

**DEVELOPMENT OF DC POWER SUPPLY USING POWER ELECTRONIC
APPLICATIONS**

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JUDUL: **DEVELOPMENT OF DC POWER SUPPLY USING
POWER ELECTRONIC APPLICATIONS**

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DEVELOPMENT OF DC POWER SUPPLY USING POWER ELECTRONIC
APPLICATIONS

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A thesis submitted in fulfillment of requirements for the award of the Bachelor of
Electrical Engineering (Power System)

Faculty of Electrical & Electronic Engineering

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NOVEMBER 2010

“I declare that this thesis entitled “Development of DC Power Supply Using Power Electronic Applications” is the result on my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidate of any of any other degree”

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Date : 29 NOVEMBER 2010

DEDICATION

*Specially dedicated to
My beloved family, and those who have guided and inspired me
Throughout my journey of learning*

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ABSTRACT

This project is about how was to develop dc power supply using the applications of power electronic. In the power generation of most of electrical circuit, dc power supply is very required and demanded. It is familiarly to provide power for control and drive circuit within the main switchmode unit. Depending on the approaching of circuit design, the power supply will be common to either input or output of the circuit modeling. The design of DC power supply depends on the output of circuit design either single output or multiple output. There are different analysis to design the circuit based on the number of output. In this project, there are many applications of power electronics are applied such as transformer, AC to DC converter or rectifier, DC-DC converter, and semiconductor devices like power transistor. The circuit design approaching depends on the combination of these power electronic applications. The power supply designed is fully conversant with various combinations and its designer should be having capability to select the most appropriate for a particular application has indeed very powerful design tools.

ABSTRAK

Projek ini adalah mengenai bagaimana untuk mencipta pembekal kuasa arus terus dengan menggunakan aplikasi-aplikasi elektronik kuasa. Dalam penjanaan kuasa kebanyakan litar elektrik, pembekal kuasa arus terus sangat diperlukan dan mempunyai permintaan yang tinggi. Ia biasanya membekalkan kuasa untuk litar kawalan dan kendalian. Bergantung dengan pendekatan rekaan litar, pembekal kuasa ini secara umum untuk sama ada kemasukan atau keluaran model litar. Model litar pembekal kuasa arus terus bergantung ke atas keluaran rekaan litar sama ada satu keluaran atau banyak keluaran. Terdapat analisis berbeza untuk merekacipta litar itu berdasarkan jumlah keluaran yang dikehendaki. Dalam projek ini, terdapat beberapa aplikasi elektronik kuasa diguna-pakai seperti penukar arust ulang-alik kepada arus terus, penukar arus terus kepada arus terus, dan komponen semikonduktor seperti transistor. Pendekatan model litar ini bergantung kepada kombinasi aplikasi-aplikasi elektronik kuasa. Pembekal kuasa arus terus direka sepenuhnya dengan pelbagai kombinasi dan pereka tersebut mempunyai kemampuan sewajarnya dengan menggunakan peralatan-peralatan yang berkualiti.

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LIST OF ABBREVIATIONS

AC	-	Alternated Current
DC	-	Direct Current
LCD	-	Liquid Crystal Display
TNB	-	Tenaga Nasional Berhad
SESCO	-	Sarawak Electrical Supply Company
SESB	-	Sabah Electricity Sdn Bhd
SMPS	-	Switch-Mode Power Supply
LDO	-	Low Drop-Out
BJT	-	Bipolar Junction Transistor
CRT	-	Cathode Ray tube
TFT	-	Thin Film Transistor
PIC	-	Programmable Interface Controller
RAM	-	Random Access Memory

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CHAPTER 1

INTRODUCTION

1.1 Overview

Regulated dc power supplies are needed for most analog and digital electronic systems. Most power supplies are designed to meet some or all of the following requirements:

- Regulated output. The output voltage must be held constant within specified tolerance for changes within specified range in the input voltage and the output loading.
- Isolation. The output may be required to be electrically isolated from the input.

- Multiple outputs. There may be multiple outputs (positive or negative) that may differ in their voltage and current ratings. Such outputs may be isolated from each other.

In addition to these requirements, common targets are to reduce power supply size and weight and improve their efficiency[1]. Traditionally, linear power supplies have been used. However, advances in the semiconductor technology have lead to the switching power supplies, which are smaller and much more efficient compared to linear power supplies. The cost comparison between linear and switching supplies depends on the power rating.

1.2 Project Background

In this project, the report is explained about the circuit of dc power supply. It is made up of AC to AC converter and AC to DC converter as main components. AC to AC converter uses step-down transformer as the device. This transformer converts 240Vac to 24Vac for usage in the next stage. In the next stage, the voltage of 24Vac is converted to regulated DC voltage using AC to DC converter or bridge rectifier and its drive circuit. Bridge rectifier converts 24Vac to 24Vdc. After that, the voltage of 24Vdc converts to regulated DC voltage using drive circuit. In addition, the DC power supply interface to liquid crystal display (LCD) using PIC16F877 for voltmeter application.

1.3 Problem Statement

Nowadays, electrical power supply is the one of important element in human being needs. The most of human activities is very depending of demand of electrical power supply. In the other words, without electrical power supply, almost the whole of activities is become postponed or worse cancelled. There is some companies that responsible in distribute electrical power supply in Malaysia such as in peninsula of Malaysia is Tenaga Nasional Berhad(TNB), Sarawak is Sarawak Electrical Supply Company(ESCO), Sabah is Sabah Electrical Supply Berhad(ESB) and any private power supply provider. For usage of daily routine, voltage are supplied is within 240Vac. The problem happen is the most electrical appliances use DC voltage. Therefore, this voltage of 240Vac must be converted to desired DC voltage. Based on this problem, DC power supply is the solution of this problem.

1.4 Objective

The objective of this project is to;

- i. Develop circuit design of DC power supply using PROTEUS software
- ii. Develop hardware circuit based on the circuit design of DC power supply

1.5 Scope of Project

There are several scopes that need to be proposed for the project;

- i. This project is focused on AC to DC converter
- ii. The DC power supply circuit able convert fix voltage of 240Vac to desired dc voltage within 0V to 35V

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There are two most familiar DC power supplies are used which are linear power supply and switching power supply[2]. Both the DC power supplies have their own differences based on the characteristics.

For linear power supply, it has the preceding discussion points out two major shortcomings of a linear power supply. It requires a low-frequency (60Hz) transformer. That means the size and weight of the transformer are larger than high-frequency transformer. Besides that, the transistors in linear DC power supply operate in active region, incurring a significant amount of power loss. It affected the overall efficiencies of linear power supply usually in a range of 30-60%.

There is different with the switching power supply. In this type of DC power supply, the switching elements such as power transistors or MOSFETs operate as a switch: either completely off and completely on. By avoiding the operation in active region, power loss of the system is able to reduce. As a result, its efficiency between 70-90% ranges. Since a high-frequency isolation transformer is used, the size and weight of switching power supplies can be significantly reduced.

2.2 Power Electronic Applications

2.2.1 Bridge Rectifier

A diode bridge is an arrangement of four (or more) diodes in a bridge configuration that provides the same polarity of output for either polarity of input. When used in its most common application, for conversion of an alternating current (AC) input into direct current a (DC) output, it is known as a bridge rectifier. A bridge rectifier provides full-wave rectification from a two-wire AC input, resulting in lower cost and weight as compared to a rectifier with a 3-wire input from a transformer with a center-tapped secondary winding[11].

AC/DC power converters are extensively used in various applications like power supplies, dc motor drives, front-end converters in adjustable-speed ac drives, High Voltage Direct Current (HVDC) transmission, Switch-Mode Power Supply (SMPS), utility interface with non-conventional energy sources, in process technology like welding, power supplies for telecommunications systems, aerospace, military environment and so on[3]. Traditionally, AC–DC power conversion has been

dominated by diode or phase-controlled rectifiers which act as non-linear loads on the power systems and draw input currents which are rich in harmonics and have poor supply power factor, thus creating the power quality problem for the power distribution network and for other electrical systems in the vicinity of rectifier.

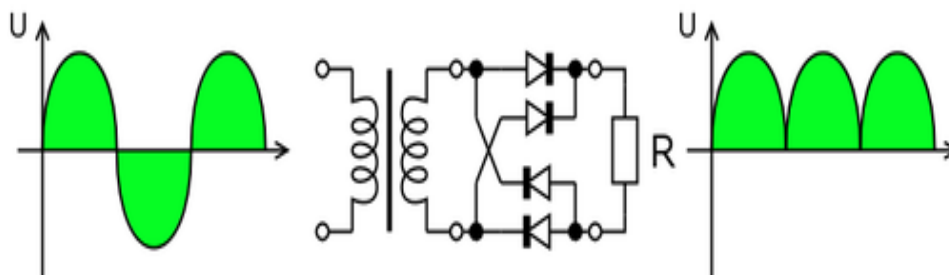


Figure 2.1 : The example circuit of rectifier [3]

According to the conventional model of current flow originally established by Benjamin Franklin and still followed by most engineers today, current is assumed to flow through electrical conductors from the positive to the negative pole[12]. In actuality, free electrons in a conductor nearly always flow from the negative to the positive pole. In the vast majority of applications, however, the actual direction of current flow is irrelevant. Therefore, in the discussion below the conventional model is retained. In the diagrams below, when the input connected to the left corner of the diamond is positive, and the input connected to the right corner is negative, current flows from the upper supply terminal to the right along the red (positive) path to the output, and returns to the lower supply terminal via the blue (negative) path like in Figure 2.2.

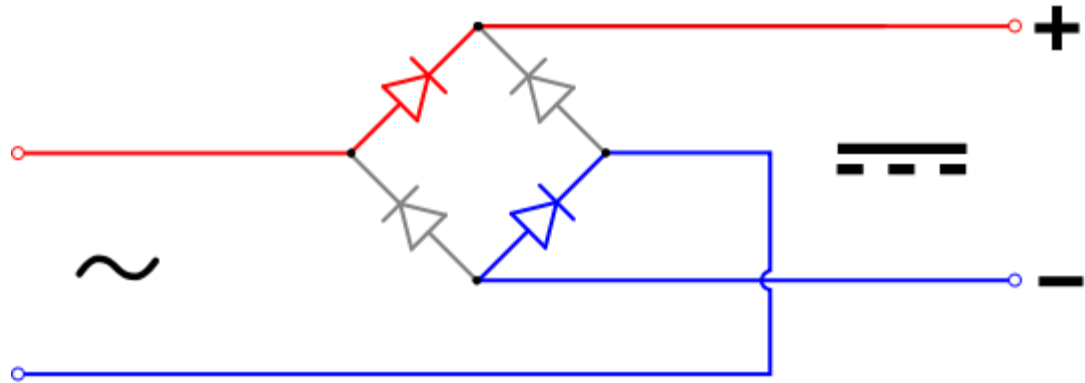


Figure 2.2 : Positive cycle of rectifier[11]

When the input connected to the left corner is negative, and the input connected to the right corner is positive, current flows from the lower supply terminal to the right along the red (positive) path to the output, and returns to the upper supply terminal via the blue (negative) path like in Figure 2.3.

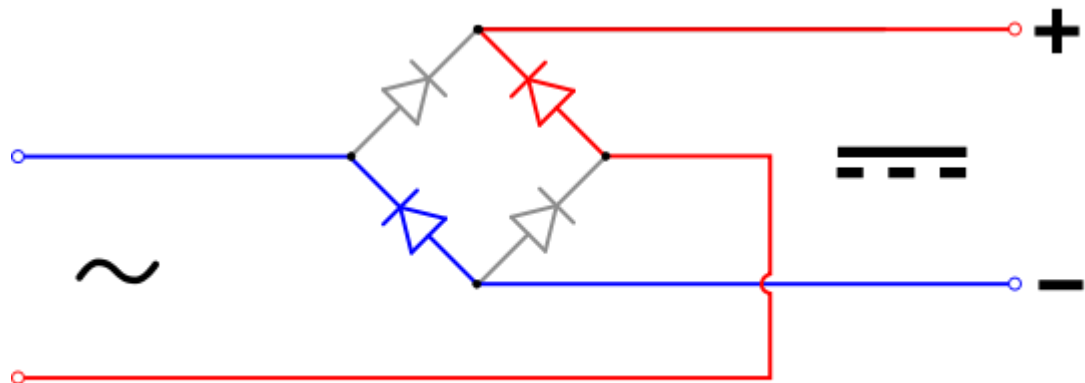


Figure 2.3: Negative cycle of rectifier[11]

In each case, the upper right output remains positive and lower right output negative. Since this is true whether the input is AC or DC, this circuit not only produces a DC output from an AC input, it can also provide what is sometimes called

"reverse polarity protection". That is, it permits normal functioning of DC-powered equipment when batteries have been installed backwards, or when the leads (wires) from a DC power source have been reversed, and protects the equipment from potential damage caused by reverse polarity.

For many applications, especially with single phase AC where the full-wave bridge serves to convert an AC input into a DC output, the addition of a capacitor may be desired because the bridge alone supplies an output of fixed polarity but continuously varying or "pulsating" magnitude, an attribute commonly referred to as "ripple".

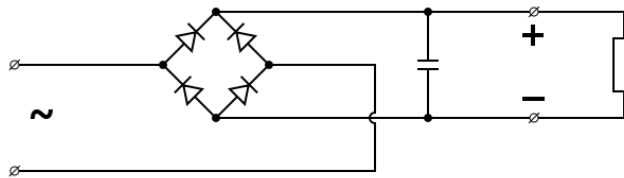


Figure 2.4 : A simple circuit of rectifier with load[12]

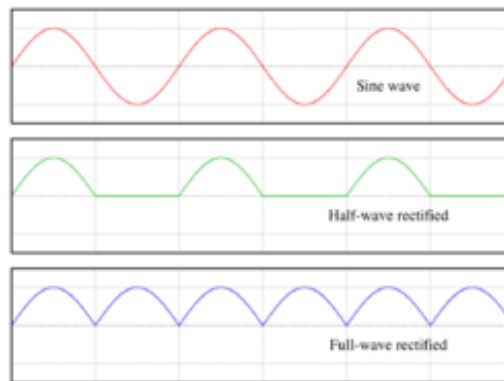


Figure 2.5 : AC, half-wave and full wave rectified signals[12]

2.2.2 DC to DC Converter

DC to DC converters are important in portable electronic devices such as cellular phones and laptop computers, which are supplied with power from batteries primarily. Such electronic devices often contain several sub-circuits, each with its own voltage level requirement different from that supplied by the battery or an external supply (sometimes higher or lower than the supply voltage). Additionally, the battery voltage declines as its stored power is drained. Switched DC to DC converters offer a method to increase voltage from a partially lowered battery voltage thereby saving space instead of using multiple batteries to accomplish the same thing. Most DC to DC converters also regulate the output voltage. Some exceptions include high-efficiency LED power sources, which are a kind of DC to DC converter that regulates the current through the LEDs, and simple charge pumps which double or triple the input voltage.

The DC-DC converters are widely used in regulated switch-mode dc power supplies and in load drive applications. The input to these converters is an unregulated dc voltage, which is obtained by rectifying the line voltage and therefore it will fluctuate due to changes in the line voltage magnitude. Switch-mode DC-to-DC converters are used to convert the unregulated dc input into a controlled dc output at a desired voltage level. This is the basic block diagram of a DC-DC converter system:

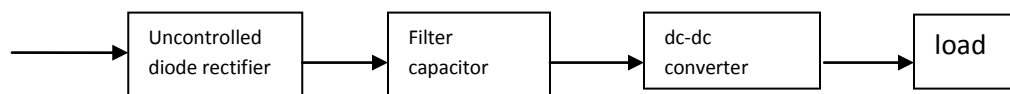


Figure 2.6 : Block diagram of DC-DC converter[4]

DC–DC converters are widely used in low- and high-power applications. Recently, multi-output DC–DC converters have been employed with multiple inductors, in which, for M output voltage, M inductors are required. As the number of output voltages increases, the number of required inductors will also be increased which leads to an increase in the cost and size of the system[4].

