DESIGN AND CONSTRUCTION OF A VARIABLE BIPOLARITY POWER SUPPLY UNIT WITH DIGITAL DISPLAY METER

BY

MOSHOOD, SARAFADEEN .A.

2003/15408EE

THIS PROJECT IS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL/COMPUTER ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE.

DECEMBER, 2009

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DEDICATION

This project work is dedicated to Almighty Allah for His guidance and protection over me throughout my undergraduate program and also to my parents Mr. Moshood Aponibi and Mrs. Moshood Wosilat.

CERTIFICATION

This is to certify that this project work was carried out by Moshood Sarafadeen A. of the Department of Electrical/Computer Engineering, School of Engineering and Engineering Technology, Minna, Niger State.

....	18/12/2009
Moshood Safarafadeen A.	Signature/Date
....	18/12/2009
Dr. J. Tsado (Project Supervisor)	Signature/Date
....	(May 6, 2010)
Name of H.O.D	Signature/Date
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External Examiner	Signature/Date

ACKNOWLEDGEMENT

All praises and adoration is due to Almighty Allah in the highest level of the whole universe for making me witness this moment of my life and for making this project work a successful one. If not for His favour and mercy, this programme cannot be completed.

Am sincerely grateful to my God fearing and intelligent supervisor in person of Dr. .J. Tsado for his assistance and perseverance in reading through my report and make necessary corrections may God Almighty continue to guide and protect you.

I thankfully recognize the effort of my parents Mr. Moshood Aponibi and Mrs. Moshood Wosilat for always being there to advice and support me for me financially, spiritually and even for advice. I also extend my acknowledgment to the MOSHOOD FAMILY, friends and well wishers. Above all, kudos to my dearest wife in person of Hajia Mujidat Bukola for her encouragement and assistance. Thank you and may God Almighty bless you all.

ABSTRACT

This project is based on the design and construction of a regulated – 15 Volts to + 15 Volts variable DC power supply with digital readout. The power supply was designed and constructed with a ripple voltage of 50mV and a power rating of 30 watts. It was designed and constructed to display the output voltage of the variable DC power supply in digital form. The regulated variable DC power supply is a special type of DC power source which supplies electronic devices of different voltage input at different time; hence it is more compact and economical than different rated DC power supply. This makes it very useful in the laboratory for performing experiments where different voltages will be needed at different time. It consists of the following six major components, which are the transformer, rectifier, filter, voltages regulator, analog to digital converter with inbuilt seven segment decoder and the seven segment display. Loading test were carried out on the power supply and the graph of current against voltage were plotted. From the results obtained, it was seen to obey Ohm's Law.

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CHAPTER ONE

1.1 Preamble

Most of the electric devices and circuit requires a d.c source for their operation. Dry cells and batteries are one form of d.c source. They have the advantage of being portable and ripple free. However, their voltages are low; they need frequent replacement and are expensive as compare to conventional d.c power supplies. Since the most convenient and economical sources of power is the domestic a.c supply, it is advantageous to convert this alternating voltage (usually, 220V rms) to a.c voltage into d.c voltage through rectification and this is accomplished with the help of a

(i) Rectifier

(ii) Filter

(iii)Voltage regulator circuit

All these elements put together make up power supply unit.

However, various types of power supply have been designed all over the world and particularly in Nigeria. These types of d.c power supplies are fixed d.c power supply, variable d.c power supply, single output d.c power supply and dual output variable d.c power supply which is the efficient one as it will be seen in the course of this study.

Dual output variable d.c power supply has two outputs in which one is negative and the other is positive. It can be used in replacement of the three states above. In addition, both the output can be varied making it adaptable for different equipments.

1.2 Aims and Objectives of this Project

1.2.1 Aims

The main aim of this study is to design and construct a variable bipolar d.c supply unit with a digital display meter.

1.2.2 Objectives

The basic objectives of this study are:

i. To identify the various power supplies available

ii. To design dual output power unit

iii. To design the power supply in a way that it can be varied

iv. To incorporate a digital display meter for measuring the voltage

1.3 Significance of Study

It is a known fact that food is essential for human being in order for them to be able to carry out various activities, so do power supply to the electronic circuit. They require power supply, for them to be excited to perform the operation they are meant for.

This study is high significant in term of its cost effectiveness that is, this only one device can be used for different electronic circuit because of its possibility to be varied. Also the problem of providing extra voltmeter for measuring the desire voltage has been eliminated by this study because of its self digital voltmeter. The device can be used to power electronic circuit (such as op-amp) which require symmetrical bipolarity power supply typically ± 15 volts.

1.4 Scope of Study

The power supply is meant for those circuits which make use of direct current only and also of voltage ranging from negative fifteen voltages to positive fifteen voltages (i.e -15V to +15V). Also, the maximum current rating is 1.0A.

1.5 Method of Study

The method adopted is design and construction. Various textbooks and newspaper relating to the study were consulted. Discussion were also held with colleagues, physical observations were made and materials related to study were also obtained on browsing some electrical websites.

CHAPTER TWO

2.1 Literature Review

The work of great scientists cannot be under viewed for what they have done. This start from discovery of electron to the generation of power supply. In fact, it is the result of the work that we are now enjoying.

Design and constructed what could be referred to as power supply that can be cause unidirectional movement of current and voltage. [5]

However, it worthy to consider the contribution of people in this century to power supply. Bird, J.O. designed and constructed of 12V d.c fixed power supply with current rating of 05A. The power supply has a high stability with temperature and of an overall efficient of 80%. The short coming of the project is that it cannot be used for appliance of voltage rating less than or greater than 12V and even the current is too small for some appliances and lastly the constructed power supply is bulk (size up 50cm x 30cm). [1]

Based, there on, this project work is aimed at improving on those aforementioned lapses. The size of power supply to be reduced and the output voltage varied. Also a digital displaying meter to be added and lastly negative voltage is generated in addition to those improvements.

2.2 Theoretical Background of the project work

In this section, the principle of operation and the characteristics of the major components used are highlighted. These are as follows:

2.2.1 The Transformer

A transformer is static (or stationary) piece of apparatus by means of which electric power in one circuit is transformed into electric power of the same frequency in another circuit. It can raise or lower the voltage in a circuit but with corresponding decreases in current. The physical basis of a transformer is mutual induction between two circuit linked by a common magnetic flux. It consist of two inductive coils which are electrically separated but magnetically linked through a path of law reluctance as shown in figure 2.1 below.

The two coils posses high mutual inductance. If one coil is connected to a sources of alternating voltage, an alternating flow is set up in the laminated core, most of which is linked with the other coil in which it produces mutually-induced e.m.f (according to faraday's laws of electromagnetic induction $e = N\, {}^{dy}/_{dy}$) if the second coil is closed, a current flow in it and so electric energy is transferred (entirely magnetically) from the first to the second coil. The coil through which the electrical energy is fed from a.c supply main, is called primary winding which the other from which the energy is drawn out, is called the secondary winding.

Transformers serve two important functions in electronic instruments. They change the a.c line voltage to a useful (usually lower) value that can be used by the circuit, and they "isolate" the electronic device from actual connection to the power line. Different types of transformer available such as; variac, auto-transformer, center-tapped transformer.

The transformer equation is given below;

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s} = k \quad \text{.................................... 2.1}$$

Where K is the transformation ratio. If $N_s > N_p$ i. e $k > 1$, then the transformer is step up. But if $N_S < N_P$ i. e $k < 1$ the transformer is known as step down transformer.

The e.m.f equation of transformer is stated below

$E_P = 4.44FN_p\phi_m$ and

$$E_s = 4.44fN_s\phi_m \quad \text{.. 2.2}$$

Where N_s = No of turns in primary

N_s = No. of turns in secondary

ϕ_m = maximum flux in core in Webbers = $B_m \times A$, where B_m is flux density.

F = frequency of a.c input in Hz

For ideal transformer, the VA of the primary side always equal to that of the secondary side, hence the efficiency is 100% [1].

