fig 3.3 Bride Rectifier Circuit.

The use of a bridge rectifier is desirable since the diode PIV rating is one half that of the other single phase full-wave rectifier method. Bridge rectifiers are now available in special package containing the four diodes. This type of rectifier was used in the design, and is of 2N250 type. The maximum current and reverse voltages are 1A and 1000V respectively.

3.6 FILTER CAPACITOR (SMOOTHING)

Smoothing is performed by a large value electrolytic capacitor connected across the D.C supply to act as a reservoir supplying current to the output when the varying D.C voltage from the rectifier is falling. The diagram of fig 3.4 shows the unsmoothed varying dc dotted line and the smoothed dc solid line. The capacitor charge

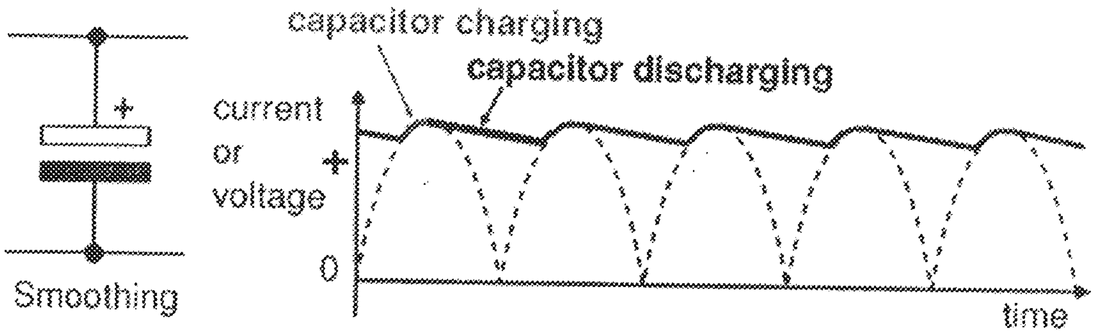


Fig 3.4 Filter capacitor (smoothing) circuit diagram

Quickly near the peak of the varying D.C. and then discharges as it supplies current to the output.

Note that smoothing significantly increases the average DC voltage to almost the peak value (1.4 x RMS value). For example 6v RMS AC is rectified to full wave D.C of about 4.6V RMS (1.4V is lost in the bridge rectifier), with smoothing this increases to almost the peak value giving 1.4 x 4.6 = 6.4V smooth D.C.

Smoothing is not perfect due to the capacitor voltage failing a little as it discharges, giving a small ripple voltage. For many circuits a ripple which is 10% of the supply voltage is satisfactory and the equation below gives the required value for the smoothing capacitor. A capacitor will give fewer ripples. The capacitor must be doubled when smoothing half-wave D.C.

Smoothing capacitor for 10% ripple $C = \frac{5x10}{VSxF}$ ....(3.10)

C = smoothing capacitance in farads (F) VS

10 = output current from the supply in amps (A)

V_s = supply voltage in volts (v), this is the peak value of the unsmoothed dc

F = frequency of the A.C supply in hertz (Hz), 50Hz.

In the project design a capacitor filter is used since it given a better smoothing operation.

For proper filtration of a power supply unit the filter circuit should be able to produce a high D.C voltage of ripple. The amplifier of this ripple usually is depends upon the value of the filter component with respect to the load. The minimum values of the required filter capacitor C_1 can be calculated from the expression which is given as

$$C_1 = \frac{1}{2\sqrt{xFrxXrxRL}} \quad \text{...(3.11)}$$

Where

R_L = is the load resistor

r = is the ripple factor and is given by r = $\frac{Vr\ (rms)}{}$ .... (3.12)

V_r = (rms) is the rms valve of the A.C component

V_{DC} = is the average value of the rectified D.C voltage.

F_r = ripple frequency and for a full – wave bridge rectifier power supply, the voltage across the filtering capacitor is about twice the transformers secondary voltage, and for this reason, a diode with a peak inverse (PIV) grater than the capacitor voltage is chosen and for these diodes are 2N250

Similarly the frequency is also twice the supply frequency that is

50Hz x 2 = 100Hz.

Therefore IF a 9Vdc supply at 100mA is required from a bridge rectifier and that the rms ripple is about 500 mV in this case