Linear regulators can only produce output at lower voltages from the input. They are very inefficient when the voltage drop is large and the current high as they dissipate as heat power equal to the product of the output current and the voltage drop; consequently they are not normally used for large-drop high-current applications[13]. The inefficiency wastes power and requires higher-rated, and consequently more expensive and larger, components. The heat dissipated by high-power supplies is a problem in itself as it must be removed from the circuitry to prevent unacceptable temperature rises. They are practical if the current is low, the power dissipated being small, although it may still be a large fraction of the total power consumed. They are often used as part of a simple regulated power supply for higher currents: a transformer generates a voltage which, when rectified, is a little higher than that needed to bias the linear regulator. The linear regulator drops the excess voltage, reducing hum-generating ripple current and providing a constant output voltage independent of normal fluctuations of the unregulated input voltage from the transformer or bridge rectifier circuit and of the load current. Linear regulators are inexpensive, reliable if good heat sinking is used and much simpler than switching regulators. As part of a power supply they may require a transformer, which is larger for a given power level than that required by a switch-mode power supply[14]. Linear regulators can provide a very low-noise output voltage, and are very suitable for powering noise-sensitive low-power analog and radio frequency circuits. A popular design approach is to use Low Drop-out (LDO) regulator that provides a local "point of load" DC supply to a low power circuit.

Electronic switch-mode DC to DC converters convert one DC voltage level to another, by storing the input energy temporarily and then releasing that energy to the output at a different voltage. The storage may be in either magnetic field storage

components (inductors, transformers) or electric field storage components (capacitors)[15]. This conversion method is more power efficient (often 75% to 98%) than linear voltage regulation (which dissipates unwanted power as heat). This efficiency is beneficial to increasing the running time of battery operated devices. The efficiency has increased since the late 1980's due to the use of power FETs, which are able to switch at high frequency more efficiently than power bipolar transistors, which have more switching losses and require a more complex drive circuit. Another important innovation in DC-DC converters is the use of synchronous rectification which replaces the flywheel diode with a power FET with low "On" resistance, thereby reducing switching losses. Most DC to DC converters are designed to move power in only one direction, from the input to the output. However, all switching regulator topologies can be made bi-directional by replacing all diodes with independently controlled active rectification. A bi-directional converter can move power in either direction, which is useful in applications requiring regenerative braking. Drawbacks of switching converters include complexity, electronic noise (EMI / RFI) and to some extent cost, although this has come down with advances in chip design. DC to DC converters are now available as integrated circuits needing minimal additional components. DC to DC converters are also available as a complete hybrid circuit component, ready for use within an electronic assembly.

2.2.3 Power Transistor

A transistor is a semiconductor device used to amplify and switch electronic signals. It is made of a solid piece of semiconductor material, with at least three terminals for connection to an external circuit. A voltage or current applied to one

pair of the transistor's terminals changes the current flowing through another pair of terminals. Because the controlled output power can be much more than the controlling input power, the transistor provides amplification of a signal. Today, some transistors are packaged individually, but many more are found embedded in integrated circuits.

Bipolar transistors are so named because they conduct by using both majority and minority carriers. The bipolar junction transistor (BJT), the first type of transistor to be mass-produced, is a combination of two junction diodes, and is formed of either a thin layer of p-type semiconductor sandwiched between two n-type semiconductors (an n-p-n transistor), or a thin layer of n-type semiconductor sandwiched between two p-type semiconductors (a p-n-p transistor). This construction produces two p-n junctions: a base-emitter junction and a base-collector junction, separated by a thin region of semiconductor known as the base region (two junction diodes wired together without sharing an intervening semiconducting region will not make a transistor)[5].

The BJT has three terminals, corresponding to the three layers of semiconductor - an emitter, a base, and a collector. It is useful in amplifiers because the currents at the emitter and collector are controllable by a relatively small base current. In an NPN transistor operating in the active region, the emitter-base junction is forward biased (electrons and holes recombine at the junction), and electrons are injected into the base region[6]. Because the base is narrow, most of these electrons will diffuse into the reverse-biased (electrons and holes are formed at, and move away from the junction) base-collector junction and be swept into the collector; perhaps one-hundredth of the electrons will recombine in the base, which is the dominant mechanism in the base current. By controlling the number of electrons that can leave the base, the number of electrons entering the collector can be controlled. Collector current is approximately β (common-emitter current gain) times the base current. It is typically greater than 100 for small-signal transistors but can be smaller in transistors designed for high-power applications.

Unlike the FET, the BJT is a low-input-impedance device. Also, as the base-emitter voltage (V_{be}) is increased the base-emitter current and hence the collector-emitter current (I_{ce}) increase exponentially according to the Shockley diode model and the Ebers-Moll model. Because of this exponential relationship, the BJT has a higher transconductance than the FET.

Bipolar transistors can be made to conduct by exposure to light, since absorption of photons in the base region generates a photocurrent that acts as a base current; the collector current is approximately β times the photocurrent. Devices designed for this purpose have a transparent window in the package and are called phototransistors.

The transistor is the fundamental building block of modern electronic devices, and is ubiquitous in modern electronic systems. Following its release in the early 1950s the transistor revolutionised the field of electronics, and paved the way for smaller and cheaper radios, calculators, and computers, amongst other things.

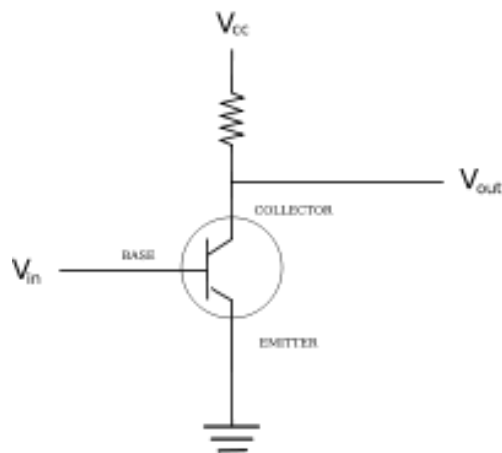


Figure 2.7 : Simple circuit to show bipolar transistor[5]

The essential usefulness of a transistor comes from its ability to use a small signal applied between one pair of its terminals to control a much larger signal at another pair of terminals. This property is called gain. A transistor can control its output in proportion to the input signal; that is, it can act as an amplifier.

Alternatively, the transistor can be used to turn current on or off in a circuit as an electrically controlled switch, where the amount of current is determined by other circuit elements.

The two types of transistors have slight differences in how they are used in a circuit. A bipolar transistor has terminals labeled base, collector, and emitter. A small current at the base terminal (that is, flowing from the base to the emitter) can control or switch a much larger current between the collector and emitter terminals. For a field-effect transistor, the terminals are labeled gate, source, and drain, and a voltage at the gate can control a current between source and drain.

The image to the right represents a typical bipolar transistor in a circuit. Charge will flow between emitter and collector terminals depending on the current in the base. Since internally the base and emitter connections behave like a semiconductor diode, a voltage drop develops between base and emitter while the base current exists. The amount of this voltage depends on the material the transistor is made from, and is referred to as V_{BE} .

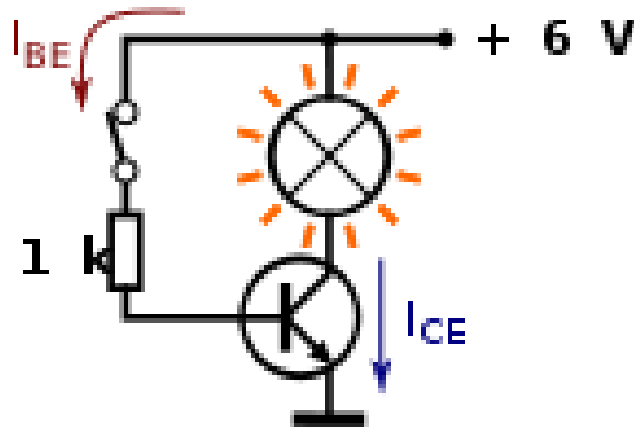


Figure 2.8 : BJT used as an electronic switch, in grounded emitter configuration[6]

Transistors are commonly used as electronic switches, for both high power applications including switched-mode power supplies and low power applications such as logic gates.

In a grounded-emitter transistor circuit, such as the light-switch circuit shown, as the base voltage rises the base and collector current rise exponentially, and the collector voltage drops because of the collector load resistor. The relevant equations:

$$V_{RC} = I_{CE} \times R_C, \text{ the voltage across the load (the lamp with resistance } R_C)$$

$$V_{RC} + V_{CE} = V_{CC}, \text{ the supply voltage shown as } 6V$$

If V_{CE} could fall to 0 (perfect closed switch) then I_c could go no higher than V_{CC} / R_C , even with higher base voltage and current. The transistor is then said to be saturated. Hence, values of input voltage can be chosen such that the output is either completely off,^[13] or completely on. The transistor is acting as a switch, and this type of operation is common in digital circuits where only "on" and "off" values are relevant.

The procedure below explains how to choose a suitable switching transistor.

1. The transistor's maximum collector current $I_c(\text{max})$ must be greater than the load current I_c .

$$\text{load current } I_c = \frac{\text{supply voltage } V_s}{\text{load resistance } R_L}$$

2. The transistor's minimum current gain $h_{FE}(\text{min})$ must be at least five times the load current I_c divided by the maximum output current from the IC.

$$h_{FE}(\text{min}) > 5 \times \frac{\text{load current } I_c}{\text{max. IC current}}$$

- Choose a transistor which meets these requirements and make a note of its properties: $I_{c(max)}$ and $h_{FE(min)}$.

There is a table showing technical data for some popular transistors on the transistors page.

- Calculate an approximate value for the base resistor:

$$R_B = \frac{V_c \times h_{FE}}{5 \times I_c} \quad \text{where } V_c = \text{IC supply voltage}$$

(in a simple circuit with one supply this is V_s)

- For a simple circuit where the IC and the load share the same power supply ($V_c = V_s$) you may prefer to use: $R_B = 0.2 \times R_L \times h_{FE}$
- Then choose the nearest standard value for the base resistor.
- Finally, remember that if the load is a motor or relay coil a protection diode is required.

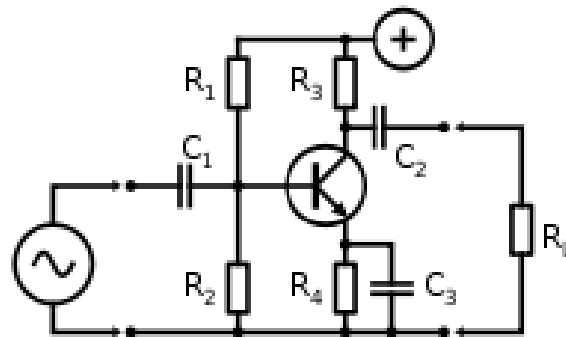


Figure 2.9 : BJT used as switching unit

The common-emitter amplifier is designed so that a small change in voltage in (V_{in}) changes the small current through the base of the transistor and the transistor's current amplification combined with the properties of the circuit mean that small swings in V_{in} produce large changes in V_{out} . Various configurations of single transistor amplifier are possible, with some providing current gain, some voltage gain, and some both.

From mobile phones to televisions, vast numbers of products include amplifiers for sound reproduction, radio transmission, and signal processing. The first discrete transistor audio amplifiers barely supplied a few hundred milliwatts, but power and audio fidelity gradually increased as better transistors became available and amplifier architecture evolved. Modern transistor audio amplifiers of up to a few hundred watts are common and relatively inexpensive.

2.3 Voltmeter (Monitoring Part)

2.3.1 Liquid Crystal Display (LCD)

A liquid crystal display (LCD) is a thin, flat electronic visual display that uses the light modulating properties of liquid crystals (LCs). LCs do not emit light directly. They are used in a wide range of applications including: computer monitors, television, instrument panels, aircraft cockpit displays, signage, etc. They are common in consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephones. LCDs have displaced cathode ray tube (CRT) displays in most applications. They are usually more compact, lightweight, portable, less expensive, more reliable, and easier on the eyes.[7] They are available in a wider range of screen sizes than CRT and plasma displays, and since they do not use phosphors, they cannot suffer image burn-in.

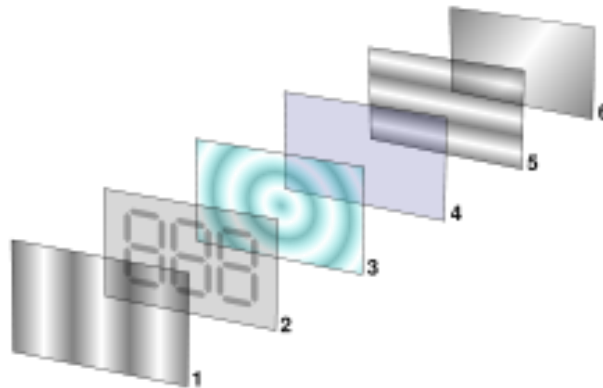


Figure 2.10 : Layers of LCD[7]

LCDs are more energy efficient and offer safer disposal than CRTs. Its low electrical power consumption enables it to be used in battery-powered electronic equipment. It is an electronically-modulated optical device made up of any number of pixels filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in colour or monochrome. The earliest discovery leading to the development of LCD technology, the discovery of liquid crystals, dates from 1888.[8] By 2008, worldwide sales of televisions with LCD screens had surpassed the sale of CRT units.

LCDs with a small number of segments, such as those used in digital watches and pocket calculators, have individual electrical contacts for each segment. An external dedicated circuit supplies an electric charge to control each segment. This display structure is unwieldy for more than a few display elements.



Figure 2.11 : Alphanumeric LCD[8]

Small monochrome displays such as those found in personal organizers, electronic weighing scales, older laptop screens, and the original Gameboy have a passive-matrix structure employing super-twisted nematic (STN) or double-layer STN (DSTN) technology the latter of which addresses a colour-shifting problem with the former and colour STN (CSTN) wherein colour is added by using an internal filter[9]. Each row or column of the display has a single electrical circuit. The pixels are addressed one at a time by row and column addresses. This type of display is called passive-matrix addressed because the pixel must retain its state between refreshes without the benefit of a steady electrical charge. As the number of pixels (and, correspondingly, columns and rows) increases, this type of display becomes less feasible. Very slow response times and poor contrast are typical of passive-matrix addressed LCDs. Colour passive-matrix displays exist, although they are limited to 16 colours.

Monochrome passive-matrix LCDs were standard in most early laptops (although a few used plasma displays). The commercially unsuccessful Macintosh Portable (released in 1989) was one of the first to use an active-matrix display (though still monochrome), but passive-matrix was the norm until the mid-1990s[10], when colour active-matrix became standard on all laptops. High-resolution colour displays such as modern LCD computer monitors and televisions use an active matrix structure. A matrix of thin-film transistors (TFTs) is added to the polarizing and colour filters. Each pixel has its own dedicated transistor, allowing each column line to access one pixel. When a row line is activated, all of the column lines are

connected to a row of pixels and the correct voltage is driven onto all of the column lines. The row line is then deactivated and the next row line is activated. All of the row lines are activated in sequence during a refresh operation. Active-matrix addressed displays look brighter and sharper than passive-matrix addressed displays of the same size, and generally have quicker response times, producing much better images.

2.3.2 PIC16F877 Microcontroller

PIC16F877 is one of family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC16F87XX originally developed by General Instrument's Microelectronics Division. The name of PIC initially referred to "Programmable Interface Controller". PIC are popular with both industrial developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, serial programming and re-programming with flash memory) capability.