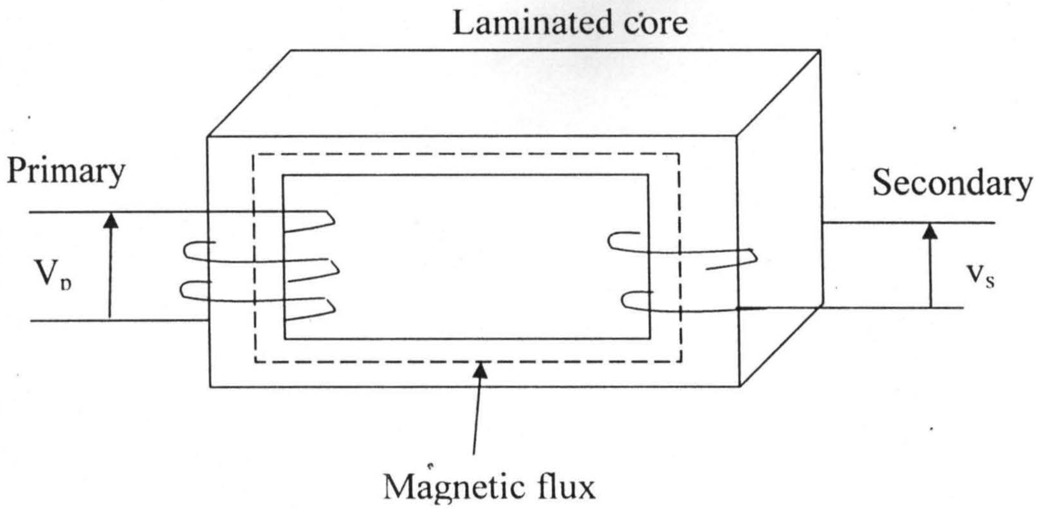


Figure 2.1 Transformer

As shown in figure 2.2 flux increases from its zero value to maximum ϕ_m in one quarter of the cycle i.e $\frac{1}{4}T\ second = \frac{1}{4f}\ second$

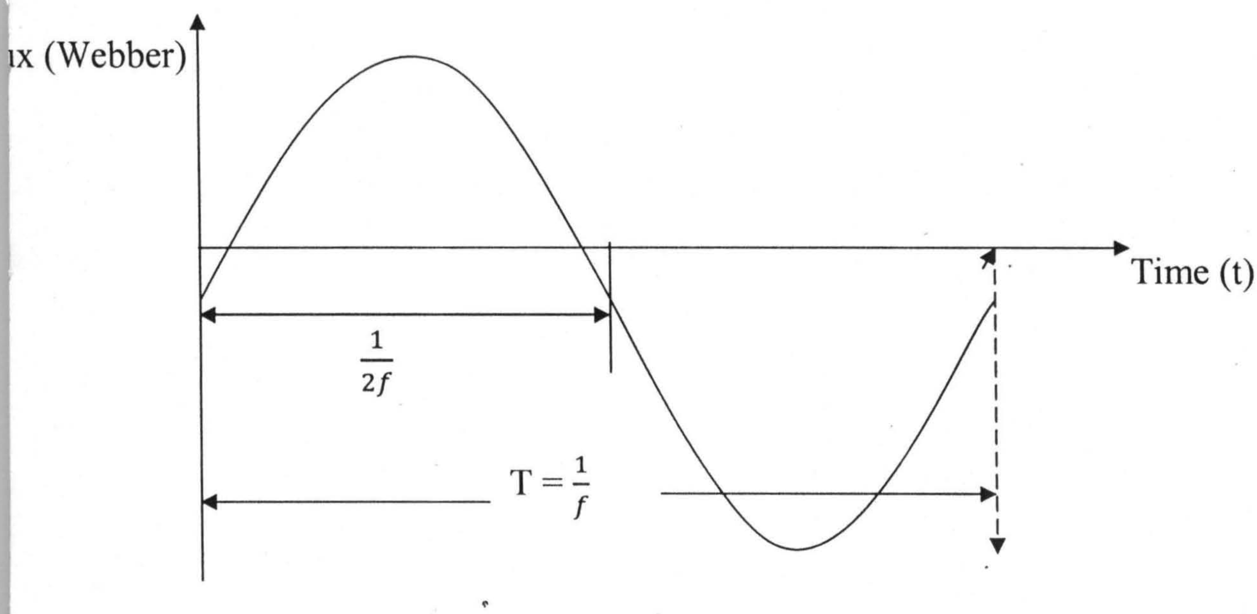


Fig. 2.2 waveform of magnetic flux variation

2.2.2 Bridge Rectifier

The purpose of power supply is to change alternating current to direct current. Alternating current flows in both direction and direct current flows only in one direction.

Since diode conduct in only one direction they rectify and hence use in constructing bridge rectifier.

The bridge rectifier circuit provides a greater d.c value from the secondary output voltage of a transformer.

During the positive half cycle (i.e when the transformer voltage is positive), diodes D_1 *and* D_2 will conduct and the current flow is along the path ABCD as shown in fig. 2.3 and a half sine wave of current results. In the negative half cycle, diodes D_3 and D_4 will conduct and current flow is along path DBCA. The current through load resistance is always in the same direction and the d.c component is twice as large as in half wave rectifier. The waveforms of the input voltage to the rectifier and its output are shown in fig. 2.4 and 2.5 respectively.

The full wave bridge d.c current and d.c voltage are given as;

$I_{dc} = \frac{2I_m}{\pi}$... 2.3

$V_{dc} = \frac{2V_m}{\pi}$ respectively 2.4

Similarly, the r.m.ss voltage and r.m. s current of bridge rectifier is given as

$V_{rms} = \frac{V_m}{\sqrt{2}}$ and $I_{rms} = \frac{I_m}{\sqrt{2}}$ respectively 2.5