$$r = \frac{500 \times 10^{-3}}{9} = 55 \times 10^{-3}$$

$F_r = 100Hz$

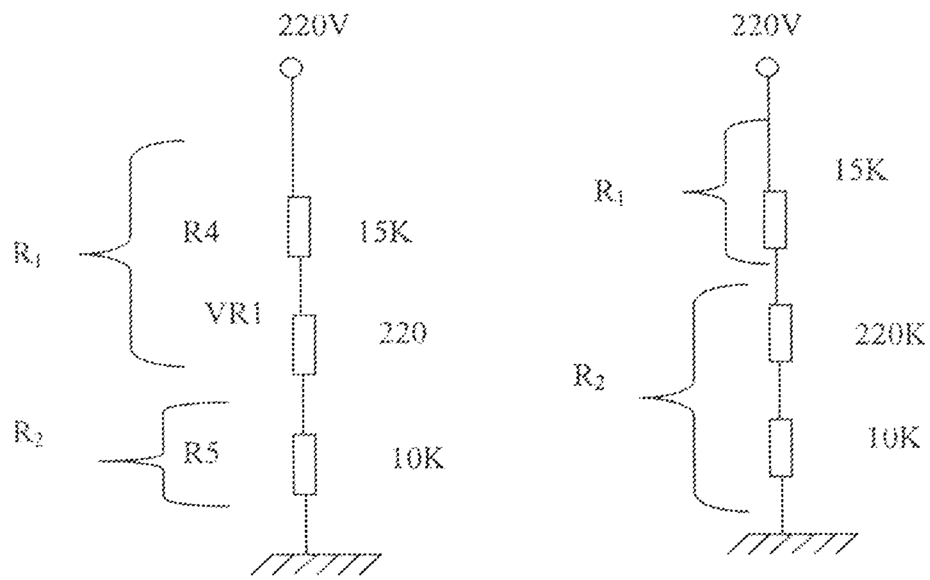
$R_2 = 270K$

$$C_1 = \frac{1}{2\sqrt{2x100\ x5510^{-3}}\ x270}$$

$c_1 = 2.3\ \mu f$

3.3 VOLTAGE DIVIDER NETWORK

The network consisting of R_4, VR_1 and R_5 as shown in fig. 3.4 below from a potential divider which serves as the variable D.C voltage source should vary from about 9vdc to 200 VDC. Now chosen R_4, VR_1 to be 15K and 220 K respectively, R_5 can be determined by using the potential divider rule as follows:-



$R1 = 15 + 220 = 235K$

$R_2\ 220 + 10 = 230K$

$$V_{out} = \frac{R_5}{R_4 VR1 + R_5} x Vs \quad \text{...} (3.13)$$

From the expression when subsituting the values yields

$$V_{out} = \frac{R_5 x 220}{15 + 220 + R_5}$$

$$R_5 = \frac{9x220}{15 + 220}$$

R_5 = 8. 112K=8.42kΩ

But R_5 is chosen to be 10KΩ (the nearest preferred standard value).

∴ R_5 = 10KΩ

3.4 BUFFER / POWER AMPLIFIER AND CONTROL CIRCUIT.

From fig 3.1a, the network consist of R_6, R_7, T_1, and V R_2, forms the buffer / power amplifier and control circuit for the miliammeter as shown in the complete circuit diagramme, it is found that the current and voltage at the base transistor T1 is equal to collector and the emitter.

The type of transistor T_1 used is of BU407 NPN (Silicon) as indicated by Manufacturers data sheet. The transistor serves the following functions:-

(i) Power amplifier

(ii) It generates high voltage for the required voltages needed for testing various zener diodes from 1V to 200V.

(iii) It also serves as a switch for ON and OFF especially when performing quick and quality tests. In considering the minimum output voltage of 9v the base current can be calculated by using this expression.

$$R_6 (R_7) \leq \frac{Vs - Vbe}{Ib} = \frac{Vs - Vbe}{Ic} \text{ hfe main} \quad \text{............} (3.14)$$

R_b = is the base resistance which is also (R7)

V_s = is the sourced D.C voltage

V_{BE} = is the base emitter voltage

I_b = is the base collector current

hfe = is forward current gain.

From the expression when substituting the values, the result can be `obtained as follows:-

$$R_b \le \frac{9-0.7}{\frac{25x10^{-3}}{12}}$$

Rb ≤ 3984 Ω ≤ 3 .9 K Ω

But Rb (R_7) is chosen to be 1.5 K (preferred standard value).

∴ R_7 = 1.5 K

R_c (R6) in conjunction with VR_2 forms the current limiting network for the millianmeter. considering a minimum collector current (CI) of about 5mA to flow through the millianmeter and a voltage drop of about 32V across R_6. Therefore the value of R_6 can be determined using the given equation:-

$$R_6 = \frac{Vd}{I_{C\ (min)}} \quad \text{.. (3.15)}$$

Where V_d = is the voltage drop across the R_6

I_c = is the collector current (min)

$$\Rightarrow R_6 = \frac{32}{5x10^3} = 6.4\ K$$

∴ R_6 = 6.8 K ± 5%

The value of R_3 is obtained by considering the minimum zener diode voltage under test and in this project work it is 3.3v again allowing for a zener current (I_z) of about 20mA. R_3 is computed as follows:-

$$R_3 = \frac{Vs - Vz}{Iz} \qquad \text{...} (3.16)$$

$$R_3 = \frac{220 - 3.3}{20x10^{-3}}$$

$$R_3 = \frac{216.7}{0.02} = 108,35\ \Omega$$

$\therefore\ R_3 = 10.8k.$

But R_3 is choose to be $10K\Omega$ (nearest preferred standard value is 10k)

$\therefore\ R_3 = 10k\Omega$

D_5 IN4007 is used as isolation to protect the milliammeter against the

reveres voltage, so without this diode D_5 the voltage will reverse and automatically the milliammeter will be destroyed.