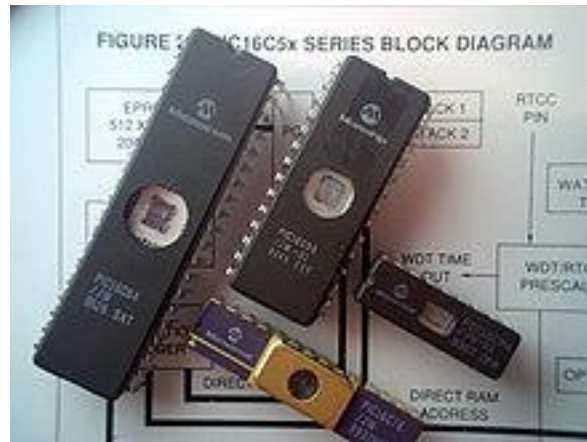


Figure 2.12 : Samples of PIC16F877

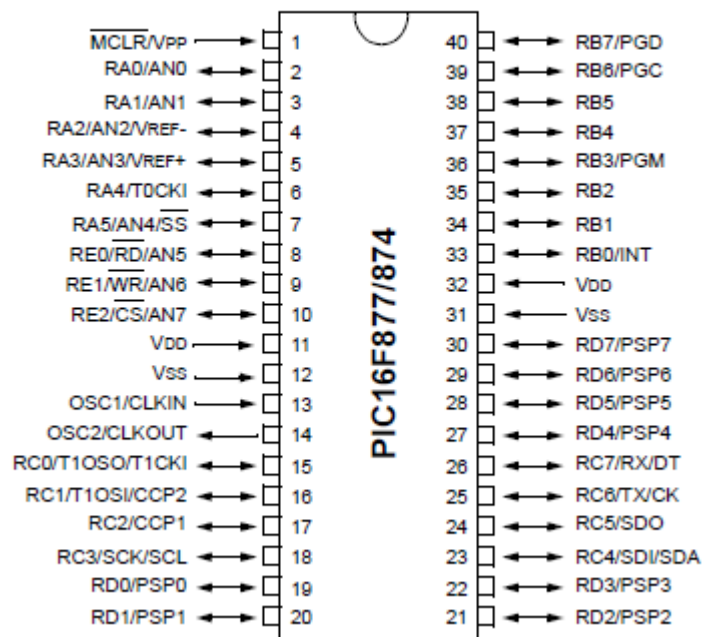


Figure 2.13 : Overview of PIC16F877

The PIC16F877 architecture is characterized by the following features:

- Separate code and data spaces (Harvard architecture) for devices
- A small number of fixed length instructions
- Most instructions are single cycle execution (2 clock cycles), with one delay cycle on branches and skips
- One accumulator (W0), the use of which (as source operand) is implied (i.e. is not encoded in the opcode)
- All RAM locations function as registers as both source and/or destination of math and other functions.
- A hardware stack for storing return addresses
- A fairly small amount of addressable data space (typically 256 bytes), extended through banking
- Data space mapped CPU, port, and peripheral registers
- The program counter is also mapped into the data space and writable (this is used to implement indirect jumps).

There is no distinction between memory space and register space because the Random Access Memory (RAM) serves the job of both memory and registers, and the RAM is usually just referred to as the register file or simply as the registers.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Methodology is a description of process, or may be expanded to include a philosophically coherent collection of theories, concepts or ideas as they relate to a particular discipline or field of inquiry. It may refer to nothing more than a simple set of methods or procedures, or it may refer to the rationale and the philosophical assumptions that underlie a particular study relative to the scientific method. For example, scholarly literature often includes a section on the methodology of the researchers. Besides that, methodology also can be defined the analysis of the principles of methods, rules, and postulates employed by a discipline or in the other

words the systematic study of methods that are, can be, or have been applied within a discipline.

3.2 The Block Diagram Of DC Power Supply

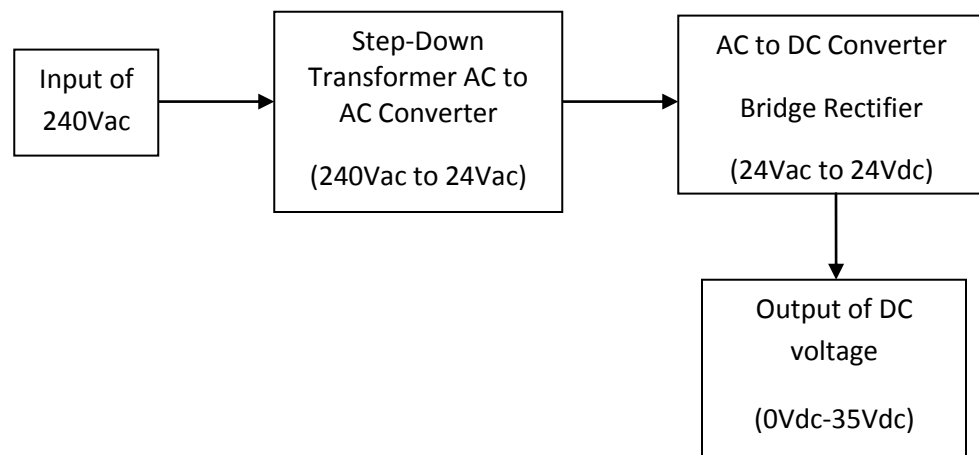


Figure 3.1 : The block diagram of dc-dc converter

3.3 The Circuit Of DC Power Supply

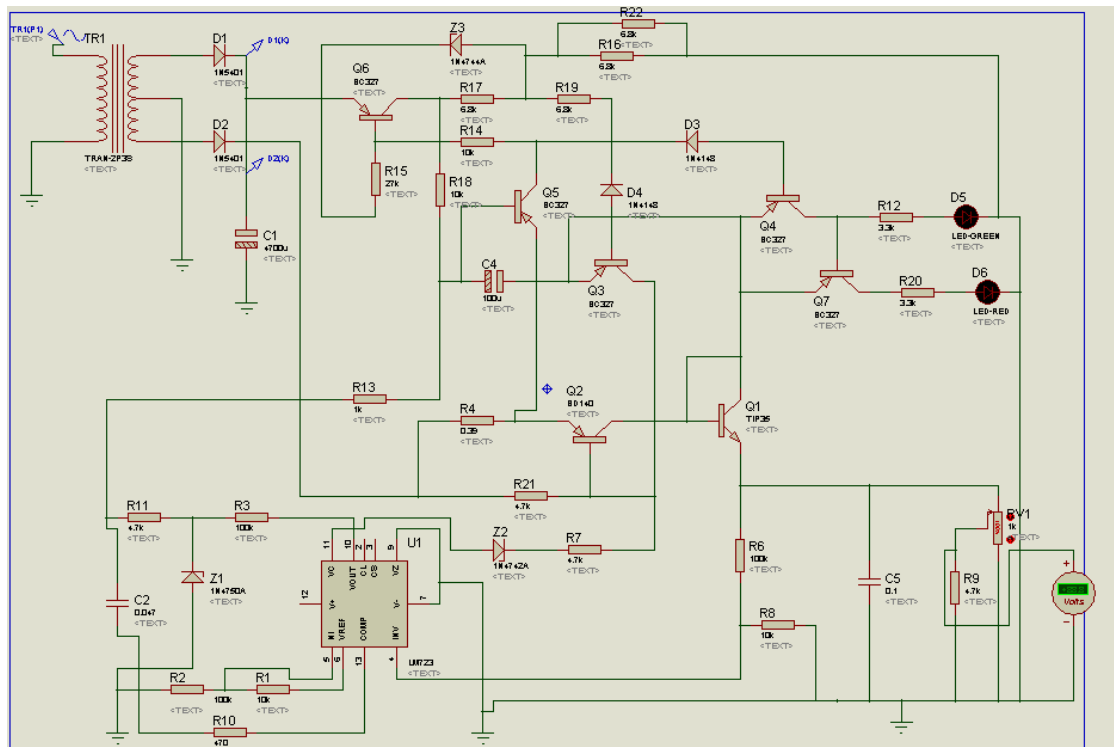


Figure 3.2 : Circuit design of DC power supply

3.4 Stages of Development Of Dc Power Supply

There are a few stages needed to develop a complete circuit of DC power supply. The DC power supply should be designed in some stages in order to convenient in troubleshooting error connection, observation data, minimizing circuit connection error and finally less complicated in develop hardware circuit. In this

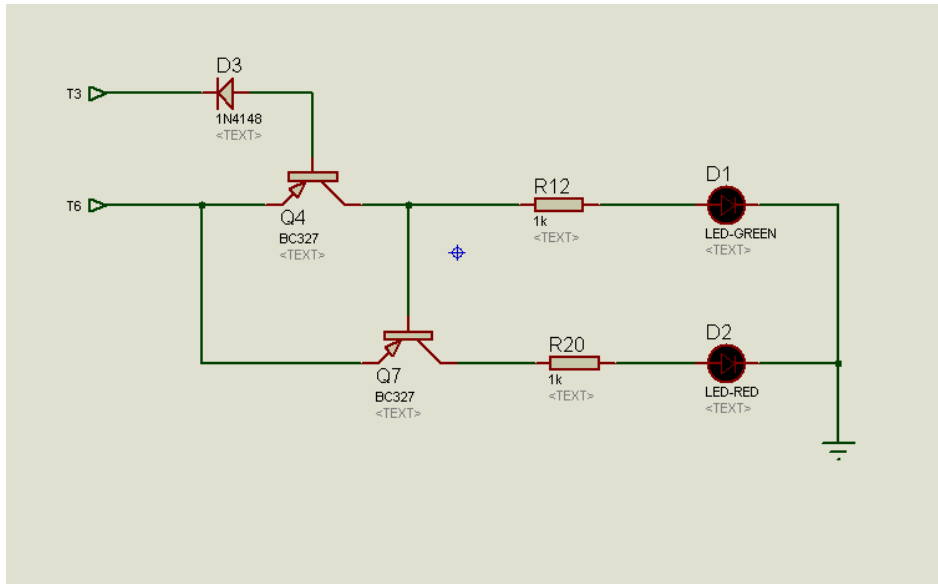


Figure 3.5 : Connection circuit of stage 3

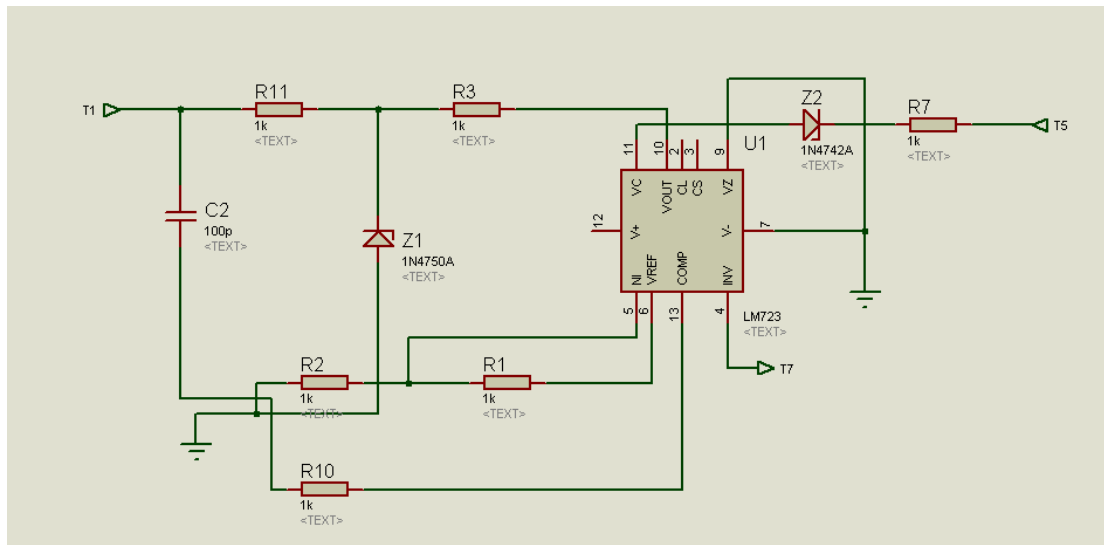


Figure 3.6 : Connection circuit of stage 4

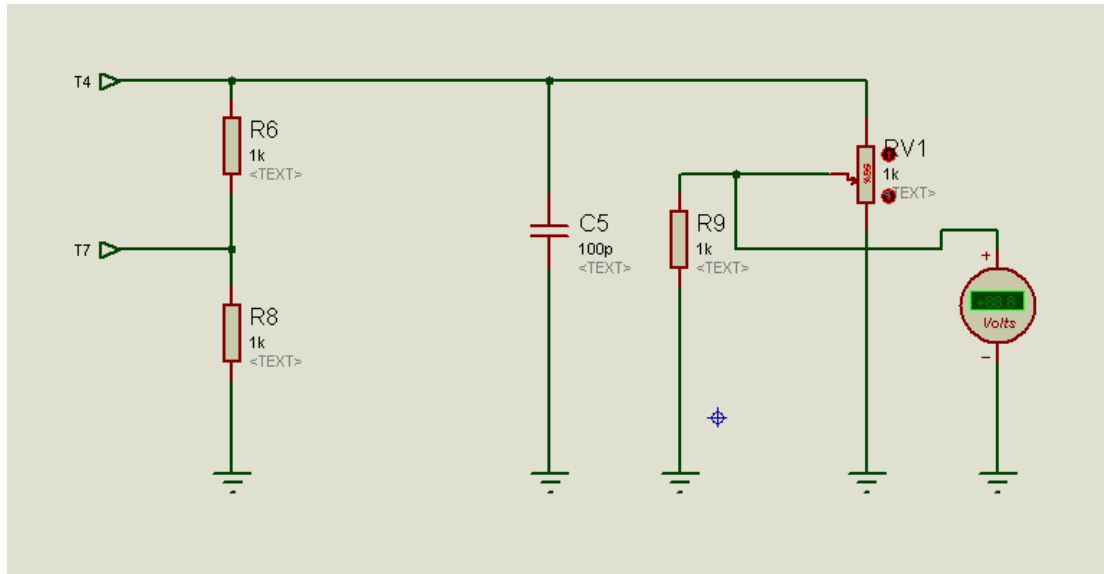


Figure 3.7 : Connection circuit of stage 5

3.5 Voltmeter Circuit

3.5.1 Overview

Familiarly, most DC power supply in market have voltage display device in order to display the voltage of DC power supply output. Regarding for this purpose, the DC power supply is developed with voltmeter circuit. Even though this circuit is not important but it is efficient when was not has voltmeter device. In the other words, it will be important part during certain time especially urgent condition.