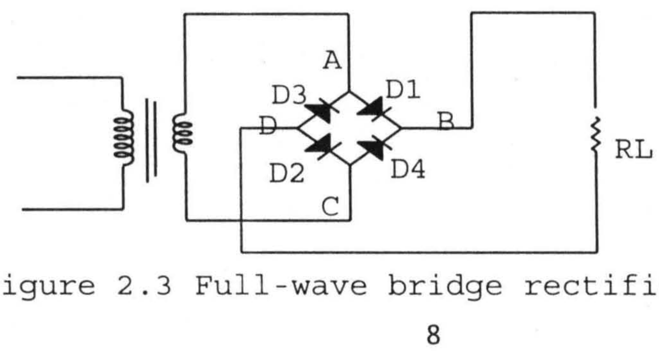


Figure 2.3 Full-wave bridge rectifier circuits

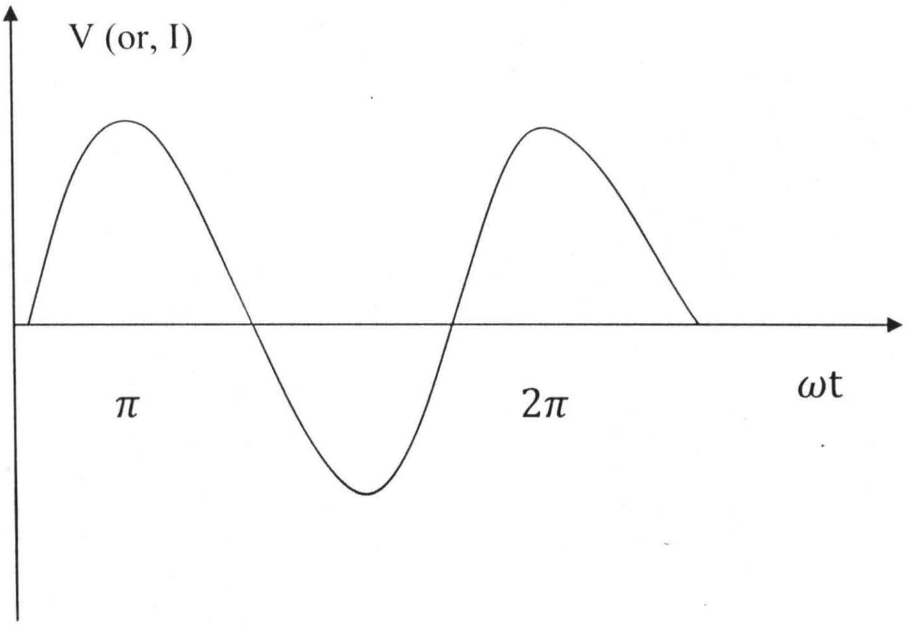


Fig. 2.4 The utility supply waveform

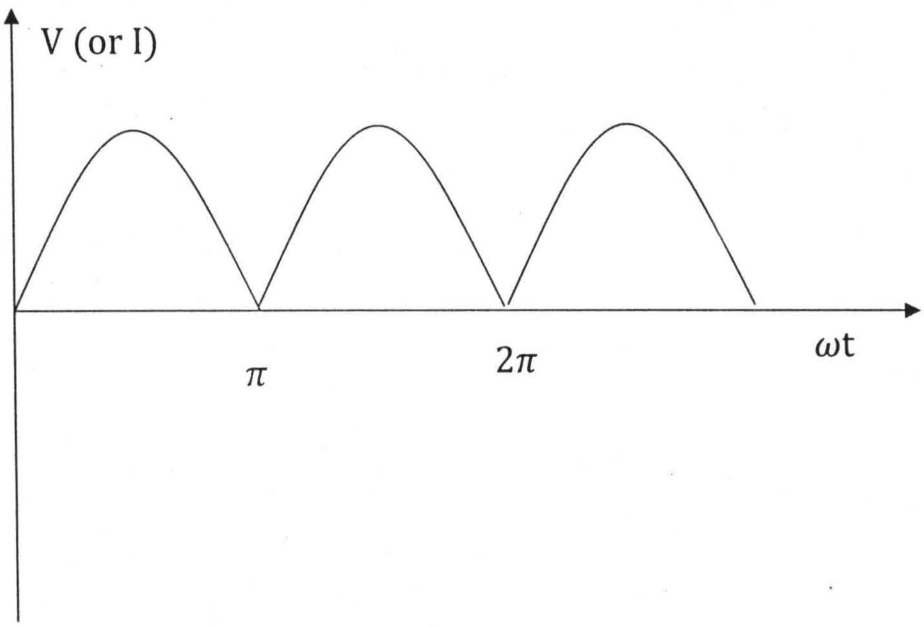


Fig. 2.5 the rectified waveform

2.2.3 Hybrids Circuit

The circuit shown in fig. 2.6 is a combination of the center tapped transformer and the bridge type full-wave circuit, and it provides three different outputs from a single winding. If B is chosen as a reference point A and C, the voltage between B and A and B and C are center-tapped full-wave outputs, equal in voltage, but of opposite polarity. Each voltage, as in other center-tapped circuits, will be very approximately the same as that across each half of the winding. The third output appears between C and A and is the bridge circuit output equal to double that from B and A or from B to C [3].

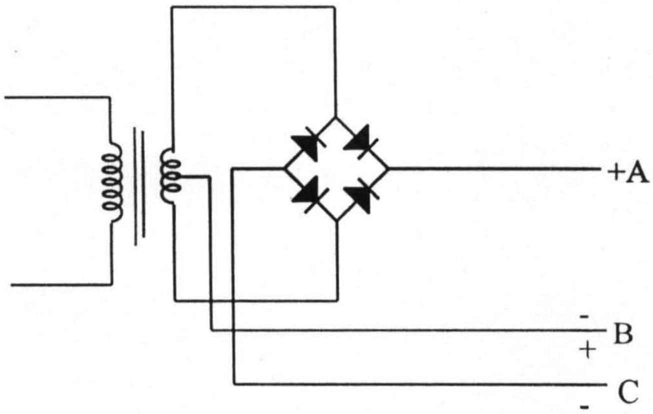


Fig 2.6 Three voltage output circuit

2.2.4 Filter

Filter circuit are used to minimize the ripple content in the rectified output which is pulsating and has d.c value and some a.c components called "ripple". Fitter thus, converts a pulsating output from a rectifier into a very steady d.c level.

Capacitor filter is used to reduce the ripple voltage. The capacitor is a tank that stores charges during the period when the diode is conducting and release charge to the load during non-conducting period. Apart from shunt capacitor filter, other types of filter are RC filter, Pi or C-L-C filter, LC filter and series inductor b\filter.

The equation of filter is as shown below:

Ripple voltage $V_{r(p-p)} = \frac{dQ}{C} = \frac{I_{dc}T_r}{c}$............................2.6

$\frac{V_{dc}}{f_r C R_L}$ for half wave

$\frac{V_{dc}}{2f_r C R_l}$ for full wave

In the fig. 2.7 below, the peak $\frac{V_r}{2}$ of the triangular waveform has its r.m.s value as

$\mathbf{V_{rms} = \frac{Vr(p-p)}{2\sqrt{3}} = \frac{V_{dc}}{4\sqrt{3}f_r C R_L}}$...**2.7**

Where $R_L = \frac{V_{dc}}{I_{dc}}$

But ripple factor $= \frac{V_{rms}}{V_{dc}}$

Hence $\gamma = \frac{1}{4\sqrt{3}f_r C R_L}$...2.8

Also from the figure 2.7 below

$V_{dc} = V_{ip} - \frac{V_{r(p-p)}}{2}$, where $V_{ip} = V_p - V_d$...........................2.9

$V_{dc} = V_{ip} - \frac{V_{dc}}{4f_r C R_L}$..2.10

$V_{ip} = V_{dc} + \frac{V_{dc}}{4f_r C R_L}$..2.11

$$1 + \frac{1}{4f_r C R_L} = \frac{V_{ip}}{V_{dc}}$$

$$C = \frac{V_{dc}}{4f_r C R_L (V_{ip} - V_{dc})} \quad \text{.......... 2.12}$$

Where V_{ip} is the peak rectifier output voltage. The figure 2.6 shows the waveform for rectifier output after filtering.

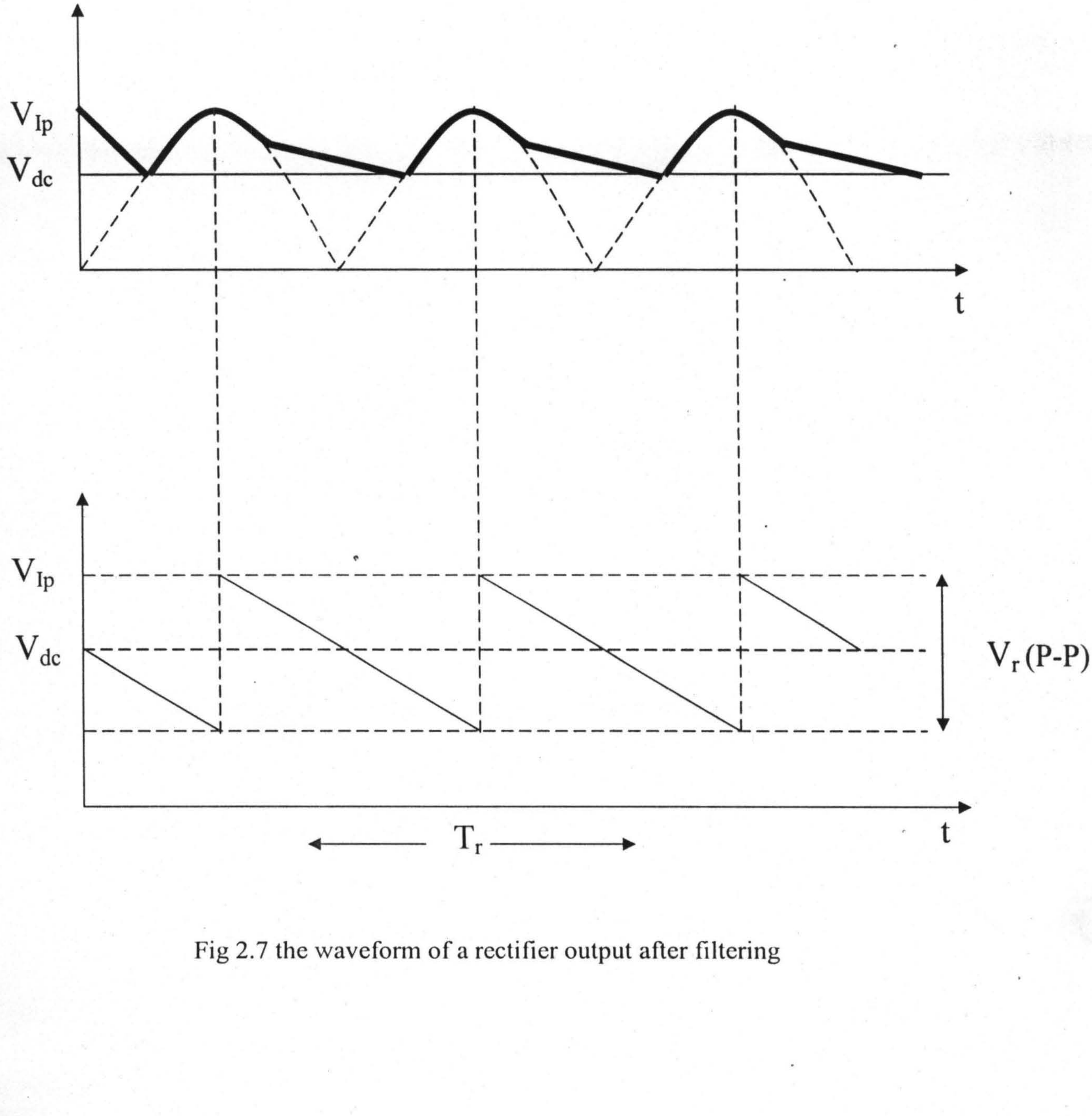


Fig 2.7 the waveform of a rectifier output after filtering

2.2.5 The voltage regulator

Its main function is to keep terminal voltage of d.c supply constant even when a.c input voltage to the transformer varies (deviation from 220V are common) or the load varies.