3.5 ASTABLE MULTIVIBRATOR

An astable multivibrator is simply an oscillator that generates continuous streams of rectangular off-on pulses that switch between two voltage levels. Two astable multivibrators circuits are designed using IC555 timer with external resistors and a capacitor to set the time of the out put signal and also to flash both the green and yellow LED's indicators when performing quality and quick test respectively. The circuits are shown in fig 3.5 a & b.

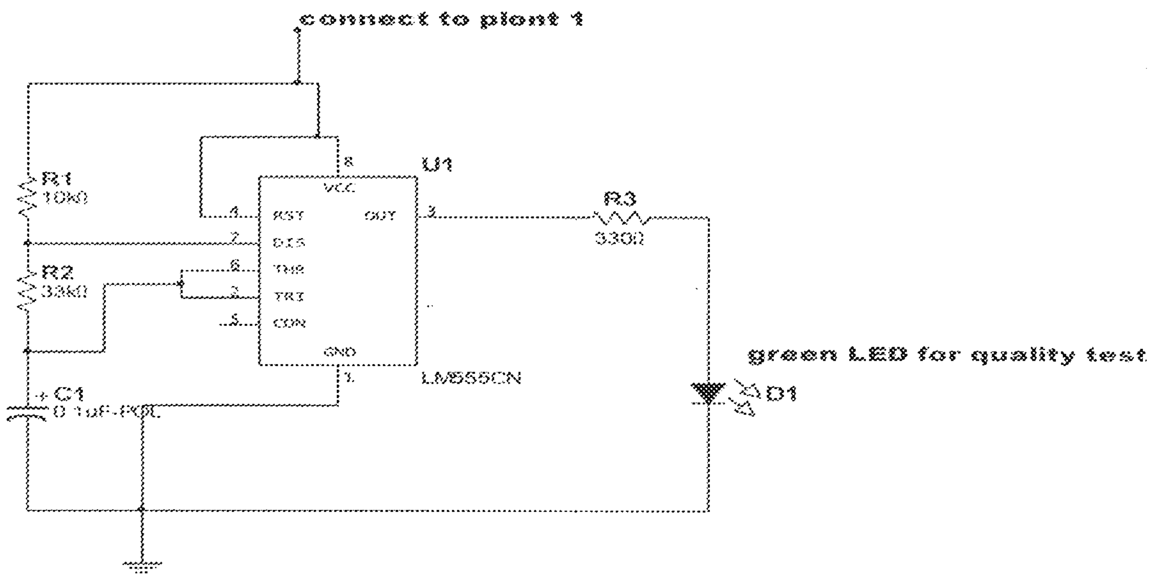


Fig 3.5 Astable Multivibrator Circuit to Indicate Quality Test

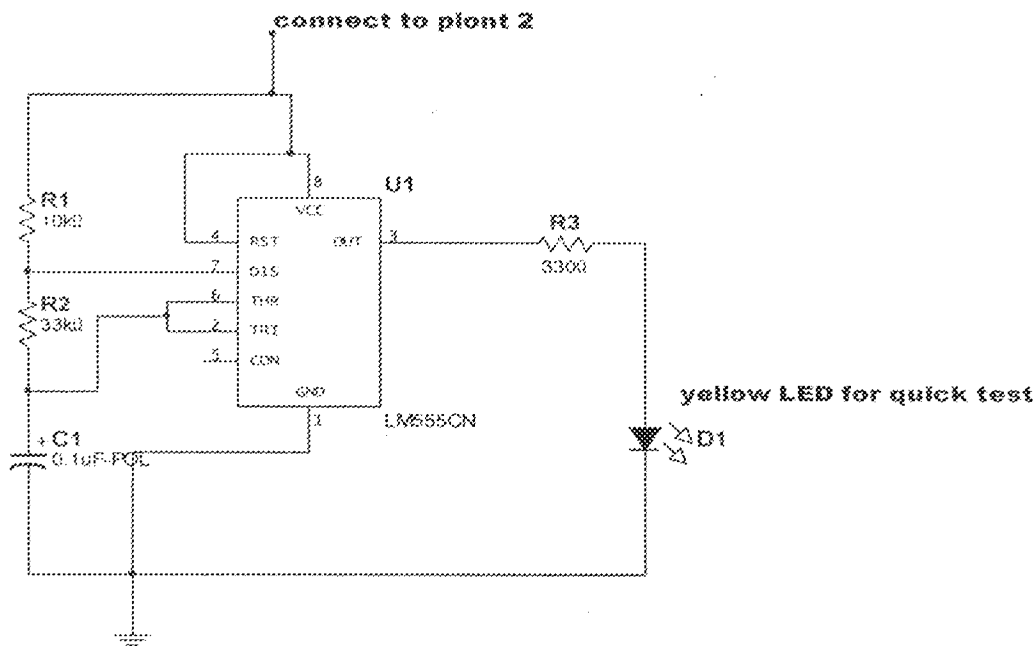


Fig 3.5 b Astable Multivibrator Circuit to Indicate Quick Test

Astable multivibrator circuit is designed using an external resistor and a capacitor to set the timing of the output signal.