3.5.2 Voltmeter Circuit Design

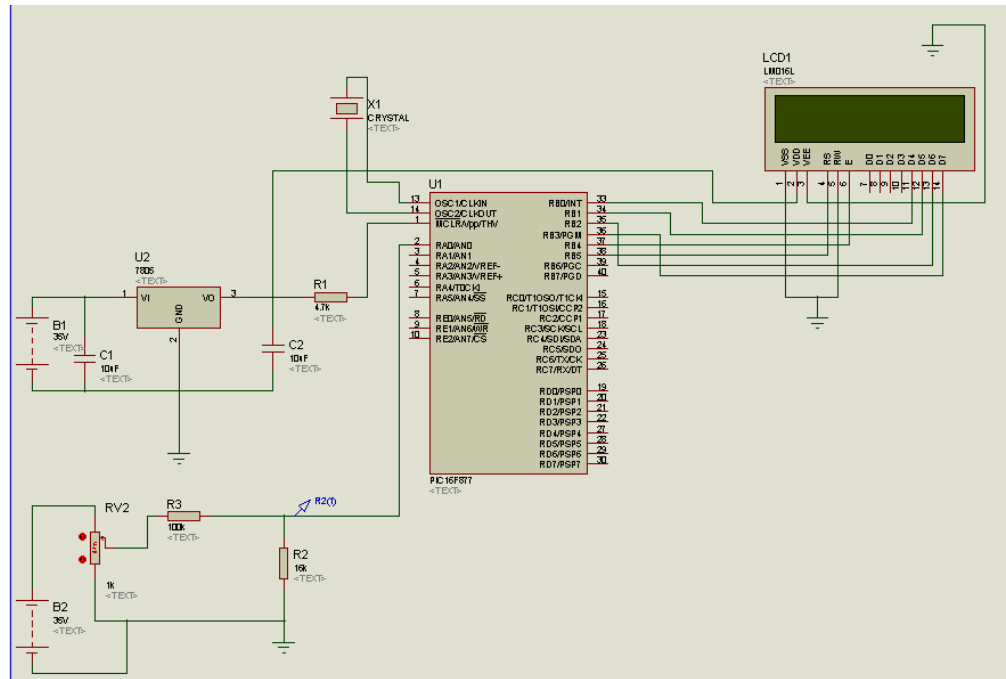


Figure 3.8 : Voltmeter circuit design

3.5.3 PIC16F877 Programming Code for Voltmeter Circuit

```

DEFINE    LCD_DREG PORTB           'LCD Data bits on PORTB

DEFINE    LCD_DBIT 0                'PORTB starting address

DEFINE    LCD_RSREG PORTB          'LCD RS bit on PORTB

DEFINE    LCD_RSBIT 5              'LCD RS bit address

```



```

DEFINE    LCD_EREG PORT          'LCD E bit on PORTB

DEFINE    LCD_EBIT 4             'LCD E bit address

DEFINE    LCD_BITS 4             'LCD in 4-bit mode

DEFINE    LCD_LINES 2           'LCD has 2 rows

Res Var Word                    'A/D converter result

Volts Var Word                  'Result of conversion in mV

Conv Con 137                    '35000/256 = 136.72, take 137

TRISA = 1                                'RA0 (AN0) is input

TRISB = 0                                'PORTB is output

PAUSE 5000                            'Wait 0.5sec for LCD to initialize

'

'Initialize the A/D converter

'

LCDOUT  $fe, 1                       ' Clear LCD screen

LCDOUT  $FE,2, "PSM 2010"            ' Display PSM 2010

LCDOUT  $FE,$C0, "FKEE"

PAUSE 5000                            ' Wait .5 second

LCDOUT  $fe, 1                       ' Clear LCD screen

```


LCDOUT \$FE, 1	'Clear LCD
AGAIN:	'Start A/D conversion
ADCON0.2 = 1 complete	'Wait until conversion is complete
WT: PAUSE 1	
IF ADCON0.2 = 1 THEN WT	
Res = ADRES	'Get result of conversion
Volts = Res * Conv	'Result in mV
LCDOUT \$FE,2,"V = ", DEC5 Volts	'Display result
PAUSE 1000	'Wait 1 second
GOTO AGAIN	'Repeat
END	'End of program

3.6 Circuit Testing Methods

3.6.1 Overview

In this project, the DC power supply circuit is tested in two stages are those simulation by PROTEUS software and testing voltage output using oscilloscope. First, the DC power supply circuit design is simulated using PROTEUS software. Then, DC power supply is built and the voltage output is tested using oscilloscope in laboratory. During both testing stages, the circuit will be troubleshoot if having problems in running function.

3.6.2 Simulating Circuit Design

Before going hardware circuit development, the circuit design must be tested using proper software. This stage's purpose is to ensure the circuit design can be function. First, there need to design the circuit in PROTEUS software.

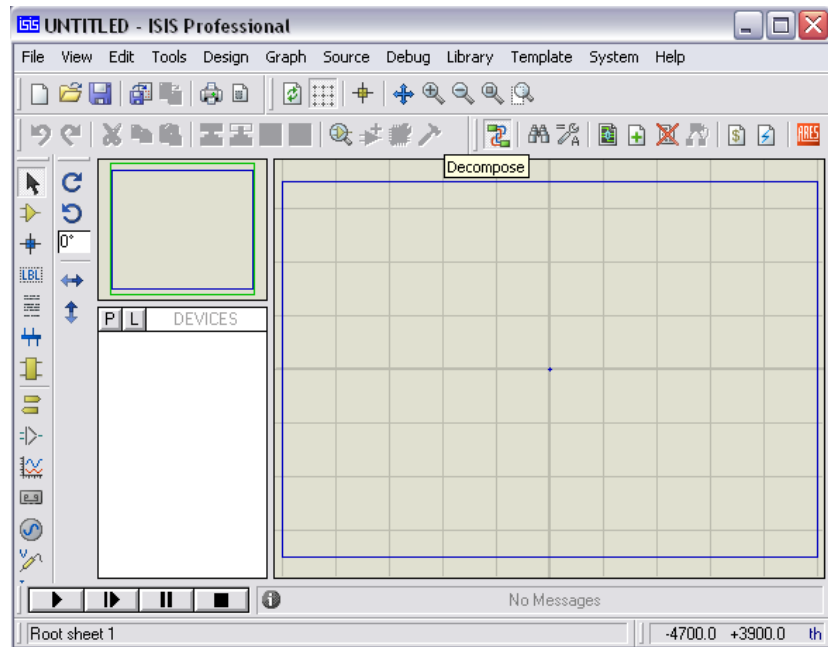


Figure 3.9 : PROTEUS Software

PROTEUS software is one of the most efficient software is used by DC power supply and drive circuit designer. In this software, the result of any design can be simulated either success or failed especially at the output of circuit design. If the simulation in PROTEUS is functioned, that means since hardware is successes. There have few steps to use PROTEUS software in order to simulate dc power supply circuit design. First, there need to design the circuit based on actual specifications of components like in Figure 3.10 so that less error.

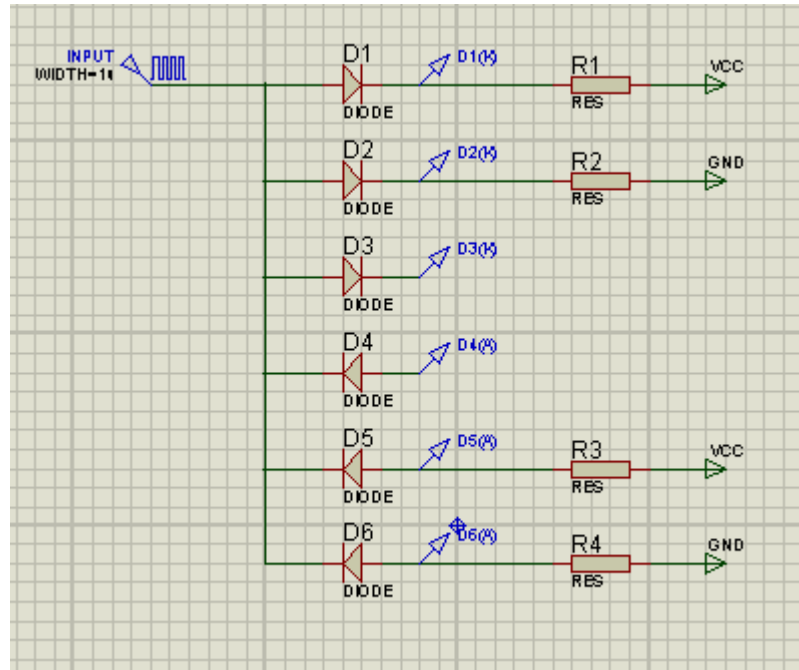


Figure 3.10 : Sample circuit for simulation

Then, select “Graph” menu at left of side bar. In the option of “Graph, there are several types of graph can be selected based those data are wished. Basically, the most PROTEUS user apply “ANALOGUE” option like in Figure 3.11 because this graph is suitable to any outputs. So, select “ANALOGUE” option and the image like Figure 3.12 will be displayed.

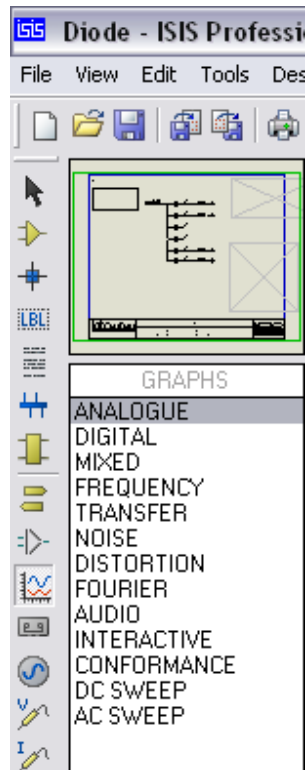


Figure 3.11 : Step 1-select ANALOGUE ANALYSIS

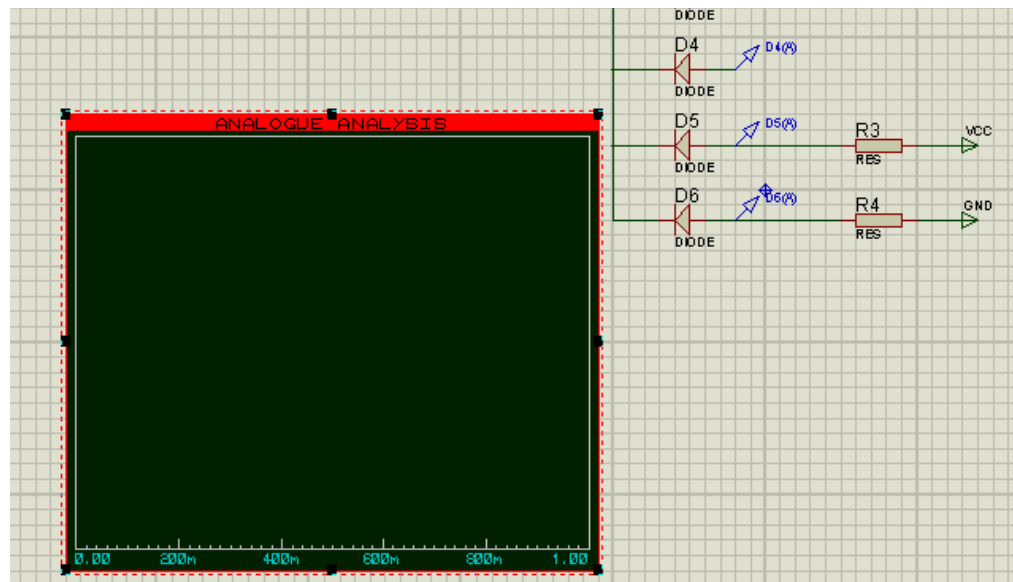


Figure 3.12 : Step 2-Display ANALOGUE ANALYSIS graph

After that, when the image of “ANALOGUE ANALYSIS” has displayed, there need to going to next step is that adding trace. Refer to PROTEUS software, trace is a point that be tapping at any part on DC power supply circuit design in order to validate any reading in the graph analysis. In this step, “right-click” on the “ANALOGUE ANALYSIS” and select “add traces” or use shortcut by typing “CTRL+T” like in Figure 3.13. The image of “Add Transient Trace” will be displayed like in Figure. Select any probe in “Add Transient Trace” based desired output is wished to observe and then click “OK”.

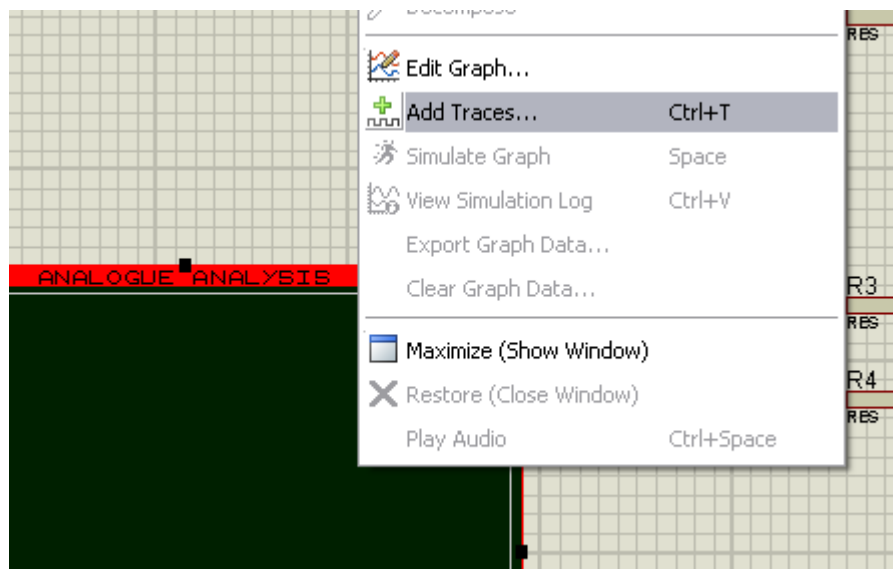


Figure 3.13 : Step 3-Adding traces

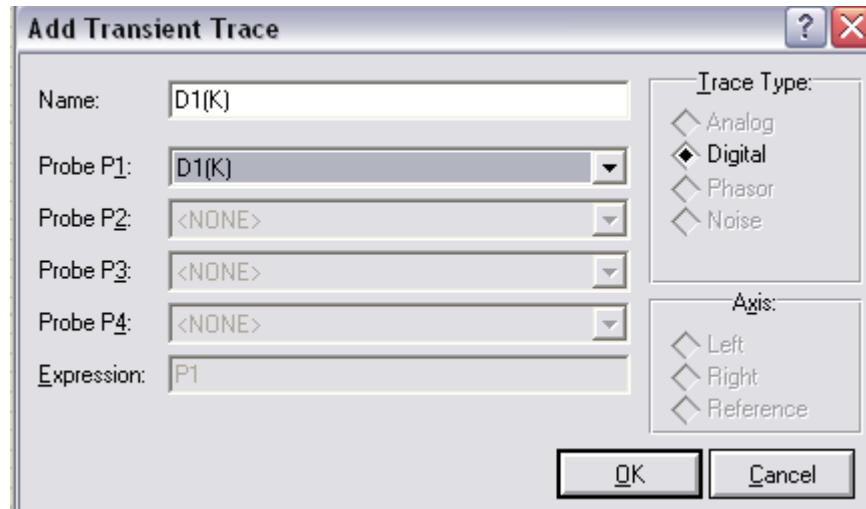


Figure 3.14 : Step 4-select probe

Finally is the step of simulating the graph either display any output or nothing. In the step, “right-click” again on the graph and select “Simulate Graph” option or typing “SPACE” button on keyboard like in Figure 3.15. The graph will be displayed in “ANALOGUE ANALYSIS” as the data of output like in Figure 3.16. This graph can be used as data in Result and Discussion.

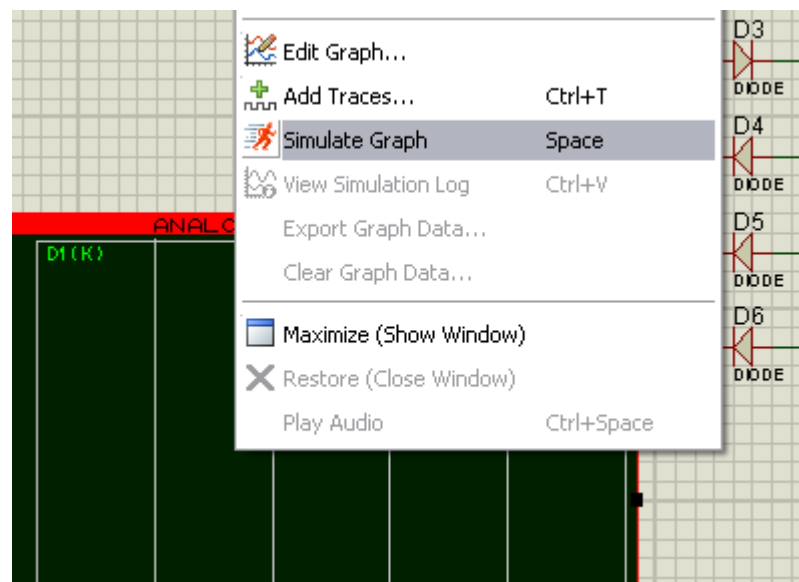


Figure 3.15 : Step 5-Simulate graph

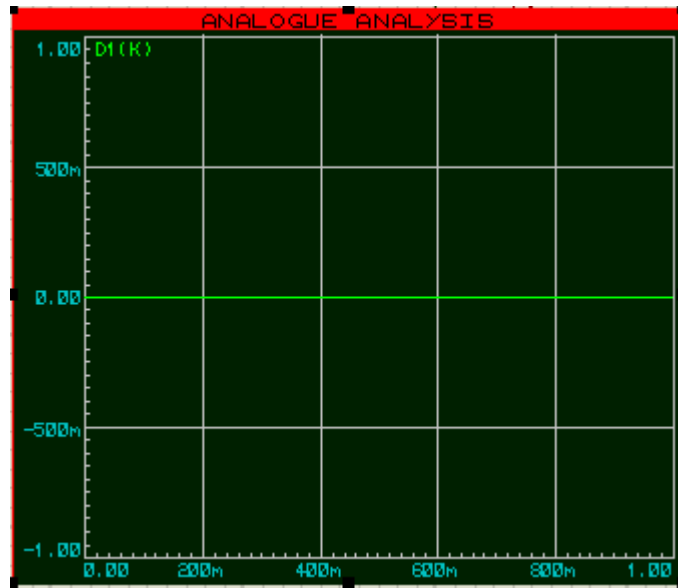


Figure 3.16 : Step 6-Display result

3.6.3 Testing Hardware Circuit

In this stage, it needs to test the output for each part in the DC power supply circuit. There must test part by part in the circuit from input part to output part. Based on the project, this stage is did when the circuit construction is started. First, the output of bridge rectifier is tested either the part produces 240 Vdc from input of 240Vac. Finally, the output of the DC power supply circuit is tested is that after output of 240 Vdc becomes input at dc-dc converter. The device are used in this stage are oscilloscope and multimeter. The oscilloscope is used to measure the value of output and input and display the shape of voltage waveform. The multimeter is used to measure of magnitude of voltage only.