There are regulators of various types such as 7800 series. Their output voltage can be adjusted higher than their fixed (or set) voltages by adding external resistors. For example the output voltage of 7805 can be adjusted higher than 5v. But the performance and reliability of 7800 series to produce voltage higher than its fixed value is considered not to be good. The LM317T is an IC regulator whose output voltage can be adjusted over a wide range.It output voltage can adjust from12V to 37V, it is a 3 terminal IC regulator. The figure 2.7 below shows the easiest way to use it.

LM337T is the negative counterpart of LM317T

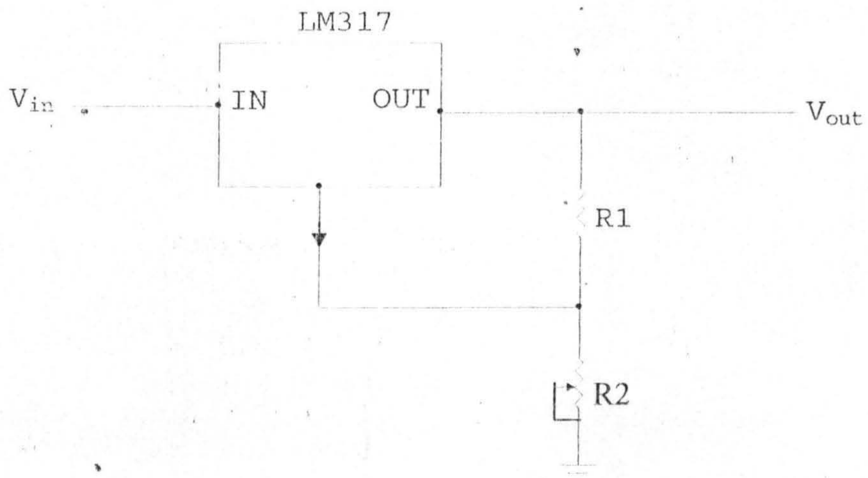


Fig. 28 Three terminal adjustable regulator

In operation, the LM317T develops a constant 1.25V reference, voltage (V_{ref}) between the output and adjustment terminal. This constant reference voltage produces a constant current, (I_{ref}) through R_1 regardless of the value of R_2. The value of current through R_2 is the sum of I_{ref} and I_{adj}.

The equation below can be used to calculate the output voltage when R_1 and R_2 are known.

$$V_{out} = V_{ref}\left(1 + \frac{R_2}{R_1}\right) + 1_{adj}R_2 \ldots\ldots\ldots\ldots\ldots\ldots 2.13$$

Where I_{adj} is a very small current at the adjustment terminal typically in the range of 50mA [4].

2.2.6 Voltage Divider

Its function is to provide different voltage for difference electronic circuits, that is, to make the voltage a variable one. It consists of number of resistors connected in series across the output terminals of the voltage regulator. Figure 2.8 shows circuits arrangement of voltage divider.

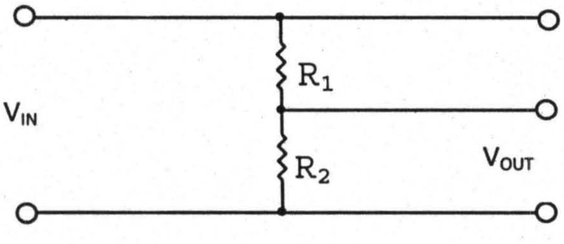


Fig. 2.9 voltage divider circuit

The current I through the resistance R_1 and R_2 is given as:

$$I = \frac{V_{in}}{R_1+R_2} \ldots\ldots\ldots\ldots\ldots\ldots 2.14$$

Where V_{out} across R_2 is given as:

$$V_{out} = IR_2 = \frac{R_2 V_{in}}{R_1 + R_2} \quad \text{..............................2.15}$$

2.2.7 Digital Readout

The purpose of this unit is to sense the output voltage of the power supply unit and display it in digital form. It consists of three main parts, which are:

1. The analog to digital converter
2. The decoder drive (BCD) and
3. The seven segment display

2.2.7.1 Analog to Digital Converter (ADC)

An analog to digital converter is required in interfacing a digital system to an analogue environment. It takes in analog input voltage and after certain time duration produces a digital output code which represents the analogue input.

The resolution of an ADC refers to the number of bits in the output binary word. Another important specification of an ADC is the conversion time. The time taken for analogue to digital conversion depends on the type of ADC used.

1. Parallel comparator or flash A/D converter
2. Single ramp A/D converter
3. Dual ramp A/D converter
4. Counter feedback A/D converter
5. Successive approximation A/D converter

2.2.7.2 Decoder Driver

For seven segment display LED to appropriately display the measured value, the digitized value must be currently decoded from the output of the ADC. It converts the binary output of the ADC to decimal number. The output pin is connected to the seven-segment display unit through a unit resistor called the limiting resistor.

2.2.7.3 Seven Segment Display

Considering the fig. 2.10 a seven segment display consisting of mostly 7 or sometimes 8 or 9 light emitting diodes which can represent numerals from 0 to 9. The seven segments are labeled "a" to "g" and each segment is controlled through one of the display LEDs. The 8^{th} and the 9^{th} are used for the decimal point. It can either have right-handed or left handed decimal point or sometimes both.

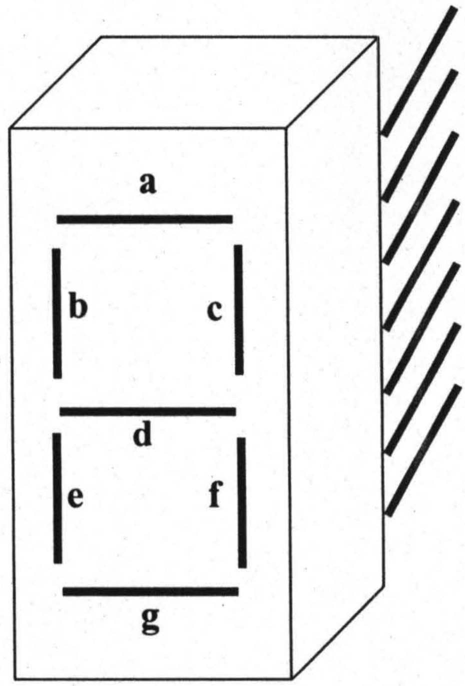


Fig 2.10 segment reference letters of seven segment display LED

There are two types, they are: the common cathode and the common anode.

a. Common cathode display: The cathode of each of the LEDs are connected together to form a common point or pin. In this case, the common pin is granted such that when other pins are connected to the high output of common cathode decoder for all the segments to light up. The internal configuration of a common seven segment display LED.

b. Common anode display: The anode of each of the LED is connected together to form a common point or pin, in this case, the common pin has to be connected to a high (+5v); such that when the other pins are connected to the ground pin will make each segment light up. The internal configuration of a common anode. Seven segment display LED is shown in fig. 2.11 [5]

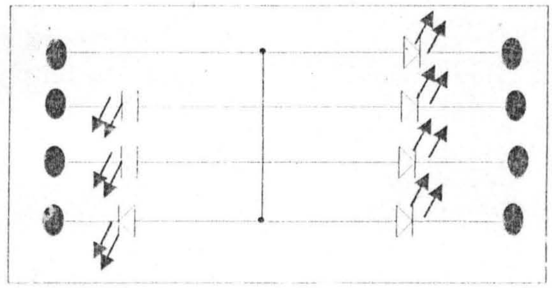


Fig. 2.11 The configuration of a common anode display unit

CHAPTER THREE

3.1 Methodology of Design

The design process involves the calculation of values of each component used in the circuit with constraints of size, weight and cost.