Capacitor C charges towards V_{cc} through R_1 and R_2. The frequency of operation of the astable circuit is dependent upon the values R_1, R_2 and C.

The frequency can be calculated with the formula.

$F = 1/(0.693 \times C(R_1 + 2R_2)$ .... (3.17)

$F = 1/(0.693 \times 0.1 \times 10^{-6} (10+33 \times 2)$

$F = 1/(0.693 \times 0.1 \times 10^{-6} (43 \times 2)$

F = 189,868,6109

$F \approx 189Hz$

The frequency is in Hz, R1 & R2 are in ohms and C is in farads.

The time duration between pulses is known as the period (T). the pulse is on for t_1 second and then off for t_2 Seconds

The total period $(T) = t_1 + t_2$

Thus the time is related to the frequency by the following relationship

$F = 1/T$ or T/F

The time intervals for the ON and OFF position of the output depend upon the values of R_1 and R_2. The ratio of the time duration, when the output pulse is high, to total period is known as the duty-cycle. The duty –cycle can be calculated with the formula.

$D = t_1/T$

$= (R_1+R_2)/(R_1 + 2R_2)$ .... (3.18)

You can calculate t_1 and t_2 from formula below.

$t_1 = 0.693(R_1 + R_2)C$

$t_2 = 0.693 \times R_2 \times C$

$t_1 = 0.693(10+33 \times 2) \times 0.1 \times 10^{-6}$

$t_1 \quad = \quad 5.2668 \times 10^{-6}$

$t_2 \quad = \quad 0.693 \times 33 \times 2 \times 0.1 \times 10^{-6}$

$t_2 \quad = \quad 4.5738 \times 10^{-6}$

The total period (T) = $t_1 + t_2$

$T = 5.2668 \times 10^{-6} + 4.5738 \times 10^{-6}$

$\therefore T = 9.840 \times 10^{-6}$

The duty –cycle can be calculated with the formula.

$D = t_1/t = (R_1+R_2)/(R_1 + 2R_2)$ ………………… (3.19)

$D = \frac{5.2668x10^{6}}{9.8406x10^{-6}} = 5.352x10^{-6}$ $\quad \therefore D = 5.657 \times 10^{-6}$

