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JUDUL: **BATTERY LEVEL MONITORING SYSTEM**

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BATTERY LEVEL MONITORING SYSTEM

AIESYAH BINTI GHAZALI

Submitted to the Faculty of Electrical and Electronic Engineering
In partial fulfillment of the requirement of the degree of
Bachelor in Electrical Engineering (Power System)

Faculty of Electrical and Electronic Engineering
Universiti Malaysia Pahang

JUNE 2012

"I declare that this work as the product of my own effort with the exception of excerpts cited from other works of which the sources were duly noted"

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Dedicated, in thankful appreciation for supporting, encouraging, and understanding of my beloved mother, father and friends.

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ABSTRAK

Tujuan sistem pemantauan bateri adalah untuk mengukur dan memantau bateri yang boleh dicas semula. Nilai yang akan dipantau adalah voltan bateri.Nilai voltan yang dipaparkan dapat memberitahu masa yang tinggal sebelum bateri kehabisan cas atau dalam keadaan yang tidak baik. LCD akan digunakan untuk memapaparkan nilai voltan. Untuk projek ini litar pengecas bateri 12 V bateri asid plumbum dibina. Pemantauan mengecas dan menyahcas bateri dan juga nilai voltan bateri akan dipaparkan pada paparan LCD. Ia terdiri daripada tiga bahagian iaitu litar pengecasan, litar kawalan dan litar pemantauan untuk paparan LCD. Pengecas bateri dapat mengecas bateri asid plumbum dan mampu untuk melindungi bateri dari terlebih cas. Selain itu, ia juga akan menunjukkan nilai voltan bateri. Otak sistem adalah PIC16F876A. Segala proses dalam system ini diuruskan oleh PIC16F876A, ianya adalah termasuk data yang perlu dipaparkan pada skrin LCD. Arahan diberikan dengan menggunakan butang dari pilihan menu pada paparan LCD. Selain daripada itu system ini juga mempunyai masa kaunter untuk menghentikan pengecasan dari terlebih cas bateri untuk mengelakan bateri rosak dengan cepat.

ABSTRACT

The purpose of battery level monitoring system is to measure and monitors the fundamentals parameter of a rechargeable battery. The parameters that will be measured and monitored are the output voltage of the battery. The output voltage is used in the real-time calculation of the remaining time before the rechargeable battery is exhausted and in case of malfunction. The LCD will be used as the voltage output display. For this project a battery charger circuit for 12 V sealed lead acid battery is develop. The monitoring of charging and discharging state of the battery and also the battery voltage value is displayed by using LCD. It is consist of three basic part that is the charging circuit, controller circuit and the monitoring circuit. The battery charger is able to charge a sealed lead acid battery and able to protect the battery from overcharge. Besides that, it also will show the battery voltage value. The brain of the system is a PIC16F876A, the microcontroller. The processes are managed by this microcontroller, that is including the data need to be displayed on the LCD screen. The instructions are given by using push buttons from a menu option. There is also a timing counter to stop the charging from been overcharge the battery to prevent damage to the battery.

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LIST OF SYMBOLS

DC	-	Direct Current
AC	-	Alternating Current
MOSFET	-	Metal Oxide semiconductor field effect transistor
PIC	-	Peripheral interface controller
LCD	-	Liquid Crystal Display
Pb	-	Lead
PbO_2	-	Lead Oxide
H_2SO_4	-	Sulphuric Acid
$PbSO_4$	-	Lead sulphate
H_2O	-	Water
H^+	-	Hydrogen
UPS	-	Uninterruptable Power Supply
SOC	-	State of Charge
Hz	-	Hertz
Ah	-	Ampere Hour
ADC	-	Analogue to Digital Converter
SLA	-	Sealed Lead Acid
LED	-	Light Emitting Diode

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CHAPTER 1

INTRODUCTION

1.1 Background

The secondary battery or rechargeable batteries are like the primary battery, the powers are produced from chemical energy to electrical energy. The difference is that the rechargeable battery can forced to the other way by externally supplied electrical energy to chemical energy [1]. The battery is one of the most important sources and stored energy for electrical equipment. In electrical applications, including uses in automobiles, boats and electric vehicles the rechargeable batteries are increasingly becoming an important source of clean portable power in a wide variety. Rather than disposal batteries the rechargeable batteries have lower total cost of use and environmental impact. They may have a higher initial cost, but can be recharged very cheaply and used many times. There are many methods for charging the batteries depending on their chemical composition, capacity, and methods of the construction and the type of the exploitation [2].