The design of the power supply is represented in the block diagram shown in fig. 3.1

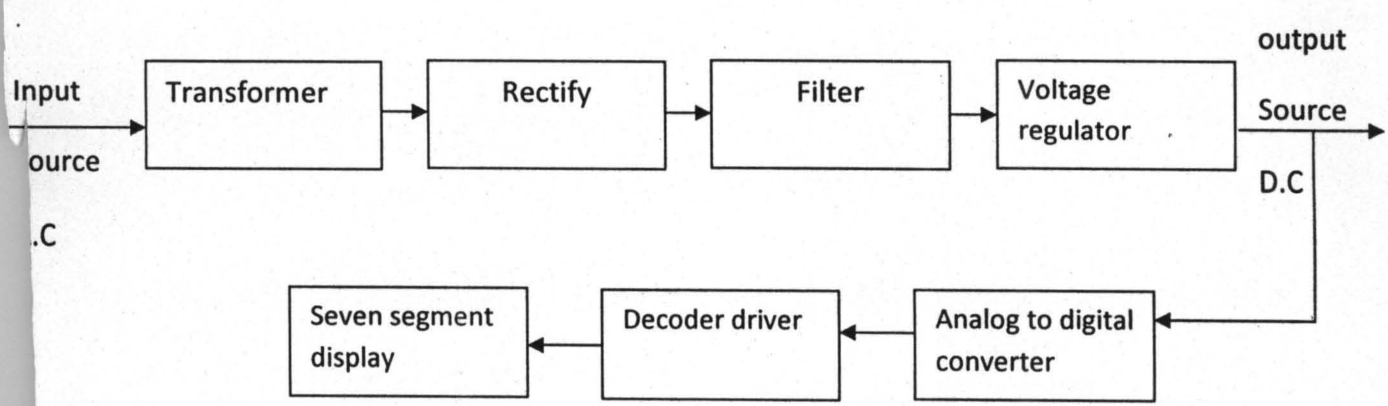


Fig. 3.1 the block diagram of a -15V to +15V variable DC power supply with digital readout

3.1 Transformer Calculation

The transformer used was designed as a centre-tapped, step down from 220V to 12V basically for bridge connections.

Turn ratio $\frac{N_1}{N_2} = \frac{E_1}{E_2} = \frac{220}{12} = 18.3$

3.2 Bridge Rectifier Design

D_1 to D_4 should be able to carry current $= \frac{3.0}{2} = 1.5$

Since two diode conduct at a time (for either positive or negative cycle of the supply). The peak inverse voltage (PIV) of the diode must be greater than the peak value of the voltage at the secondary, that is PIV>70.71V.[6]

3.3 Filter Design

The filter capacitor is chosen to provide acceptable low ripple voltage, with voltage rating sufficient handle the worse case of no load and high line voltage.

V_p (peak voltage at the secondary terminal) is

$= V_{rms} \times \sqrt{2}$

$= 25 \times \sqrt{25}$

$= 35.36V$

The diode forward drop $V_D = 0.64$ (for silicon) and f = 50Hz however, the require input DC voltage should be such that $V_{dc} > 25V$ and $V_{dc} > 35.36V\ that\ is, <$ $V_{dc} < 33.36V$

Selecting in the range, $V_{dc} = 32v$

C_1 and C_2 is calculated using the equation 3.1

$$C = \frac{V_{dc}}{4f_r R_L (V_{ip} - V_{dc})} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.1$$

But $V_{ip} = V_p - V_D$ and $V > 35.36V$

Hence $C_1 = C_2 = \frac{32}{4 \times 50 \times 15 (35.5 - 0.6 - 32)}$

$= 3.8713 \times 10^{-3}$

$= 3871\mu F$

C_1 and C_2 were chosen to be $4700\mu F, 35V$ for conservative purpose.

3.4 Design of voltage regulators

Considering the maximum input Voltage

$V_{in} = 25 \times \sqrt{2} - V_D$

$= 25 \times 1.414 - 0.6$

$= 34.36V$ and the maximum output voltage to be obtained (which is 15V).

The maximum current to be passed was also considered to be 1.5A. hence, the voltage regulator LM317T is preferred for positive voltage supply while LM337T is preferred for negative voltage supply based on their specification in the data book.

The fig. 3.2 shows the 1.25V biasing resistor connected to the regulator.

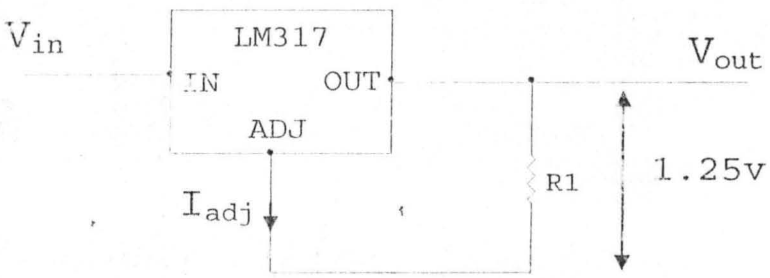


Fig. 3.2: the arrangement of voltage regulator and the 1.25V voltage referencing resistor.

I_{adj} ranges from $50\mu A$ to $100\mu A$ nut assume $I_{adj} = 100\mu A$ but 1_R should always be $10 \times I_{adj}$ that is, $1_R = 10 \times 1_{adj}$

$= 10 \times 100\mu A$

$= 1000\mu A$

$= ImA$

But I_R is preferred as 5ma for conservation purpose hence, using ohm' law

$V_{ref} = I_R R$

$R = \frac{V_{ref}}{I_R}$

$= \frac{1.25}{5 \times 10^{-3}}$

$= 250\Omega$

Hence $R_1 = R_3 = 250\Omega$ is chosen

3.5 Design of Voltage Divider

R_2 is calculated using the equation 3.2

$$V_{out} = V_{R1}\left(1 + \frac{R_2}{R_1}\right) + I_{adj} R_2 \quad \text{.................................. 3.2}$$

But $V_{R1} = V_{ref} = 1.25$ volts (from data sheet)

$V_{out} = V_{dc} = 15V, R_1 = 250\Omega$ and $I_{adj} = 100\mu A$

$15 = 1.25\left(1 + \frac{R_2}{250_1}\right) + 100 \times 10^{-6} R_2$

$R_2\left(\frac{1.25}{250} + 10^{-4}\right) = 15 - 1.25$

$R_2(0.0051) = 13.75$

$R_2 = \frac{13.75}{0.0051} = 2696.08\Omega$

$= 2700\Omega$

$= 2.7\Omega$

Hence $R_2 = R_4 = 2.7\Omega$

The values of all other components used are listed in the appendix and they were selected with due consideration.

3.6 Display Unit

3.6.1 Component value selection

- Integrating resistor: The integrating resistor should be large enough to remain in this very linear region over the input voltage range, but small enough that undue leakage requirements are not placed on the PC board. For 2V full scale, $470k\Omega$ is near optimum.
- Integrating capacity: Those should be selected to give the maximum voltage swing that ensures tolerance buildup will not saturate the integrator swing (approximately 0.3V from either supply). In the ICL7107, when the analog common is used as a reference, a normal +2V full scale integrator swing is fine. For 3 reading/second (48Hz clock) normal values for C_{INT} are 0.22μF.
- Auto-zero capacitor: A $0.1\eta F$: The size of the auto-zero capacitor has some influence on the noise of the system. For $200mV$ full scale where noise is very important,

$0.47\mu F$ capacitor increases the speed of recovery from overload and is adequate for noise on the scale.

- Reference capacitor: A $0.1\mu F$ capacitor gives good results in most applications. However, where a large common voltage exists (i.e the REF LO pin is not analog COMMON) and a 200mV scale is used, a larger value is required to prevent roll-over error. Generally $1\mu F$ will hold the roll-over error to 0.5 count in this instance.

- Oscillator component: For all range of frequency a 100Ω resistor is recommended and the capacitor is selected from the equation:

$f = \frac{0.45}{RC}$ for 48kHz clock (3 readings/sec),

$C = 100pF$

- Reference voltage: The analog require to generate full scale output (2000 count) is $V_{in} = 2V_{REF}$. Thus, for the 200mV and 2V scale, V_{ref} should equal 100mV and IV, respectively. However in many applications where A/D is connected to a transducer, there will exist a scale factor other than unit between the input voltage and the digital reading.