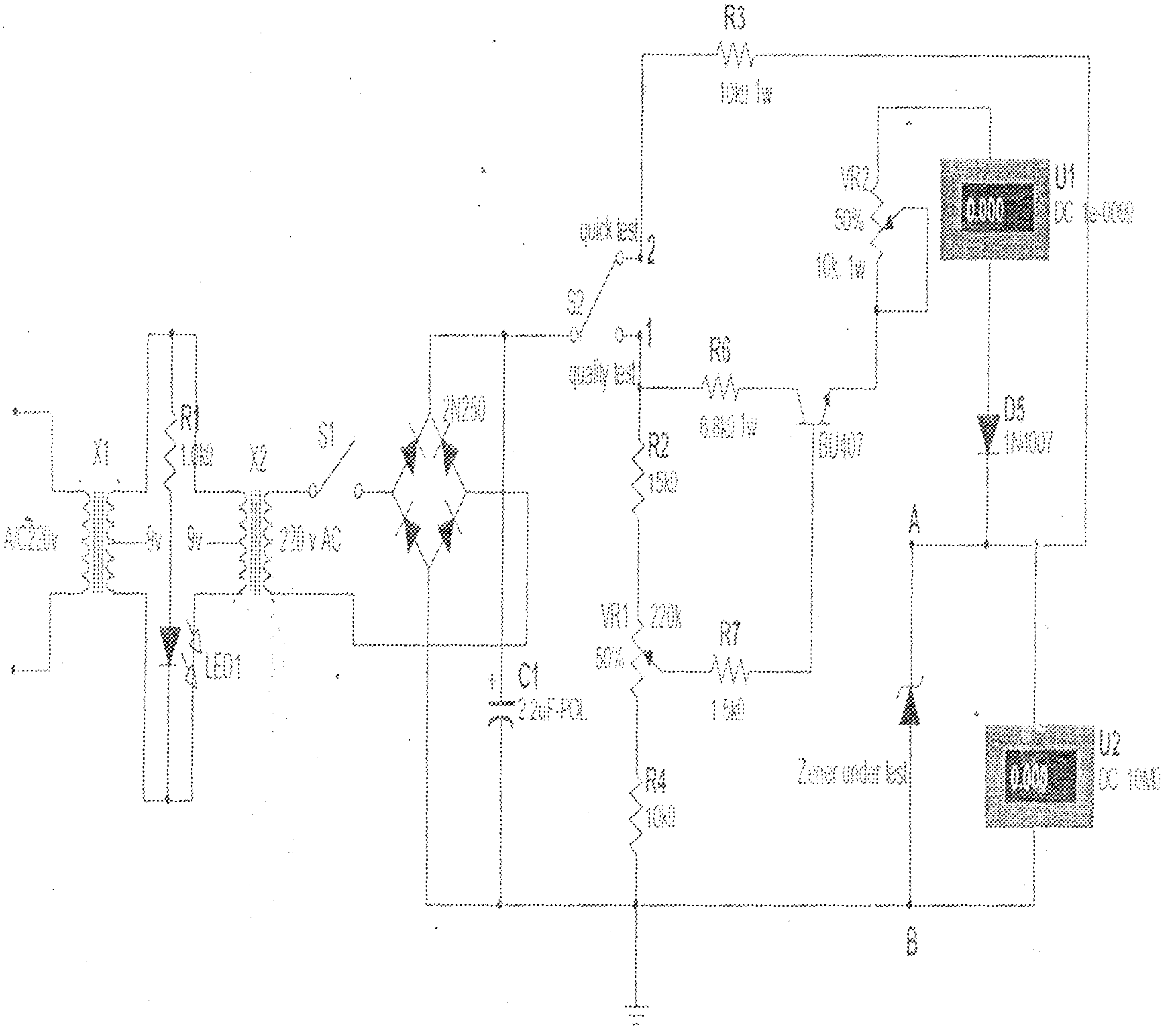


FIG 3.1a A Complete Circuit Diagram for Versatile Digital Zener Diode Tester

CHAPTER 4

CONSTRUCTION, TESTING AND CASING

4.1 INTRODUCTION

This chapter describes the procedures of the construction details and testing for the versatile digital zener diode tester under the following sub-headings:-

(i) Construction and casing

(ii) Methodology in the construction process

(iii) List of components and cost

(iv) Testing procedures.

4.2 CONSTRUCTION AND CASING

This is the most difficult aspect of the project., because different precautions was taken into consideration in the construction of the module zener diode tester. During soldering excess heat application and flicking soldering iron in removing excess solder was avoided in order not to damage some of the components, soldering iron used was cleaned, so also excessive force was not applied on the Vero board so as to avoid crack or breakage.

4.3 CONSTRUCTION

After the component analysis has been completed and the preferred values were chosen then they were first tested to ensure that they are in good working condition they were mounted first on a breadboard according to specification to ascertain their performances.The component was laid horizontally on the breadboard and care was taken in mounting each component to ensure that the correct configuration and connections were made and it worked fine.

Thereafter, the whole circuit was then carefully transferred to a single compact Vero-board in which all the components were soldered accordingly, which are then connected to plugs mounted on the top cover of the casing via connecting wires, the transformers used in this construction were chosen to meet the required specification, the diodes in the circuit fig 3.1a were also connected in the reverse bias mode according to the circuit configuration. These constructions constitute of four stages, the same process of connection and laying of component was done.

4.4 CASING

The casing of module zener diode tester is made from well finished plastic materials in which the complete circuit constructed was packaged inside with holes to provide ventilation for the circuit. The main switch is mounted at the front cover of the case. A hole was provided via which the main power supply wires ran into the case.

The single pole double throw switch (S_2 SPOT), the VR_1 VR_2 LED indicators for both quick and quality tests together with milliammeter (M_1) are viewed from the casing, the component under test terminal A and B which indicate the zener diode under test are also mounted on the top view of the casing. A view of the casing is shown in fig.4.2 the transformers were screwed to the mains cable across the circuit board in the casing which increases safety.