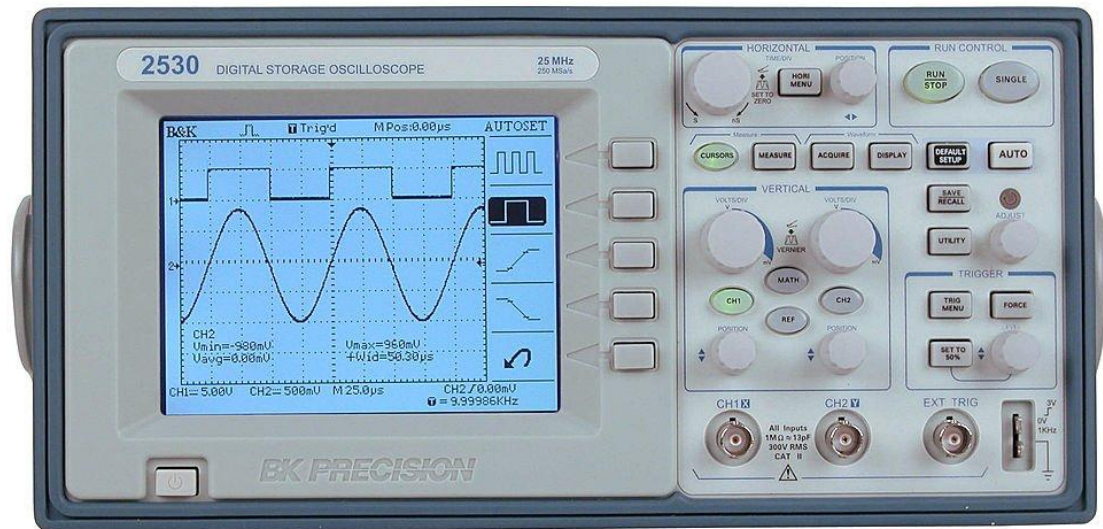


Figure 3.17 : Digital oscilloscope

3.6.4 Troubleshooting Circuit Connection or Related Problems

For troubleshooting process, the device is used multimeter already sufficient. Troubleshooting is very important before start build hardware circuit. This because there is not identified either those components are used is function or have damage. Therefore, before start to build dc power circuit, any related components are used must be troubleshot using multimeter.

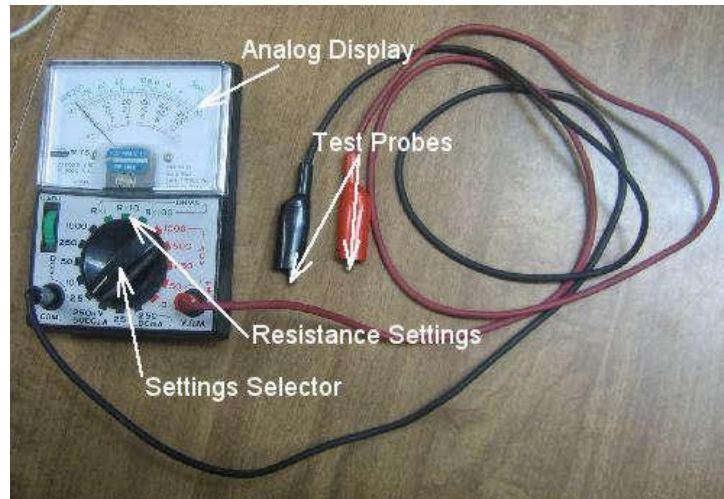


Figure 3.18 : Analog multimeter

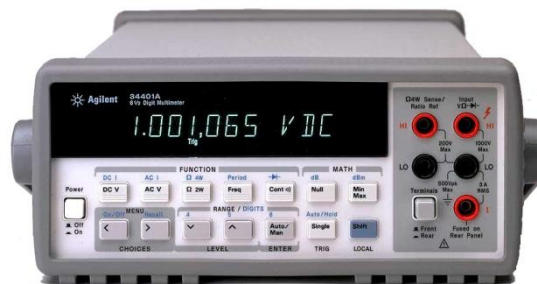


Figure 3.19 : Digital multimeter

3.7 Components of Project

3.7.1 240Vac to 24Vac Transformer

A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled conductors—the transformer's coils. A varying current in the first or primary winding creates a varying magnetic flux in the transformer's core, and thus a varying magnetic field through the secondary winding. This varying magnetic field induces a varying electromotive force (EMF) or "voltage" in the secondary winding[16]. This effect is called mutual induction. If a load is connected to the secondary, an electric current will flow in the secondary winding and electrical energy will be transferred from the primary circuit through the transformer to the load. In an ideal transformer, the induced voltage in the secondary winding (V_S) is in proportion to the primary voltage (V_P), and is given by the ratio of the number of turns in the secondary (N_S) to the number of turns in the primary (N_P) as follows:

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

By appropriate selection of the ratio of turns, a transformer thus allows an alternating current (AC) voltage to be "stepped up" by making N_S greater than N_P , or "stepped down" by making N_S less than N_P . In the vast majority of transformers, the windings are coils wound around a ferromagnetic core, air-core transformers being a notable exception. Transformers range in size from a thumbnail-sized coupling transformer hidden inside a stage microphone to huge units weighing hundreds of tons used to interconnect portions of power grids. All operate with the same basic principles, although the range of designs is wide. While new technologies have eliminated the need for transformers in some electronic circuits, transformers are still

found in nearly all electronic devices designed for household ("mains") voltage. Transformers are essential for high voltage power transmission, which makes long distance transmission economically practical.

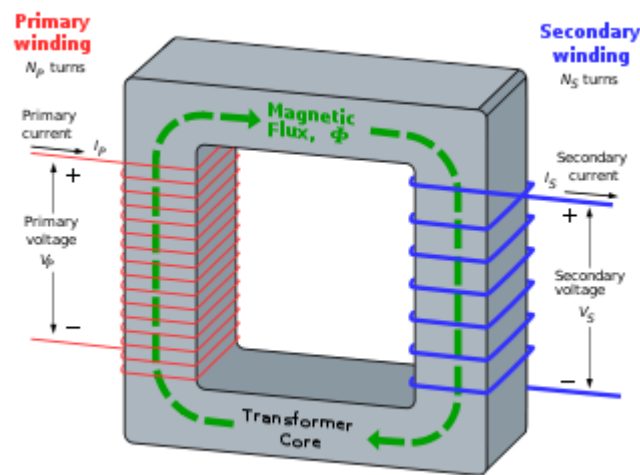


Figure 3.20 : Transformer[16]

The transformer is based on two principles: firstly, that an electric current can produce a magnetic field (electromagnetism), and, secondly that a changing magnetic field within a coil of wire induces a voltage across the ends of the coil (electromagnetic induction). Changing the current in the primary coil changes the magnetic flux that is developed. The changing magnetic flux induces a voltage in the secondary coil. An ideal transformer is shown in the adjacent figure. Current passing through the primary coil creates a magnetic field. The primary and secondary coils are wrapped around a core of very high magnetic permeability, such as iron, so that most of the magnetic flux passes through both the primary and secondary coils.

The voltage induced across the secondary coil may be calculated from Faraday's law of induction, which states that[17]:

$$V_s = N_s \frac{d\Phi}{dt},$$

where V_S is the instantaneous voltage, N_S is the number of turns in the secondary coil and Φ is the magnetic flux through one turn of the coil. If the turns of the coil are oriented perpendicular to the magnetic field lines, the flux is the product of the magnetic flux density B and the area A through which it cuts. The area is constant, being equal to the cross-sectional area of the transformer core, whereas the magnetic field varies with time according to the excitation of the primary. Since the same magnetic flux passes through both the primary and secondary coils in an ideal transformer,[26] the instantaneous voltage across the primary winding equals

$$V_P = N_P \frac{d\Phi}{dt}.$$

Taking the ratio of the two equations for V_S and V_P gives the basic equation for stepping up or stepping down the voltage

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}.$$

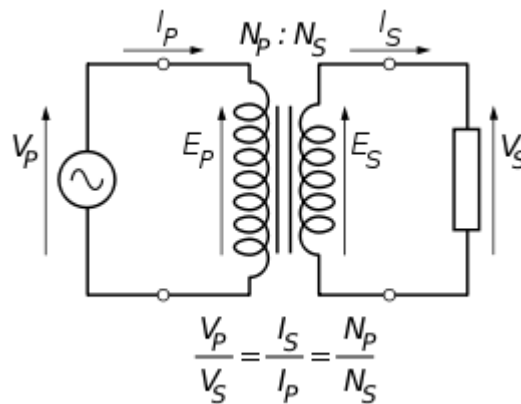


Figure 3.21 :Simple circuit of transformer[17]

If the secondary coil is attached to a load that allows current to flow, electrical power is transmitted from the primary circuit to the secondary circuit. Ideally, the transformer is perfectly efficient; all the incoming energy is transformed from the

primary circuit to the magnetic field and into the secondary circuit. If this condition is met, the incoming electric power must equal the outgoing power[18]:

$$P_{\text{incoming}} = I_P V_P = P_{\text{outgoing}} = I_S V_S,$$

giving the ideal transformer equation:

$$\frac{V_S}{V_P} = \frac{N_S}{N_P} = \frac{I_P}{I_S}.$$

Transformers normally have high efficiency, so this formula is a reasonable approximation. If the voltage is increased, then the current is decreased by the same factor. The impedance in one circuit is transformed by the square of the turns ratio. For example, if an impedance Z_S is attached across the terminals of the secondary

coil, it appears to the primary circuit to have an impedance of $Z_S \left(\frac{N_P}{N_S}\right)^2$. This relationship is reciprocal, so that the impedance Z_P of the primary circuit appears to

the secondary to be $Z_P \left(\frac{N_S}{N_P}\right)^2$.

3.7.2 LM723 Integrated Circuit

The LM723 is a monolithic integrated programmable voltage regulator, assembled in 14-lead dual in-line plastic and SO-14 micro package. The circuit

provides internal current limiting. When the output current exceeds 150mA an external NPN or PNP pass element may be used. Provisions are made for adjustable current limiting and remote shut-down.

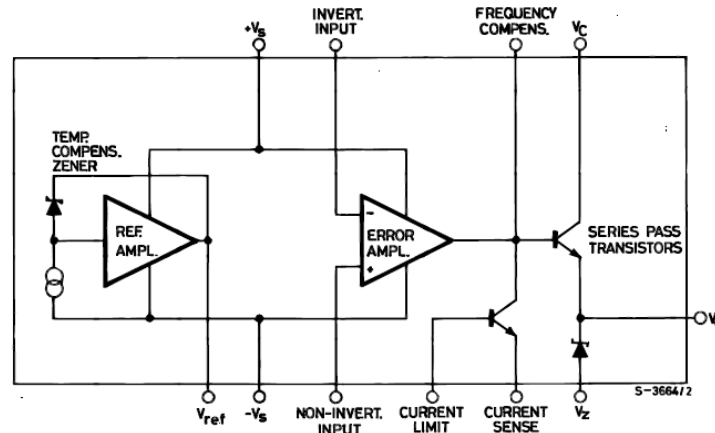


Figure 3.22 : Schematic diagram of LM723

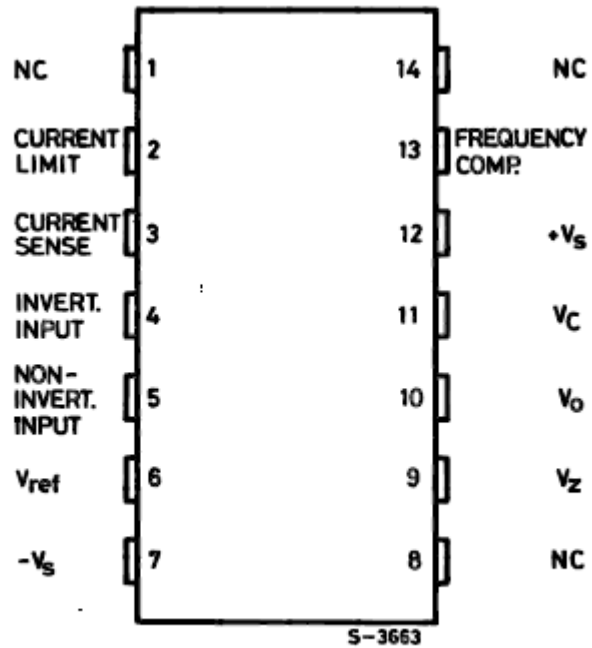
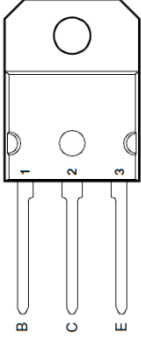
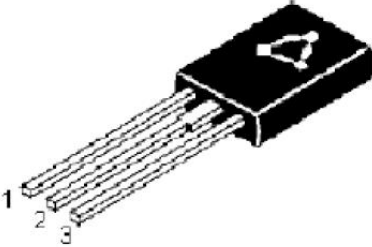


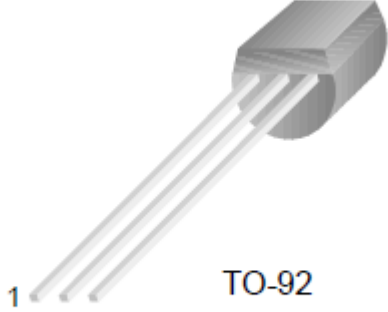
Figure 3.23 : Pin Connection of LM723

3.7.3 Transistor

In this project, the type of transistor are used is bipolar junction transistor (BJT). This kind of transistor are divided to two types are those PNP and NPN. Those transistor are used in the DC power supply is shown in the table below:

Table 3.1: Models of Transistor

Model of Transistor	Specifications
<p>1.TIP35</p> 	<ul style="list-style-type: none"> ➤ Designed for Complementary Use with the ➤ 125 W at 25°C Case Temperature ➤ 25 A Continuous Collector Current ➤ 40 A Peak Collector Current ➤ NPN transistor
<p>2.BD140</p> 	<ul style="list-style-type: none"> ➤ PNP plastic power transistors. ➤ Medium Power Linear and Switching Applications. ➤ Pin Configuration: <ol style="list-style-type: none"> 1. Emitter 2. Collector 3. Base

<p>3.BC327</p>  <p>TO-92</p>	<ul style="list-style-type: none"> ➤ Suitable for AF-Driver stages and low power output stages ➤ Complement to BC337/BC338
---	--

3.7.4 Other Components

Table 3.2: Other components are used

Type of components	Value of Components
Resistor	<p>R1,R8,R11,R14,R18=10kΩ</p> <p>R2,R3,R6=100kΩ</p> <p>R4=0.39Ω</p> <p>R5=47Ω</p> <p>R7,R9,R21=4.7kΩ</p> <p>R10=470Ω</p> <p>R12,R20=3.3kΩ</p> <p>R13=1kΩ</p> <p>R15=27kΩ</p> <p>R16,R17,R19,R22=6.8kΩ</p>
Capacitor	<p>C1=4700uF</p> <p>C2=0.047F</p> <p>C3=100uF</p> <p>C4=3.3uF</p>

Diode	D1,D2=1N5401 D3,D4=1N4148
Zener Diode	Z1=27V Z2=12V Z3=15V

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter shows the results of the project and then makes a discussion about it. This chapter included the software result, hardware results and complete hardware with software results. The software result consists of simulation of fully design of step-down transformer, LM723, and DC power supply using PROTEUS software. The hardware result consists of the output value of the whole circuit.