- ICL7107 power supplies: The ICL7107 is designed to work from ±5V supplies. The positive 5V was obtained from 7805 voltage regulator while the negative 5V from voltage regulator.

3.6.2 Multiplier design

To increase the range of the 2V full square voltmeter a resistor (multiplier) is to be connected in series with the meter as shown in the Figure 3.4

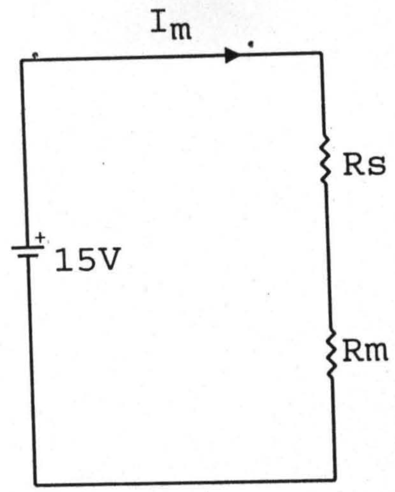


Figure 3.4 arrangement of resistance of multiplier

Resistance of multiplier, R_s is calculated using the equation 3.3

$$R_s = \frac{V_t - I_m R_m}{I_m} \quad \text{.....................................} \; 3.3$$

Where

V_t = maximum voltage to be measure that $V_t = 15v$

I_m is the current draw which is

$\frac{2V}{1 \times 10^6} = 2 \times 10^{-6} = 2\mu A$

R_m is the internet resistance of the meter which is $IM\Omega$

Hence, $R_s = \frac{15 - 2\times10^{-6} \times 1\times10^{6}}{2\times10^{-6}}$

$= 6.5M\Omega$

R_s is chosen to be $10M\Omega$ for conservative purpose.

3.6.3 Seven segment LED Display

Non-multiplexed (single digit) common anode seven segment.

Limiting resistor is necessary to limit the input voltage (the input voltage is 5v).

Minimum voltage across each anode of seven segment display is 2 volt with current of 10mA.

Maximum limiting resistance is calculated using equation 3.4

$$R_{max} = \frac{V_{in} - V_{min}}{current} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.4$$

Note V_{min} is 2V

$$R_{max} = \frac{5-2}{10mA} = 300\Omega$$

Minimum limiting resistance is calculated using equation 3.5

$$R_{min} = \frac{V_{in} - V_{m\,max}}{current} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.5$$

Note: V_{max} is 3V

$$R_{min} = \frac{5-3}{10mA} = 200\Omega$$

Selecting between R_{min} and R_{max} (but nearest to R_{max} most suitable), 270Ω were chosen for the limiting resistors.

Figure 3.4 and 3.5 show a complete circuit diagram of a bipolar d.c power supply unit and the digital display circuit connection respectively.

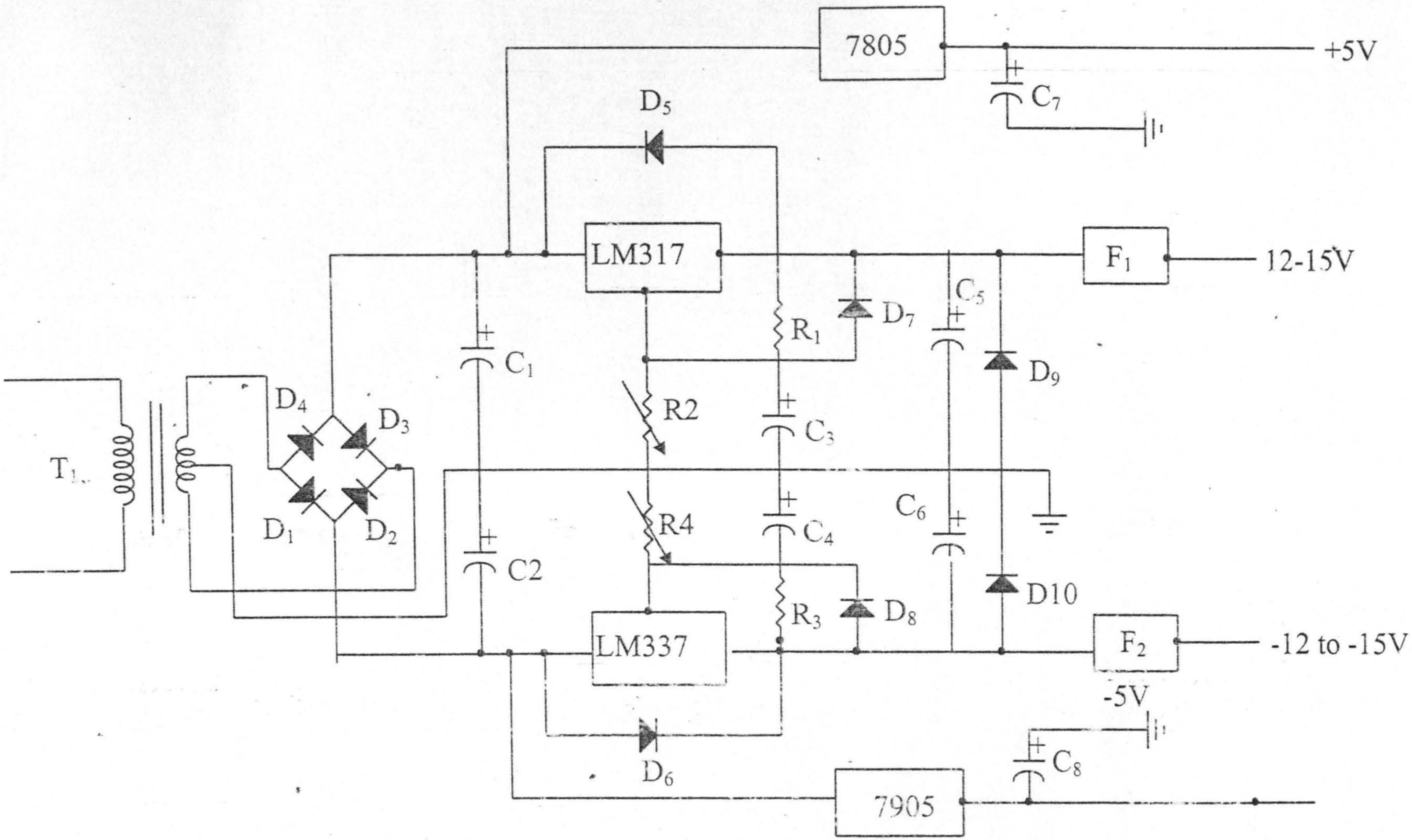


Figure 3.4 circuit diagram of a bipolar d.c power supply (-15v to +15v)