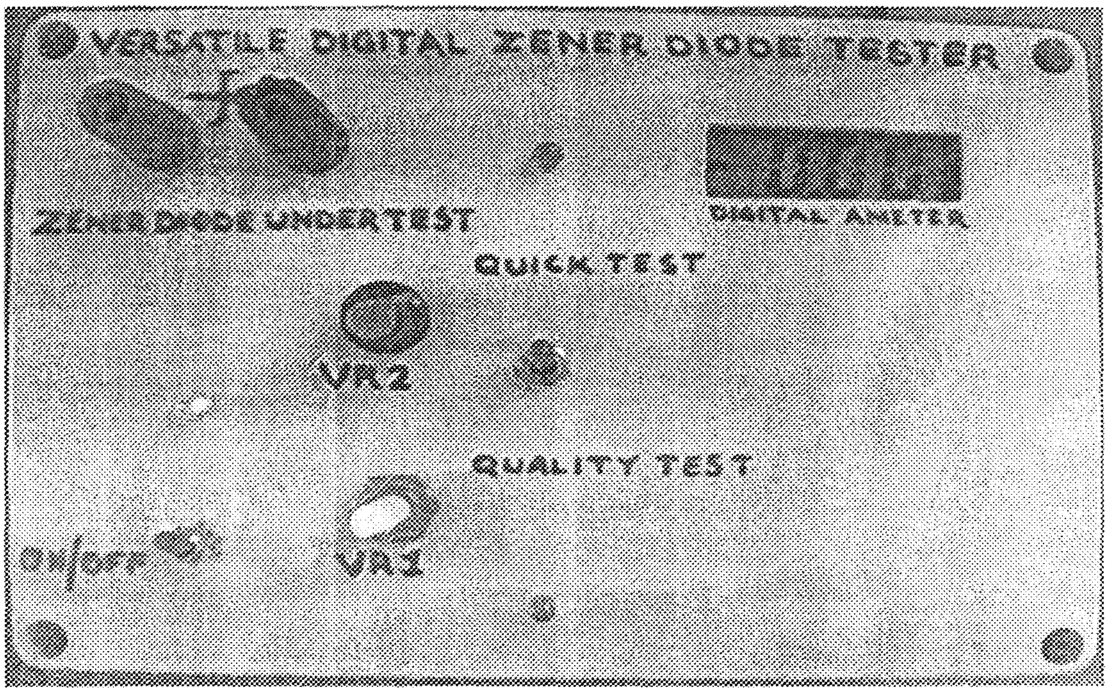


Fig 4.1 A View of Casing Indicating Quality Tests Operation Digital ammeter Before connecting any component.

4.5 METHODOLOGY IN THE CONSTRUCTION PROCESS

The methodology in the construction process depends on the type of board to be used which could be either vero-board / strip board and printed circuit board (PCB). It also depends on the size and the type of circuit to be constructed. As far as practical project is concerned at this level the vero-board is the most appropriate. The methodology in construction using the strip / vero-board is as follow:-

1. The surface of the vero-board should be inspected and cleaned in order to ensure that it has no damage, breakage and lifted track before transferring the components to the vero board and mounting them. This was done in order to avoid poor soldering
2. These component were soldered on the vero board carefully using a soldering iron of 60 watts.

3. Soldering of heat sensitive components was done quickly to avoid overheating which could lead to break-down. Components joints that were not satisfactory were seen red after the board have cool down.

4. Small capacitors and resistors were mounted flush with the board and components mounted vertically were seated squarely on the board.

When mounting components, the following were considered

(a) Component identification is visible

(b) Rows of components form neat lines.

(c) The identification of components read form left to right in relation to diagram.

In the case of transistors, ensure by checking their position of location code with the diagram in order, that the transistors' leads have been assembled to the correct positions.

In this regard, the legs of each component were pushed through the holes on the top of the vero board and were soldered onto copper strips run in rows so that all the components legs on a particular row jointed together.

4.7 TESTING

After successful completion of this project construction it was cross-checked to ensure that all connection of the various stages were made correct without any mistake. A test was carriedout using a digital multimetre to ascertain the output voltage.

The essence of the test carried out was primarily done so as to verify the design and construction as well as its performance. The test that was carried out includes the following.

i. continuity test

ii. D.C output voltages

iii sample test on various zener diodes (quality and quick test).

4.7.1 CONTINUITY TEST

This test was carried out in order to verify no open and short circuit.

4.7.2 D.C OUTPUT VOLTAGES TEST

The D.C output voltages as well as the voltages at the various test points on the circuit were measured by feeding an A.C supply input of 220 volts at 50 Hz into the circuit under test. The following results were obtained as shown in table 2.1

Table 2.1 Results Obtained At Various Test Point

test points	1	2	3	4	5
Voltage	220	188	214	214	210

4.7.3 ZENER DIODE TESTING

Data were compared to standard values for zener diode testing (quality and quick test)

From the manufacturers data sheets, it was observed that current values are high for low-voltage zener diodes. However, the dynamic impedance value will be low for low- voltage zener diodes, and vice versa for higher voltage zener diodes. To perform quality test of 1V to 200V zener diodes by the practical dynamic impedance method, you requires to have a variable D.C. power supply voltage (0 to above 120V) and current (1mA to 150mA) supply source. As shown in the circuit of fig 4.2 below.