There are many batteries charging techniques that include state-of-charge (SOC) estimations, optimization of charging control reduction of charging time, and series-connected method. Battery life time is reduced by charging and discharging cycles; this process degrades the chemical composition of the battery. The sulphation and stratification in an undercharged battery will affect the battery by shortening the lifetime of the battery. Gassing and water loss are caused by overcharging. The differences in cell chemistry, and normal differences during repeated cycles of cell charge discharge, will lead to a large non-uniformity in cell charge levels and correspondingly different cell terminal voltages. Battery life is one of major factors presently limiting the realization of economical applications [3]. Temperature is one of the variables that have a great influence over battery electrical characteristics. A battery is a very complex non-linear system that needs to be effectively monitored along its whole lifetime. The battery parameters that can be monitored can be based on current, voltage and temperature measurement [4].

1.2 Objective

The main objectives of this project are to design the charging circuit for the 12V sealed lead acid battery. The charging and discharging state of the battery and the battery voltage value are monitored.

1.3 Project Scope

To achieve the objectives of the project, several scopes had to be outlined. The scope of this project includes developing the charging circuit for the 12V Sealed Lead Acid battery. Then used an LCD screen to monitor the state of charge of the battery and the voltage value during the charging and discharging of the battery.

1.4 Problem Statement

The charging and discharging state of the battery is important to know how long the remaining time to operate the machine or load. The battery charging state does not show the voltage value during charging and discharging in the industries, this will cause of overcharging that will damage the battery [5].

1.5 Thesis Outline

This thesis consists of 5 chapters, where the first chapter is the introduction of the project. It discussed the overview and the objectives of the project. Meanwhile, chapter 2 will discuss more about the theory and the literature review for the project. It discussed about the theory of the Sealed Lead Acid battery, the methods to control the charging of the battery, and the state of charge.

CHAPTER 2

THEORY AND LITERATURE REVIEW

2.1 Introduction

The literature review is proposed to get the information that related to the project that will be developed. In this literature review, it will focus on the selection of the components and the methodology purpose that will be used for developing the circuit. A specific literature review is very important before developing a project.

2.2 Battery

Harry Morse wrote in Storage Batteries (1912), “Into our present age of power, where we reckon by thousands and tens of thousands of kilowatts, there has come down from a previous era one single from of the galvanic cell which retains sufficient commercial importance to be worth consideration in connection with modern power plant and modern power operations. This is the lead-sulphuric acid accumulator.”

The first application of lead acid battery is used in transportation. It is the most popular rechargeable battery system. Lead acid batteries have manufactured hundreds of millions each year for diverse use, including electric vehicles like golf carts and electric wheelchairs, and stationary power such as emergency light and uninterruptable power supplies (UPS) [1].

The negative electrode, lead (Pb), lead oxide (PbO2) the positive electrode and the electrolyte, sulphuric acid (H2SO4) are the chemicals in the lead acid battery. During discharge, both plates return to lead sulphate. The process is driven by the conduction of electrons from the positive plate back into the cell at the negative plate.

Negative plate reaction: Pb(s) +HSO-4 (a) → $PbSO_4$ (s) +2e$^-$
Positive plate reaction: PbO_2(s) +HSO-4(aq) +3H$^+$ (aq) +2e$^-$ → $PbSO_4$(s) +2H_2O (l)

Subsequent charging places the battery back in its charged state, changing the lead sulphates into lead and lead oxides. The process is driven by the forcible removal of electrons from the negative plate and the forcible introduction of them to the positive plate.