4.2 Software Results

4.2.1 Step-Down Transformer Results

In this project, step down transformer is used have rating conversion 230Vac to 24Vac. The circuit output testing consists of 240Vac supply, 240Vac to24Vac transformer, diode 1N5401, and capacitor 4700uF like in Figure 4.1. Before going to the simulation, there are needed to add traces at 240Vac supply of the output of transformer.

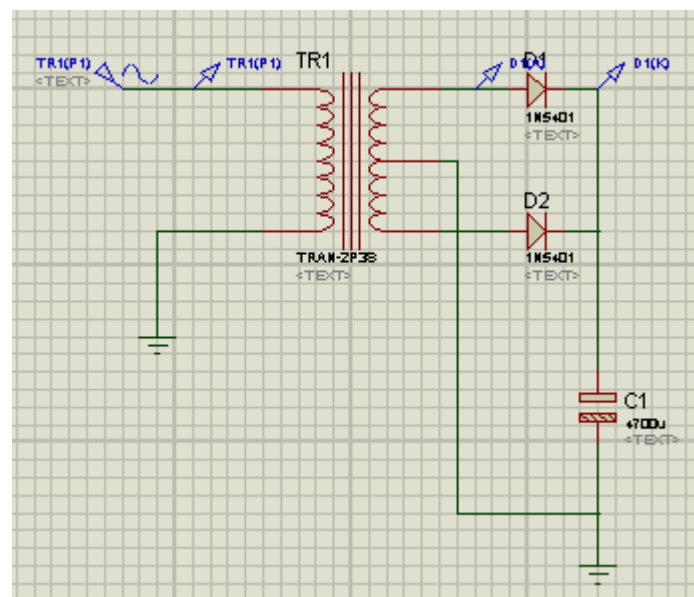


Figure 4.1 : step-down transformer

Then, both graph of input and output at the transformer are simulated and the value of both input and output are observed. Both of graph curves are shown like below:

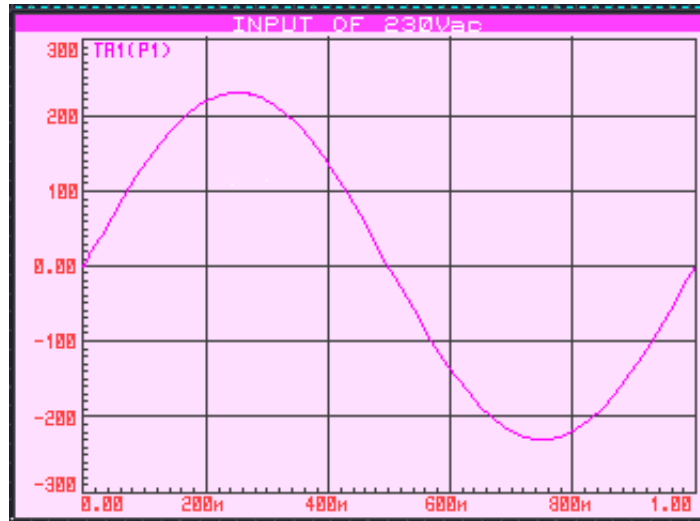


Figure 4.2 : Input of 240Vac

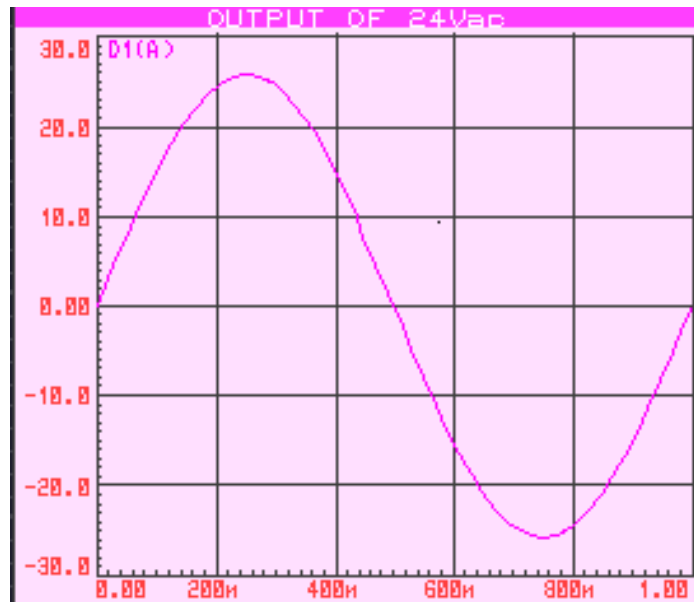


Figure 4.3 : Output of 24Vac

4.2.2 DC Power Supply Results

The simulation of DC power supply design is the most final result for software result collection. The whole circuit design of DC power supply like in Figure 4.4:

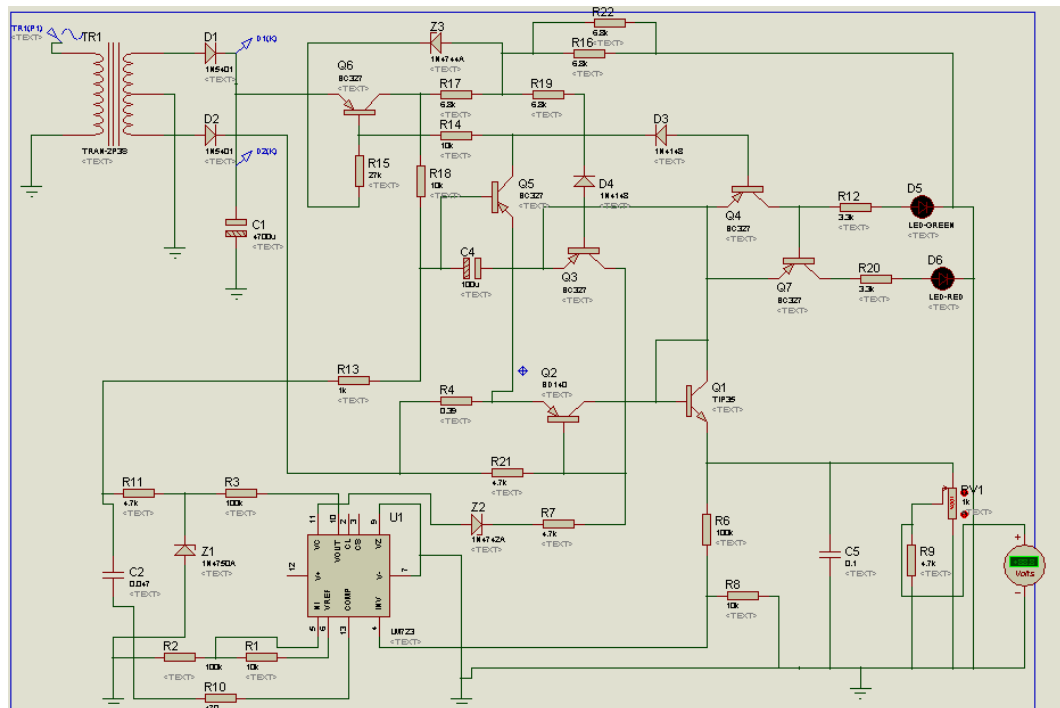


Figure 4.4 : Circuit design of Dc Power Supply in PROTEUS software

In the DC power supply design, the output value can be read and analyzed using virtual voltmeter and analogue analysis graph. First, the easy way to identify the circuit display output in PROTEUS software is using virtual voltmeter. By using voltmeter, the output is observed like in Figure 4.5:

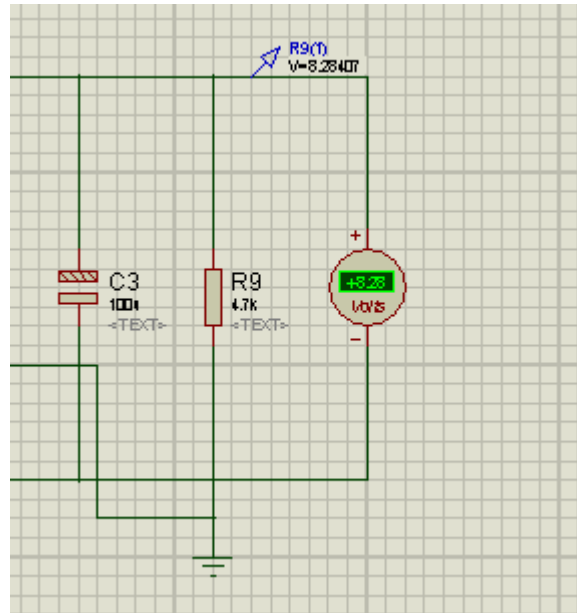


Figure 4.5 : voltmeter reading

Then, the output value is analyzed using analogue analysis graph like in Figure 4.6.

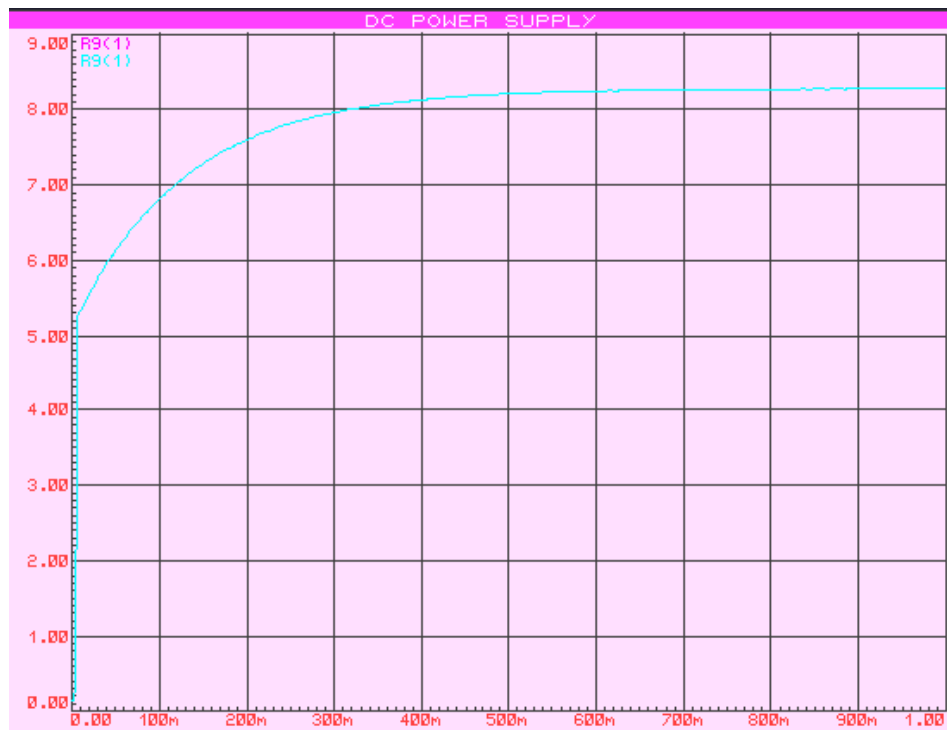


Figure 4.6 : DC power supply output

Based on the project, this DC power supply can produce regulated voltage output by adjusting potentiometer in the simulation. The table of regulated voltages is shown below:

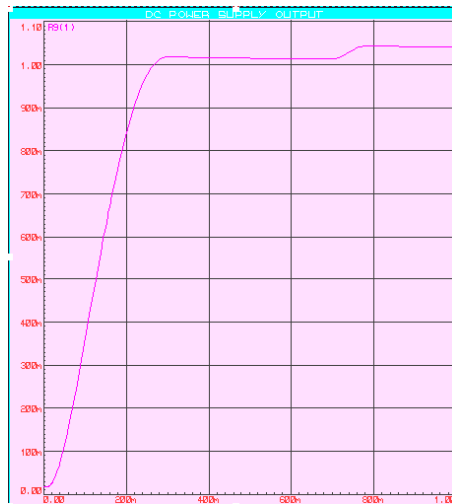


Figure 4.7 : Voltage of 1.05V

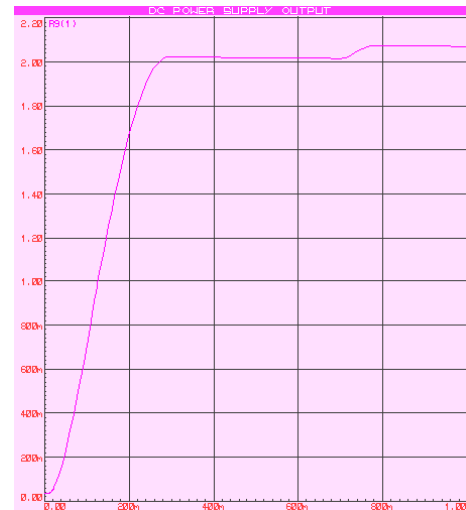


Figure 4.8 : Voltage of 2.15V

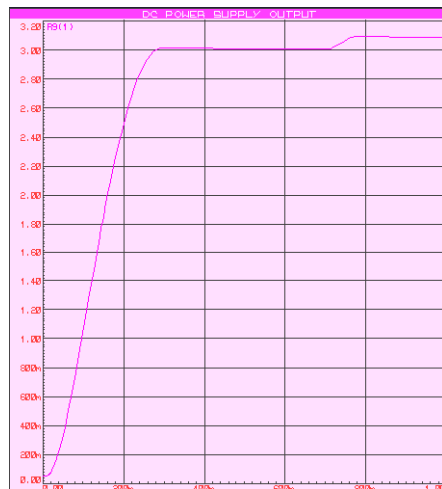


Figure 4.9 : Voltage of 3.15V

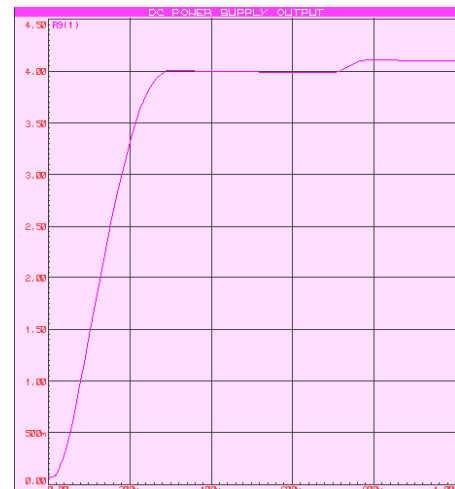


Figure 4.10: Voltage of 4.15V

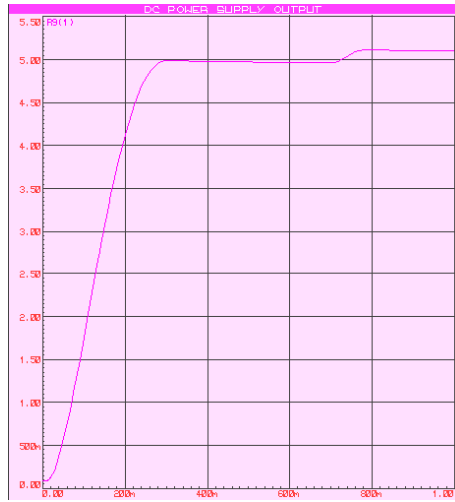


Figure 4.11 : Voltage of 5.15V

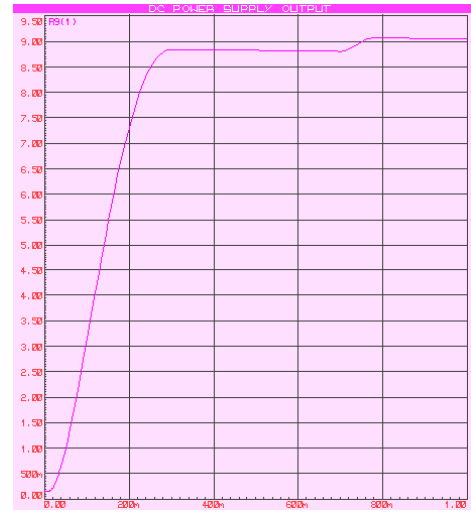


Figure 4.12 : Voltage of 9.15V

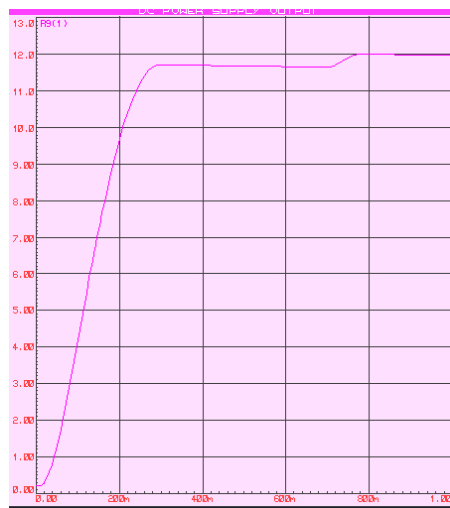


Figure 4.13 : Voltage of 12.0V

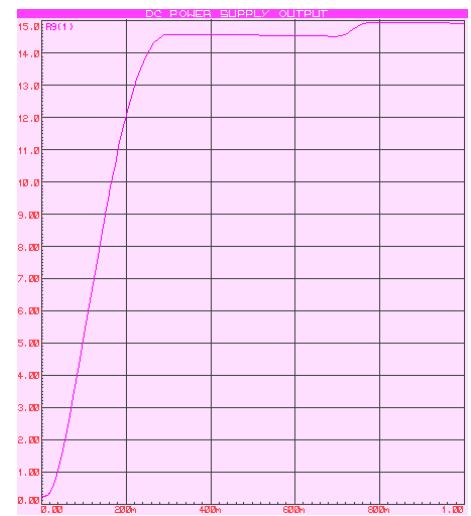


Figure 4.14 : Voltage of 15.0V

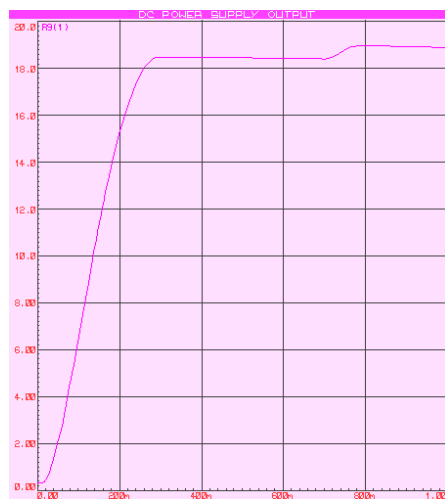


Figure 4.15 : Voltage of 19.0V

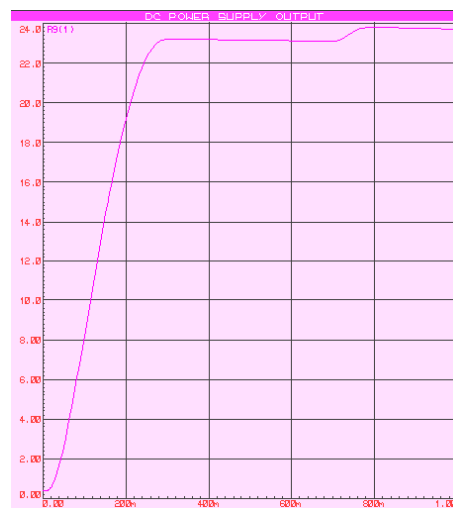


Figure 4.16 : Voltage of 24.0V

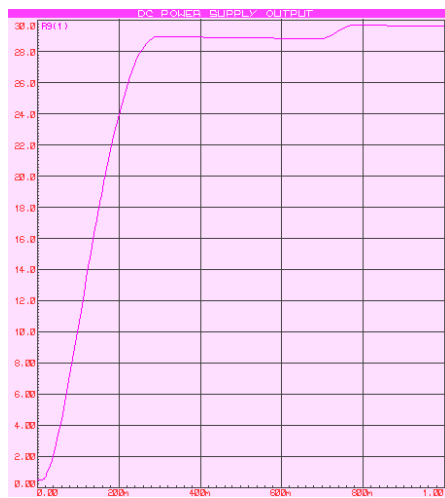


Figure 4.17 : Voltage of 30.0V

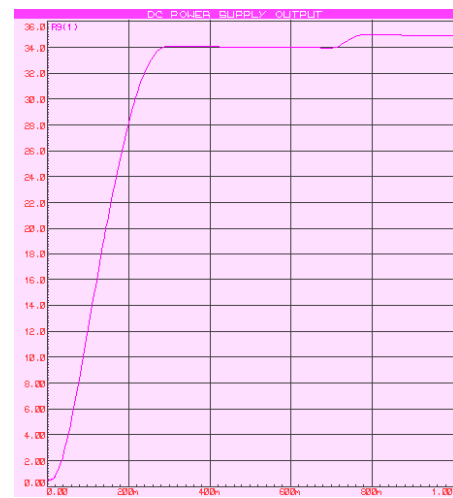


Figure 4.18 : Voltage of 35.0V

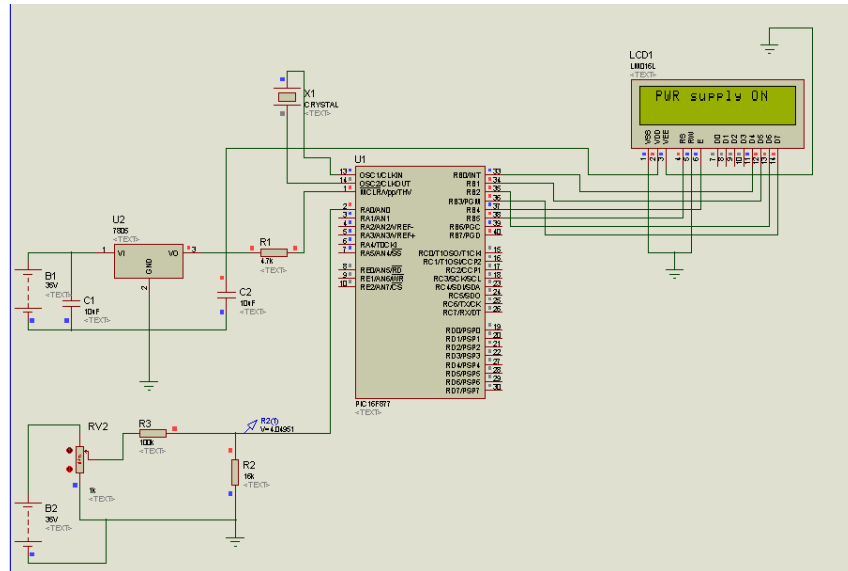


Figure 4.20 : Display power supply is on

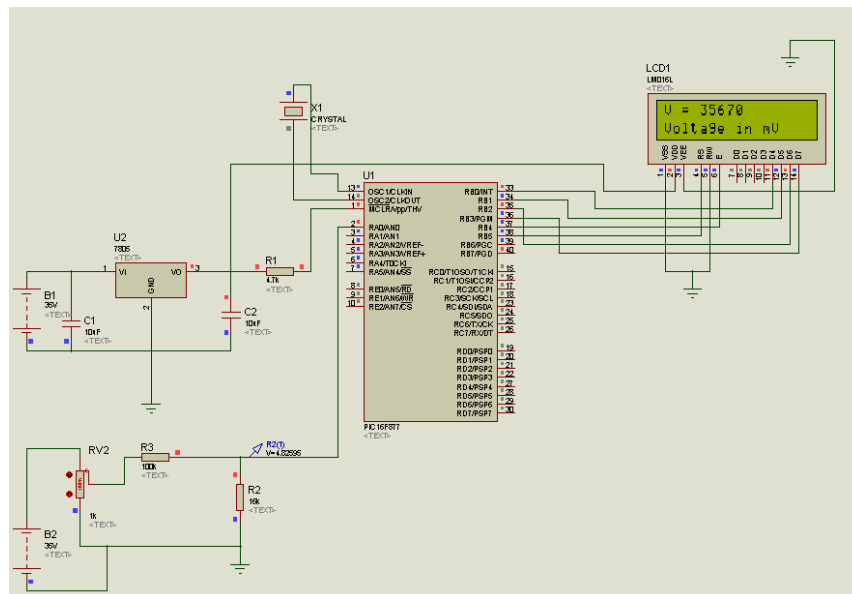


Figure 4.21 : Display maximum voltage

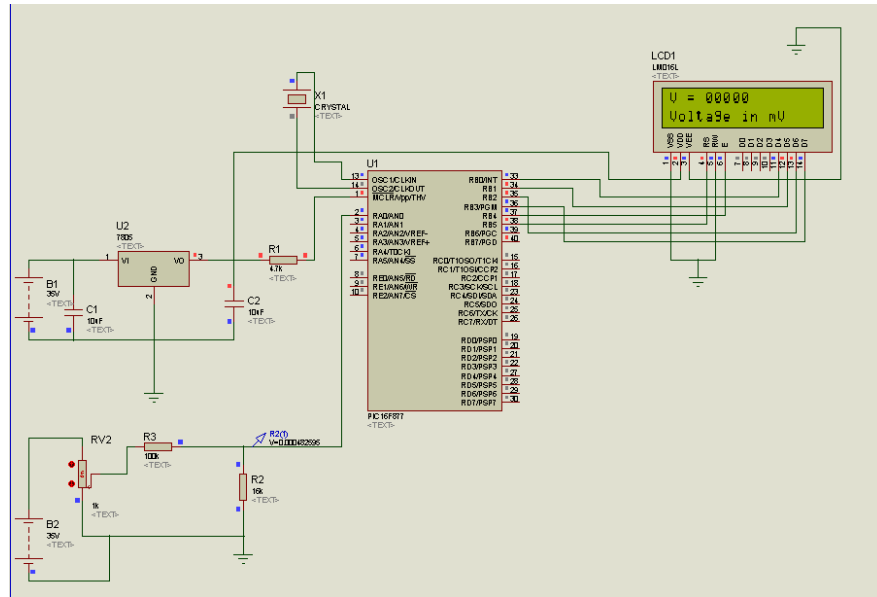


Figure 4.22 : Display minimum voltage

4.3 Hardware Results

Hardware result have included LM723 result, voltage output of DC power supply and LCD display result. The complete prototype of DC power supply is shown below:

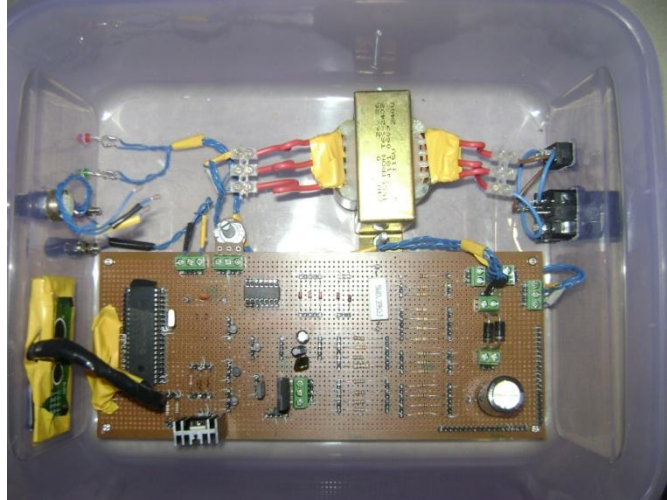


Figure 4.23: Hardware circuit of DC Power Supply

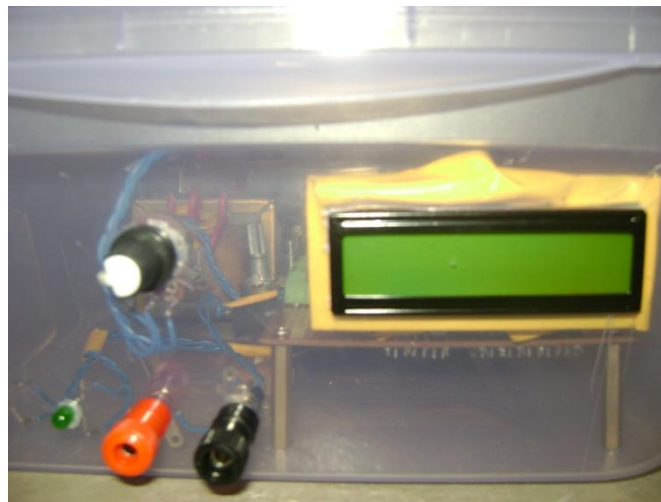


Figure 4.24: Front view of DC power supply

4.3.1 LM723 Result

The result of LM723 is in data collection. Data collection of LM723 result is in the form of voltage value for each leg of the integrated circuit. The result is shown in table below:

Table 4.1 : Data collection of LM723

LM723 leg	Value of Voltage (V)
1	0.00
2	0.00
3	0.10
4	2.46
5	6.43
6	7.08
7	0.00
8	0.01
9	9.92
10	10.12
11	8.25
12	8.20
13	0.00
14	0.01

4.3.2 Voltage Output of DC Power Supply Results

Those results of voltage output of DC power supply are obtained through data observation from oscilloscope display. According to oscilloscope observation, the result in form of graph curve and maximum voltage, V_{max} . The data observations are as below:

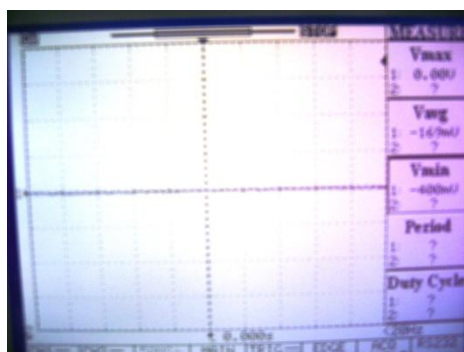


Figure 4.25: Voltage output of 0.00V

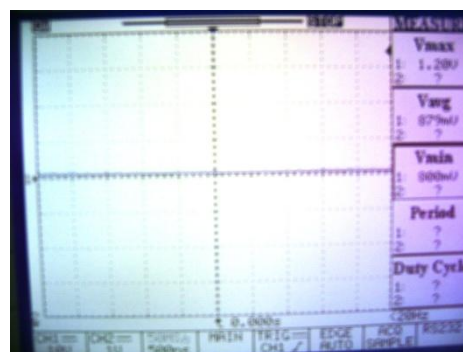


Figure 4.26: Voltage output of 1.20V

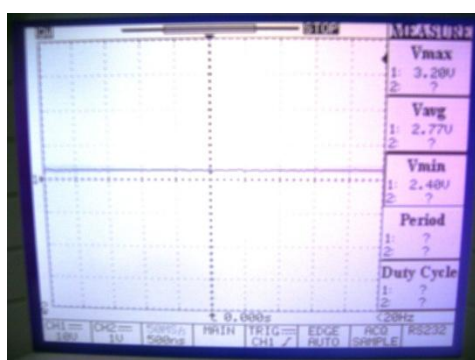


Figure 4.27: Voltage output of 3.20V

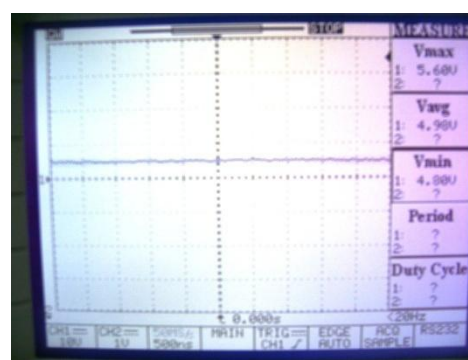


Figure 4.28: Voltage output of 5.60V

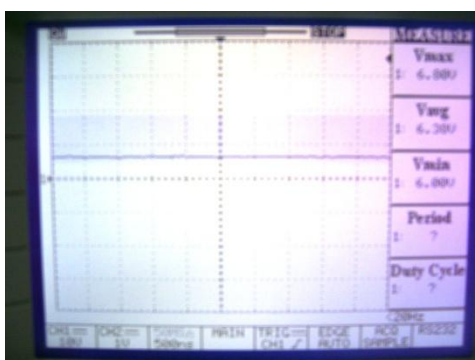


Figure 4.29: Voltage output of 6.80V

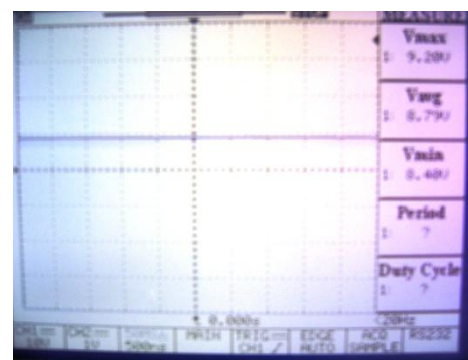


Figure 4.30: Voltage output of 9.20V

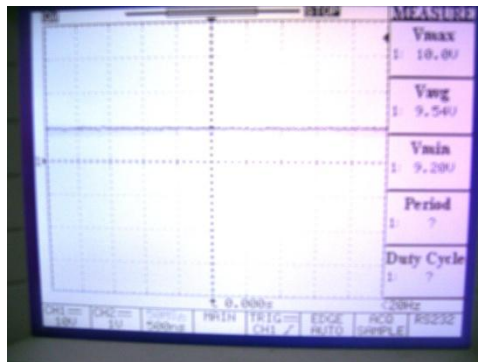


Figure 4.31: Voltage output of 10.0V

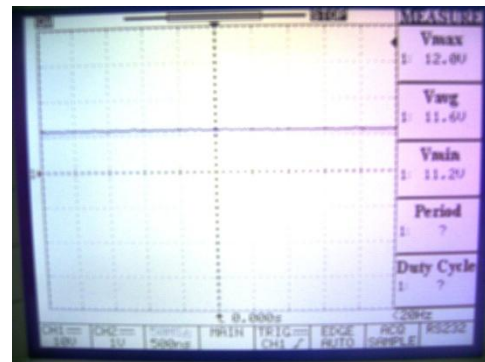


Figure 4.32: Voltage output of 12.0V

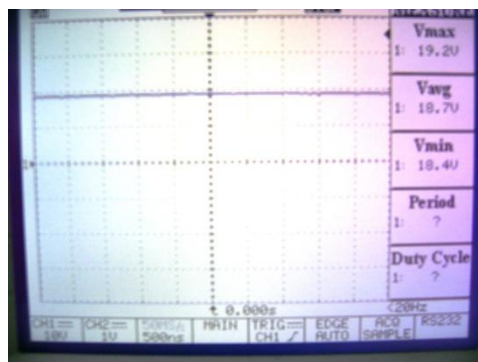


Figure 4.33: Voltage output of 19.2V

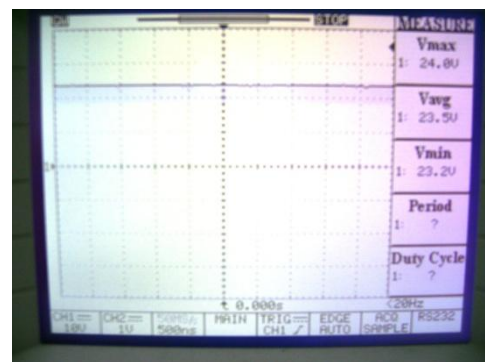


Figure 4.34: Voltage output of 24.0V

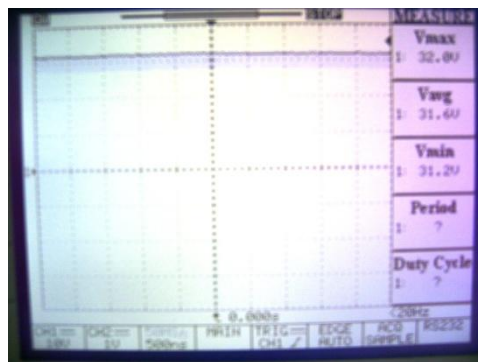


Figure 4.35: Voltage output of 32.0V

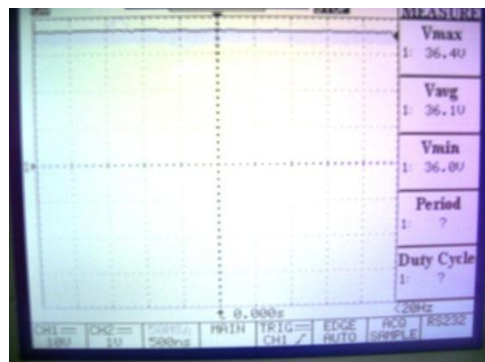


Figure 4.36: Voltage output of 36.0V

4.3.3 LCD Display Result

As the result of LCD display in simulation part, the result in hardware part should be similar also. The result of LCD display is shown below:

<p>(a)</p> <p>Figure 4.37: Display 'WELCOME'</p>	<p>(b)</p> <p>Figure 4.38: Display 'PSM 2010'</p>
<p>(c)</p> <p>Figure 4.39: Display developer</p>	<p>(d)</p> <p>Figure 4.40: Display supervisor</p>
<p>(e)</p> <p>Figure 4.41: Display DC power supply ON</p>	<p>(f)</p> <p>Figure 4.42: Display minimum voltage</p>
<p>(g)</p> <p>Figure 4.43: Display maximum voltage</p>	

4.4 Discussion

Based on the results, the observation data in simulation is nearly similar to observation data in oscilloscope. That mean, there are some significance opinion can be made. The accuracy of simulation is approaching one hundred percent before develop some hardware. The probability circuit design able to function in reality is depends on simulation in PROTEUS software. As an opinion, in development of power drive circuit, has the PROTEUS software or any related software more than enough. The reason is the functional of a circuit design can be considered from the simulation in PROTEUS software. If the circuit has programming codes, the code should be compiled in Micro Code Studio either functions or not.

During development of the circuit, there are some possibilities of in order to run the circuit design to make it functions. The problems that always occur such as voltage output not similar to simulation result, any load unable to run like DC motor cannot rotates and light emitting diode (LED) not blinking and other problem that always disturb progress of any project. Actually, this problem can be solved by refer the circuit design in simulation. Based on the observation during doing the final year project, most problems is caused by wrong connection in circuit design or in the other words the circuit not follows specifications that included in the simulation. As a solution, any person should re-troubleshoot the circuit design and compare to the circuit connection in simulation. Consequently, there will find out more answer that causes the problem

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As a conclusion, the circuit of DC power supply in this project has been fully developed either simulation or hardware circuit completely. The DC power supply able to produce DC voltage output within 0V to 35V. According to the output are obtained, those scope of the project has been covered up. In the other words, the project of development of DC power supply fully successful.

In the simulation part, there are two parts have been developed which are circuit design of DC power supply and voltmeter circuit. There need to simulate both circuits using PROTEUS software. First, the circuit of DC power supply has been developed stage by stage. There are five stages need to go through in order to

complete the circuit development. After that, the whole circuit has been simulated and successful running based on the scope of project. Then, the circuit of voltmeter is developed by interfacing the DC power supply circuit with LCD using PIC16F877 microcontroller. PIC16F877 have been programmed with voltmeter programming HEX file. As a result, the LCD can display alphanumeric characters and values of voltage output.

Finally, in the hardware part, the prototype of DC power supply need to be developed based on the simulation in PROTEUS software. Usually, the hardware circuit able to run if the simulation of DC power supply circuit and voltmeter successful running.

5.2 Future Recommendations

In this project, the development of DC power supply is able to run successfully and produce regulated DC voltage output. The output of the DC power supply can be adjusted from 0Vdc to approaching 35Vdc. Nevertheless, this DC power supply has a few weaknesses compared to any available DC power supply. Among them are the current at output unable to be adjusted and no cooling system. Hence, there have some suggestions in order to improve the performance of the DC power supply. Among them are:

1. Develop a drive circuit that can increase the current at output without affected the regulated voltage output.
2. Interface the circuit with temperature sensor and motor fan for cooling system using PIC16F877.

5.3 Costing and Commercialization

5.3.1 Costing

In familiar, most of the project that involves development of hardware is more cost especially in purchasing any related components. The costing of the project is listing in table below:

Table 5.1: Costing of Project

Devices/ Components	Rating Of Components	Manufacturer	Perunit Cost (RM)	Quantity	Costs (RM)
Resistor	10k Ω		0.10	4	0.40
	100k Ω		0.10	3	0.30
	0.39 Ω		0.50	1	0.50
	47 Ω		0.10	1	0.10
	4.7k Ω		0.10	4	0.40
	470 Ω		0.10	1	0.10
	3.3k Ω		0.10	2	0.20
	1k Ω		0.10	1	0.10
	27k Ω		0.10	1	0.10
	6.8k Ω		0.10	4	0.40
Capacitor	4700uF		0.30	1	0.30
	0.047F		0.30	1	0.30
	100uF		0.30	1	0.30
	3.3uF		0.30	1	0.30

Light Emitting Diode (LED)	Green		0.30	1	0.30
	Red		0.30	1	0.30
Potentiometer	5k		2.50	1	2.50
Voltage Regulator	LM723		3.50	1	3.50
NPN transistor	TIP35		2.50	1	2.50
PNP transistor	BD140		1.50	1	1.50
	BC327		0.60	5	3.00
Diode	1N5401		0.60	2	1.20
	1N4148		0.60	2	1.20
Zener Diode	27V (1/4W)		0.50	1	0.50
	12V (1/4W)		0.50	1	0.50
	15V (1/4W)		0.50	1	0.50
Socket			10.00	1	10.00
Connector			1.00	1	1.00
PIC16F877	microcontroller	Microchip	40.00	1	40.00
LCD			120.00	1	120.00
Sticker tape	Black		1.00	1	1.00
	Yellow		1.00	1	1.00
Binding post			1.50	2	3.00
PCB stand			1.20	4	4.80
Cable Auto			1.20	1	1.20
Power cord			13.00	1	13.00
Screw & Nut			2.00	1	2.00
LAVA container			9.00	1	9.00
				TOTAL	221.30

5.3.1 Commercialization

Based on the table costing table, the total cost of the project is RM 221.30. In the market, most of cost of available DC power supply in range within RM 198.50 to RM 601.90 according the price in Farnel Newark. That means, the cost of the project is reasonable when compare to available DC power supply. The cost of the project can be minimized by reduce cost in purchasing component especially make choice in purchasing LCD and PIC16F877. In the other words, the supplier that put the cheapest one should be chose without ignore the quality of LCD and PIC16F877.

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APPENDIX A
Datasheet of PIC16F877



PIC16F87X

28/40-Pin 8-Bit CMOS FLASH Microcontrollers

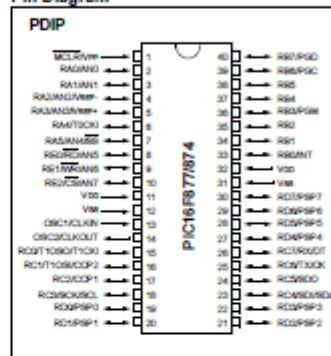
Devices Included In this Data Sheet:

- PIC16F873 • PIC16F876
- PIC16F874 • PIC16F877

Microcontroller Core Features:

- High performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input
DC - 200 ns instruction cycle
- Up to 8K x 14 words of FLASH Program Memory,
Up to 368 x 8 bytes of Data Memory (RAM)
Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to the PIC16C73B/74B/75/77
- Interrupt capability (up to 14 sources)
- Eight level deep hardware stack
- Direct, indirect and relative addressing modes
- Power-on Reset (POR)
- Power-up Timer (PWRT) and
Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC
oscillator for reliable operation
- Programmable code protection
- Power saving SLEEP mode
- Selectable oscillator options
- Low power, high speed CMOS FLASH/EEPROM
technology
- Fully static design
- In-Circuit Serial Programming™ (ICSP) via two
pins
- Single 5V In-Circuit Serial Programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.0V to 5.5V
- High Sink/Source Current: 25 mA
- Commercial, Industrial and Extended temperature
ranges
- Low-power consumption:
 - < 0.6 mA typical @ 3V, 4 MHz
 - 20 µA typical @ 3V, 32 KHz
 - < 1 µA typical standby current

Pin Diagram

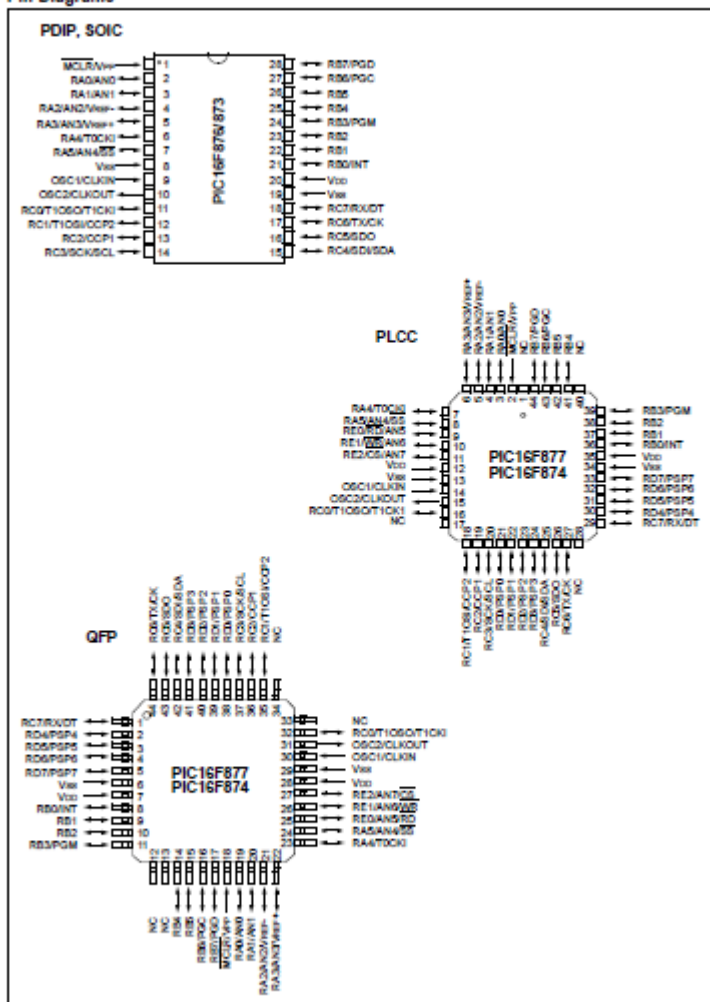


Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler,
can be incremented during SLEEP via external
crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period
register, prescaler and postscaler
- Two Capture, Compare, PWM modules
 - Capture is 16-bit, max. resolution is 12.5 ns
 - Compare is 16-bit, max. resolution is 200 ns
 - PWM max. resolution is 10-bit
- 10-bit multi-channel Analog-to-Digital converter
- Synchronous Serial Port (SSP) with SPI™ (Master
mode) and I²C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver
Transmitter (USART/SCI) with 9-bit address
detection
- Parallel Slave Port (PSP) 8-bits wide, with
external RD, WR and CS controls (40/44-pin only)
- Brown-out detection circuitry for
Brown-out Reset (BOR)

PIC16F87X

Pin Diagrams



PIC16F87X

Key Features PICmicro™ Mid-Range Reference Manual (DS3023)	PIC16F873	PIC16F874	PIC16F876	PIC16F877
Operating Frequency	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz
RESETS (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
FLASH Program Memory (14-bit words)	4K	4K	8K	8K
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory	128	128	256	256
Interrupts	13	14	13	14
I/O Ports	Ports A,B,C	Ports A,B,C,D,E	Ports A,B,C	Ports A,B,C,D,E
Timers	3	3	3	3
Capture/Compare/PWM Modules	2	2	2	2
Serial Communications	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Communications	—	PSP	—	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels	5 input channels	8 input channels
Instruction Set	35 Instructions	35 Instructions	35 Instructions	35 Instructions