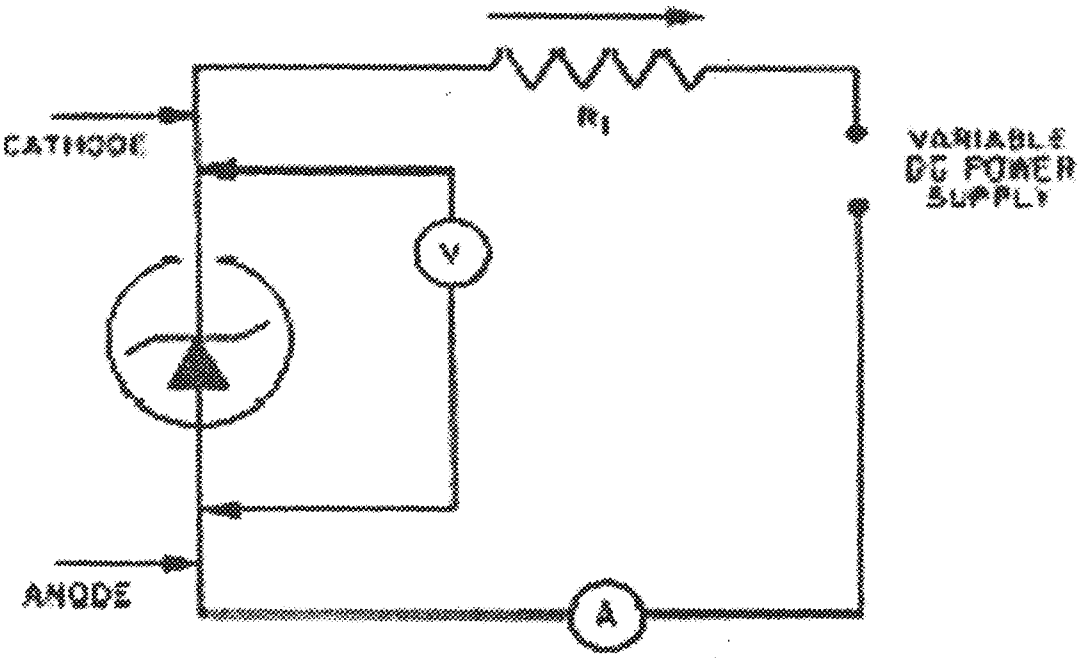


Fig 4.2 Zener Diode under Tests across Terminals A and B

In this circuit the variable power supply is used to adjust the input voltage to a suitable value for the zener diode being tested. Resistor R1 limit the current through the diode with the zener diode connected as shown in fig 4.2. No current will flow until the voltage across the diode is equal to the zener voltage. If the diode is connected in the opposite direction current will flow at a low voltage, usually less than 1volt. Current flow at low voltage in both directions indicates the zener diode is defective.

4.7.4 TEST FOR OPERATING VOLTAGE AND EFFECIENCY

In this test some samples of zener diodes were tested for operating voltage and efficiency.

PROCEDURE:

1. the operating voltage: the unit is switched to low that is the zener diode is in series with a resistor R3 as shown in fig 3.1a. it is then connected to a multimetre where the operating voltage is noted and recorded the results are shown in table 2.4 the zener diode is

connected with the cathode the positive (+ve) terminal a and the anode to the negative (-ve) terminal b of voltmeter. See the main circuit in fig 3.4 of appendix 1.

2. The efficiency: with the zener still under test, the unit is then switch to (HIGH) in order to by-pass the series resistor R_3,any increase in the reading is observed and component under test is inefficient.

Table 2.2 sample zener diodes tests

COMPONENT VZ	QUICK TEST	QUALITY TEST	IZ MIN	IZ MAX	VOLTAGE ACROSS
1.0	1.0	0.8	0.4	0.9	200
2.0	2.0	1.00	0.4	0.6	178
3.0	3.0	7.00	0.7	15.00	165
4.7	4.8	3.9	1.7	11.6	167
8.2	8.5	4.5	3.7	10.00	170
12	12	4.00	1.22	14.00	164
15	15	4.00	1.25	14.00	160
20	20	4.00	1.20	14.00	164
22	22	4.00	1.22	14.00	160
164	164	4.00	1.47	15.00	169

The result revealed that zener diodes with lower operating voltage increase in values when more current is allowed to flow. This is because diodes with low operating voltages are inefficient.

4.8 PROBLEMS ENCOUNTERED DURING CONSTRUCTION, TESTING, AND TYPING OF THE PROJECT:

The major problem faced during the project works, was the frequent power failure (PHCN) this took me a longer period of time to finish the construction and type setting, I spend almost four weeks before finishing the typing due to power failures. Another problem encountered during testing the circuit, at the first time there was a short circuited especially the side of quality test. This also took me a lot of time troubleshooting at the end I have to change all the components before its works properly.

4.9 THE CIRCUIT LIMITATION

(1) The power rating of this project works within a minimum of 160 volts and maximum of 220 volts

(2) The circuit is only capable of measuring zener diodes voltages between the range of 1volt up 200volts and 0-20mA current respectively

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

After successful completion of the design and construction of a versatile digital zener diode tester it works as expected, and the desire target has been achieved because it gave the exact values of the minimum and maximum currents zener diodes tested so for, from various test conducted.

The tester module is reliable and portable to have around the workshop which makes it easier to handle with little risk involved. The module can be used for testing zener diode voltage V_z from 1v volts up to 200 volts as well as zener current Iz from 0-20mA with digital multimetre as well as miliammeter respectively.

In this design VR_1 of 220k and VR_2 of 10k were chosen to be used to select both the minimum and maximum zener voltages and current of the component under test.