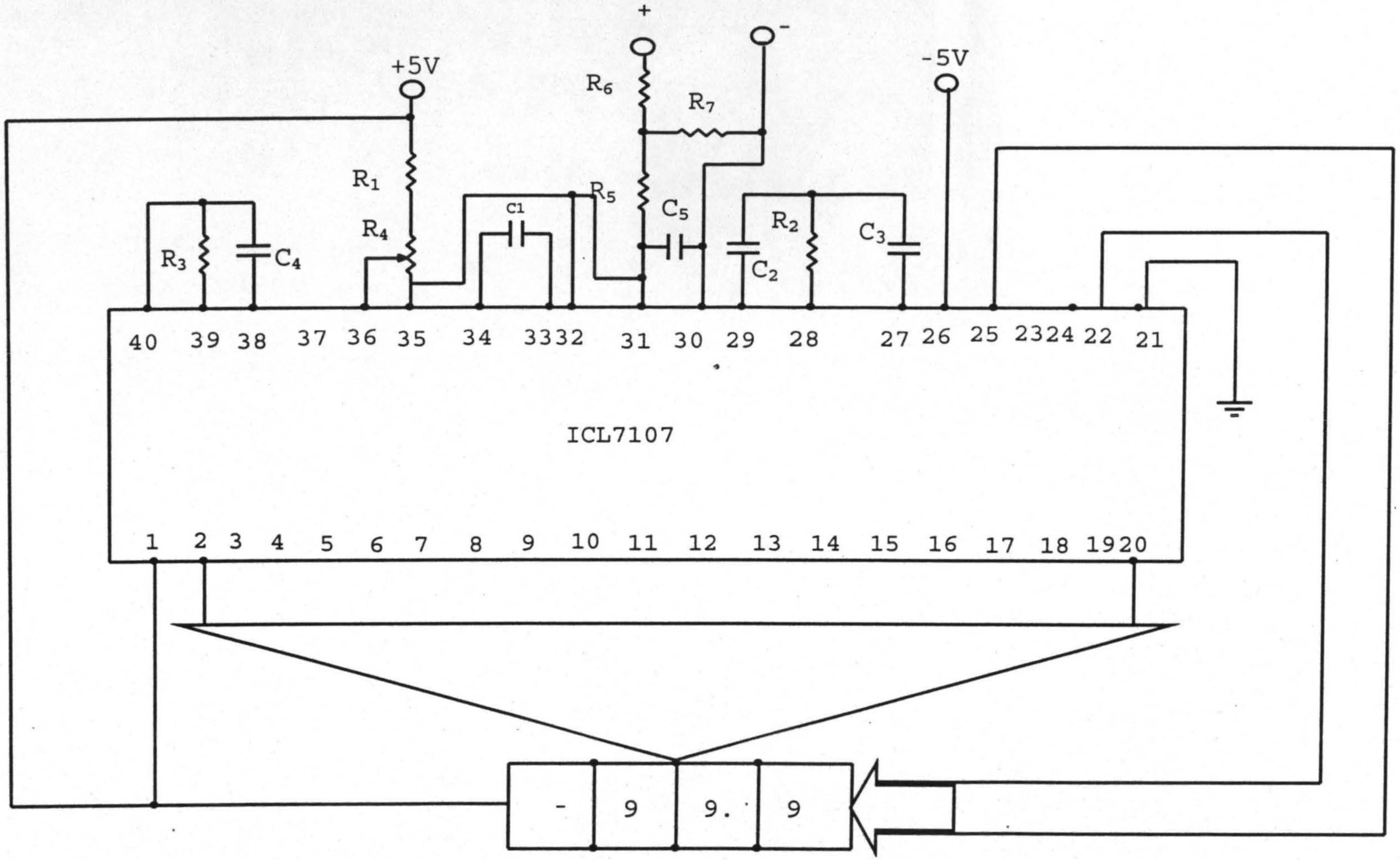


Figure 3.5 Circuit connection of the digital display

Where $C_1 = 100\mu F$ R_1 =B $24k\Omega$ $R_6 = 100M\Omega$

$C_2 = 0.047\mu F$ $R_2 = 470k\Omega$ $R_7 = 100k\Omega$

$C_3 = 0.22\mu F$ $R_3 = 100k\Omega$

$C_4 = 100pF$ $R_4 = 1k\Omega$

$C_5 = 10\mu F$ $R_5 = 1M\Omega$

CHAPTER FOUR

MATERIAL SELECTION, CONSTRUCTION AND TESTING

4.1 Material Construction

The components and devices employed in the construction of this variable bi-polar voltage supply are those readily and available and obtained in the market. In selecting most of this components and devices, adequate consideration and alteration were made to cater for such problem as rigidity, heat transfer, rusting (metal case painted) and the cost of production or of purchasing these components and devices.

4.2 Construction and Testing

Having ensured that the design is theoretically correct, a test was carried out with the components mounted on the bread board. The performance of each stage of the design was evaluated. Some adjustments were made where necessary, especially in the resistance values where calculated values could not be readily obtain in the market or have too clumsly and numerous equivalents.

Thus, the whole design was later t transferred into the vero board and all components soldered with the arrangement of figure 3.4 and 3.5 being established and tested again. A final test was carried out after the circuits has been housed (cased) and appropriate response was obtained. The housing (casing) of the circuit is made of metal in rectangular shape.

4.2 Loading with 500Ω Resistor

The 500Ω resistor was connected with one leg to the positive and the other to the ground and the voltage applied was varied using the potentiometer. The voltage was varied in steps of IV and the corresponding current was measured and recorded. This procedure was repeated with load with the load connected to the negative supply

Table 4.1 and 4.2 show the voltage values and corresponding current values obtained for positive and negative supply respectively.

Table 4.1: Result of loading positive supply with 500Ω resistor.

Voltage	Current (mA)
2.0	4.1
3.0	6.1
4.0	8.0
5.0	10.1
6.0	11.9
7.0	14.0
8.0	16.0
9.0	18.1
10.0	20.0
11.0	22.1
12.0	24.1
13.0	26.1
14.0	28.0
15.0	29.9

Table 4.2: Result of loading negative supply with 500Ω resistor

Voltage (V)	Current (mA)
-2.0	-4.1
-3.0	-6.1
-4.0	-8.0
-5.0	-10.1
-6.0	-11.9
-7.0	-14.0
-8.0	-16.0
-9.0	-18.1
-10.0	-20.0
-11.0	-22.1
-12.0	-24.1
-13.0	-26.1
-14.0	-28.0
-15.0	-29.9

4.3.1 Loading with 1Ω resistor

The procedure of section 4.2.1 was followed and table 4.3 & 4.4 were obtained.

Table 4.3: Result of loading the positive supply with $1k\Omega$ resistor.

Voltage (V)	Current (mA)
2.0	2.1
3.0	3.1
4.0	4.0
5.0	5.1
6.0	5.9
7.0	7.0
8.0	8.0
9.0	9.1
10.0	10.1
11.0	11.0
12.0	12.0
13.0	13.1
14.0	14.0
15.0	15.1

Table 4.4: Resulting of loading the negative supply with $1k\Omega$ resistor

Voltage	Current (mA)
-.2.0	-2.1
-3.0	-3.1
-4.0	-4.0
-5.0	-5.1
-6.0	-5.9
-7.0	-7.0
-8.0	-8.0
-9.0	-9.1
10.0	-10.1
-11.0	-11.0
12.0	-12.0
-13.0	-13.1
-14.0	-14.0
-15.0	-15.1

4.3.2 Loading with a $2k\Omega$ resistor

Figure 4.1 show a circuit connection of loading with $2k\Omega$ resistor.

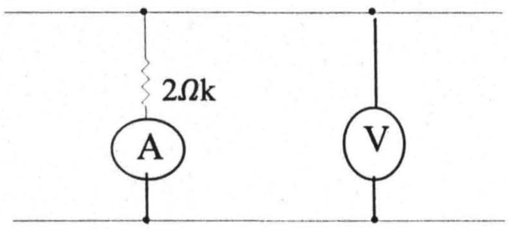


Figure 4.1 loading with 2k resistor

Table 4.5 and 4.6 show voltage values and corresponding current values obtained during the loading for both positive and negative supply respectively.

Table 4.5: Result of loading the positive with $2k\Omega$ resistor

Voltage (V)	Current (mA)
2.0	1.0
3.0	1.6
4.0	2.1
5.0	2.5
6.0	3.0
7.0	3.4
8.0	4.0
9.0	4.5
10.0	5.1
11.0	5.5
12.0	6.1
13.0	6.5
14.0	7.0
15.0	7.6

TABLE 4.6: Result of loading the negative supply with $2k\Omega$ resistor

Voltage (V)	Current (mA)
-2.0	-1.0
-3.0	-1.6
-4.0	-2.1
-5.0	-2.5
-6.0	-3.0
-7.0	-3.4
-8.0	-4.0
-9.0	-4.5
-10.0	-5.1
-11.0	-5.5
-12.0	-6.1
-13.0	-6.5
-14.0	-7.0
-15.0	-7.6

4.3.3 Data Analysis and Result

The types of data collection for this study is reports scrutinizing. Also some experimentation was done during the testing of the equipment.