5.2 RECOMMENDATIONS

It is recommended that this project should be preferred for possible school laboratories work shops and industrial used. It will prove useful to many laboratories were zener diode testers are not enough to go round the larger number of students performing experiment at the same time. It is especially also helpful when testing out a batch of unmarked and untested devices. Finally it will therefore be suggested that a little modification be introduce by providing of an inbuilt miliammetre and the module tester should be improved to be able to test zener diodes available in circulation not only a limited range rating in any further designing by any one wishing to produce a zener diode tester in future project.

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ZENER DIODE DATA

The following data is a useful quick reference for standard 1W zeners. The basic information is from the Semtech Electronics data sheet for the 1N47xx series of zeners. Note that a 'A' suffix (e.g. 1N4747A) means the tolerance is 5%, and standard tolerance is usually 10%. Zener voltage is measured under thermal equilibrium and DC test conditions, at the test current shown (I_{zt}). In table 1.2 below.

Type	V_Z (Nom)	I_{zt}	R_{zt}	R_z at ...	Current (mA)	Leakage uA	Leakage Voltage	Peak Current (mA)	Cont. Current (mA)
1N4728	3.3	76	10	400	1	150	1	1375	275
1N4729	3.6	69	10	400	1	100	1	1260	252
1N4730	3.9	64	9.0	400	1	100	1	1190	234
1N4731	4.3	58	9.0	400	1	50	1	1070	217
1N4732	4.7	53	8.0	500	1	10	1	970	193
1N4733	5.1	49	7.0	550	1	10	1	890	178
1N4734	5.6	45	5.0	600	1	10	2	810	162
1N4735	6.2	41	2.0	700	1	10	3	730	146
1N4736	6.8	37	3.5	700	1	10	4	660	133
1N4737	7.5	34	4.0	700	0.5	10	5	605	121
1N4738	8.2	31	4.5	700	0.5	10	6	550	110
1N4739	9.1	28	5.0	700	0.5	10	7	500	100
1N4740	10	25	7.0	700	0.25	10	7.6	454	91
1N4741	11	23	8.0	700	0.25	5	8.4	414	83
1N4742	12	21	9	700	0.25	5	9.1	380	76
1N4743	13	19	10	700	0.25	5	9.9	344	69
1N4744	15	17	14	700	0.25	5	11.4	304	61
1N4745	16	15.5	16	700	0.25	5	12.2	285	57
1N4746	18	14	20	750	0.25	5	13.7	250	50
1N4747	20	12.5	22	750	0.25	5	15.2	225	45

IN4748	22	11.5	23	750	0.25	5	16.7	205	41
IN4749	24	10.5	25	750	0.25	5	18.2	190	38
IN4750	27	9.5	35	750	0.25	5	20.6	170	34
IN4751	30	8.5	40	1000	0.25	5	22.8	150	30
IN4752	33	7.5	45	1000	0.25	5	25.1	135	27
IN4753	36	7.0	50	1000	0.25	5	27.4	125	25
IN4754	39	6.5	60	1000	0.25	5	29.7	115	23
IN4755	43	6.0	70	1500	0.25	5	32.7	110	22
IN4756	47	5.5	80	1500	0.25	5	35.8	95	19
IN4757	51	5.0	95	1500	0.25	5	38.8	90	18
IN4758	56	4.5	110	2000	0.25	5	42.6	80	16
IN4759	62	4.0	125	2000	0.25	5	47.1	70	14
IN4760	68	3.7	150	2000	0.25	5	51.7	65	13
IN4761	75	3.3	175	2000	0.25	5	56.0	60	12
IN4762	82	3.0	200	3000	0.25	5	62.2	55	11
IN4763	91	2.8	250	3000	0.25	5	69.2	50	10
IN4764	100	2.5	350	3000	0.25	5	76.0	45	9

Table 1.2 - Zener Characteristics, 1N4728-1N4764s

1. I_{zt} = zener test current
2. R_{zt} = dynamic resistance at the stated test current
3. R_z = dynamic resistance at the current shown in the next column
4. Leakage current = current through the zener below the knee of the zener conduction curve, at the voltage shown in the next column
5. Peak current = maximum non-repetitive short term current (typically < 1ms)
6. Continuous current = maximum continuous current, assuming that the leads at 10mm from the body are at ambient temperature

TABLE 1: Maximum and Minimum Test Current Values

Zener diode	I_T (min)	I_T (max)
3.3v to 4.3v	10mA	15mA
4.7v 18v	5mA	10mA
20v to 39v	2mA	4mA

Note: Zener diode power ratings are 250mw, 400mw and 500mw.

TABLE 1: Maximum and Minimum Test Current Values

Zener diode	I_T (min)	I_T (max)
3.3v to 12v	10mA	15mA
13 to 27v	5mA	10mA
30v to43v	2mA	5mA
47v to 75v	1.5mA	3mA
82v to 120	1mA	2mA

Note: Zener diode power rating is 1 watt