The result obtained from loading is analyzed graphically as shown in fig 5.1 and fig. 5.2

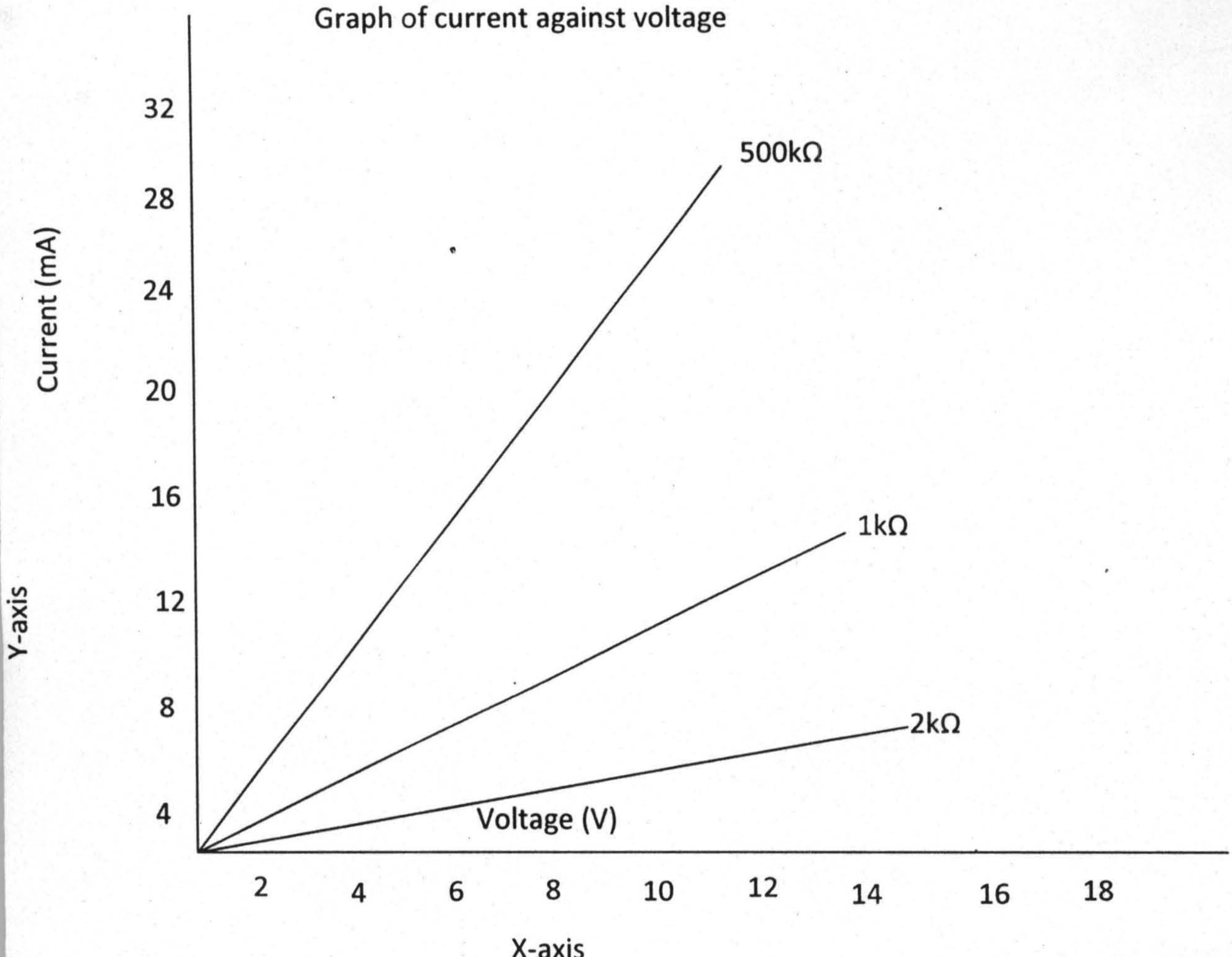
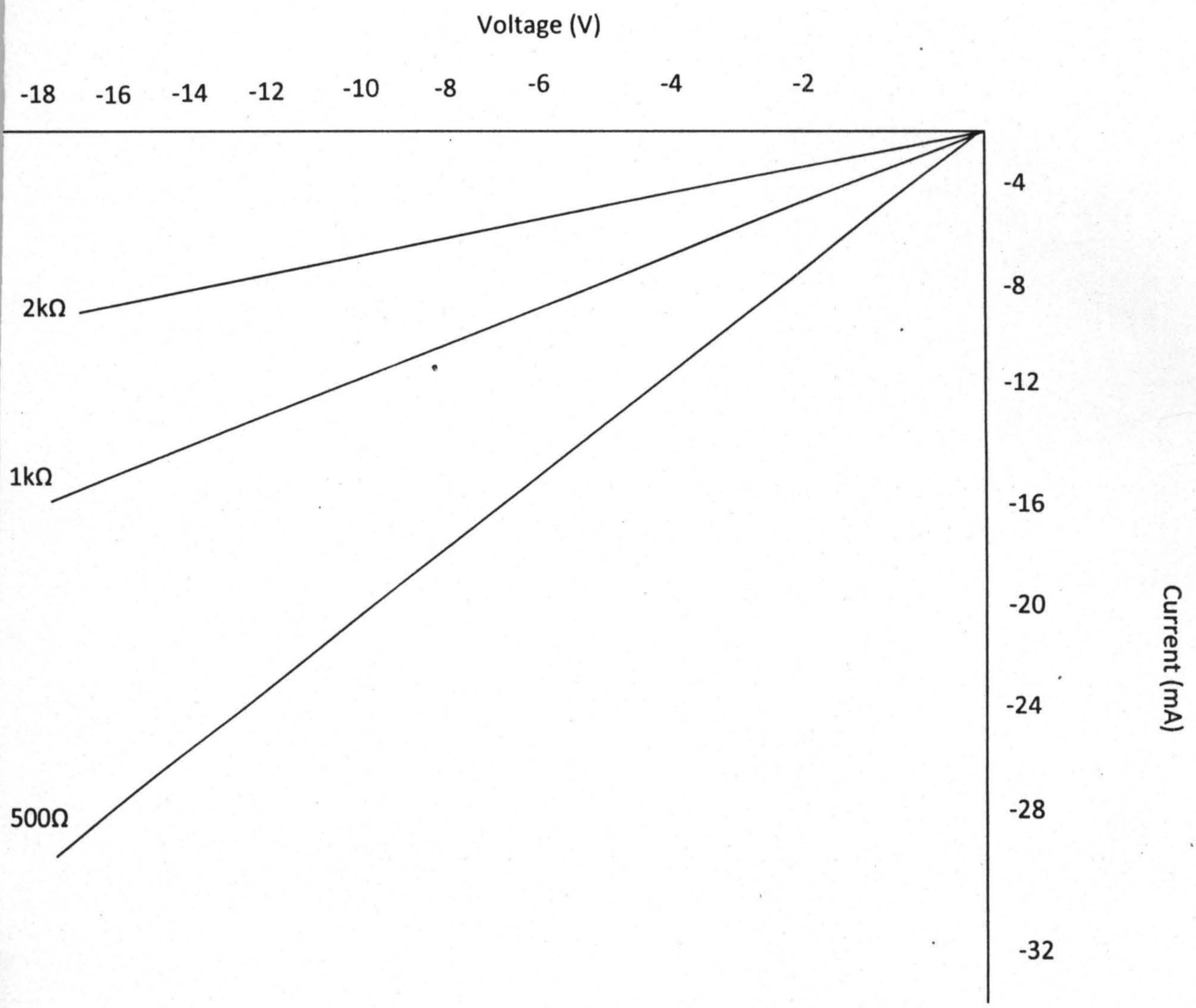


Figure 5.1 Graph of positive output resistor loading

Graph of current against voltage



CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

A regulated variable DC power supply has been designed and constructed. It has a voltage range of -15V to +15V, with a 50mV ripple voltage, with a power rating of 30 watts and also with digital voltage readout.

From the results of testing it can be seen that the current drawn varies directly proportional to the voltage with a constant resistance which is the statement of basic law of electricity (Ohm law).

The variable DC power supply can be used various types of electronic equipment such as radio, rechargeable lamp, amplifier etc.

5.2 Recommendations

Further work should be carried out in the following areas

- ✓ Design and construction of a wider voltage range power supply
- ✓ Design and construction with a higher power rating
- ✓ Design and construction of a power supply in such a way that the size will be further reduced.

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APPENDIX A:

COMPONENTS VALUE

Table A: Names Of Component and their Value used in this Project

Name of components	Values
Transformer	220/12V centre-tapped
Diodes D_1 To D_2	IN50401
Filter Capacitor C_1 And C_2	$4700\mu F$
Resistor R_1 and R_1	250Ω
Resistors R_2 and R_4	2.7Ω
Capacitors C_3 and C_4	$10\mu F$
Diodes D_5 and D_{10}	IN4004
Capacitor C_5 and C_6	$10\mu F$
Resistor R_s	$10M\ \Omega$
Limiting Resistor R_6	$270\ \Omega$
Capacitors C_7 and C_8	$10\ \mu F$