Negative plate reaction: $PbSO_4$ (s) +H$^+$ (aq) +2e$^-$ → Pb(s) + HSO−4 (aq)
Positive plate reaction: $PbSO_4$ (s) +2H_2O (l) →PbO_2 (s) +HSO−4 (aq) +3H$^+$ (aq) +2e$^-$

The characteristic of the lead acid battery is in Table 2.1.

Table 2.1: Characteristics of Lead Acid battery [6].

Gravimetric Energy Density	Internal Resistance	Cycle Life	Fast Charge	Overcharge time	Self-discharge /month	Cell voltage (Nominal)	Load current	Operating Temperature
30-50 (Wh /kg)	<100[1] 12V pack	200 to 300[2]	8–16 h	High	5%	2V	5C[7]	-20 to 60°C

Every rechargeable battery has its own advantage and disadvantages. The advantage and disadvantage for lead acid battery can be seen in the Table 2.2.

Table 2.2: Advantages and limitations of lead acid batteries [6].

Advantages	Limitations
Low self-discharge rate	Cannot be stored in a discharged condition.
Mature, reliable and well-understood technology	Poor energy to density limits use to stationary and wheeled application
Inexpensive and simple to manufacture in terms of cost per watt hours	Allows only a limited number of full discharge cycles
Low maintenance requirements – no memory; no electrolyte to fill	The electrolyte and the lead content can cause environmental damage
Capable of high discharge rates.	Thermal runaway can occur with improper charging

2.3 Microcontroller

PIC microcontrollers are popular processors can be used for many applications. It is developed by Microchip Technology with built-in RAM, memory, internal bus, and peripherals. PIC stood for “Programmable Intelligent Computer” but is now generally called as a “Peripheral Interface Controller” [7]. PIC microcontrollers in the PIC16 and PIC18 families are considered mid-level microcontrollers; it can run up to 20MHz with 2.5 to 6.0 colts input [7, 8]. It can be programmed in Assembly, C or a combination of the two. Other high-level programming languages can be used but embedded systems software is primarily written in C [7].

2.3.1 Origins

The original PIC was built to be used with GI's new 16-bit CPU, the CP1600.While generally a good CPU, the CP1600 had poor I/O performance, and the 8-bit PIC was developed in 1975 to improve performance of the overall system by offloading I/O tasks from the CPU.

The PIC used simple microcode stored in ROM to perform its tasks, and although the term wasn't used at the time, it is a RISC design that runs one instruction per cycle (4 oscillator cycles).

In 1985 General Instruments spun off their microelectronics division, and the new ownership cancelled almost everything — which by this time was mostly out-of-date. The PIC, however, was upgraded with EPROM to produce a programmable channel controller, and today a huge variety of PICs are available with various on-board peripherals (serial communication modules, UARTs, motor control kernels, etc.) and program memory from 512 words to 32k words and more [9].

2.3.2 PIC Memory organization

A PIC Microcontroller chip combines the function of microprocessor, ROM program memory, some RAM memory and input-output interface in one single package which is economical and easy to use. The PIC – Logicator system is designed to be used to program a range of 8,18, 28 pin programmable PIC microcontroller which provides a variety of input –output, digital input and analogue input options to suit students' project uses [9].

Programmable “FLASH Memory” chips have been selected as the most economical for student use. If a student needs to amend to control system as the project is evaluated and developed, the chip can simply be taken out of the product and reprogrammed with an edited version of the floe sheet. The PIC devices generally feature is sleep mode (power saving), watchdog timer and various crystal or RC oscillator configuration, or an external clock. [9]

2.4 Battery Charging Control Methods

There are many types of battery charging techniques that include constant current, constant voltage, Two-step, Pulse charging, and Reflex™ charging [3]. However, not all charging method can be successfully used for every kind of battery [1].

2.4.1 Constant Voltage Charging

Constant voltage charging is easily implemented and controls. At the initial stage of charging the large charging currents need to be limited to protect the devices. The charging will hold when the battery voltage reaches the default value charging voltage and the charging current will decrease with time. The temperature will rise because of the charging, and this will cause the degradation of the battery life [3]. The battery charging characteristic for the constant voltage charging is shown in the Figure 2.1.

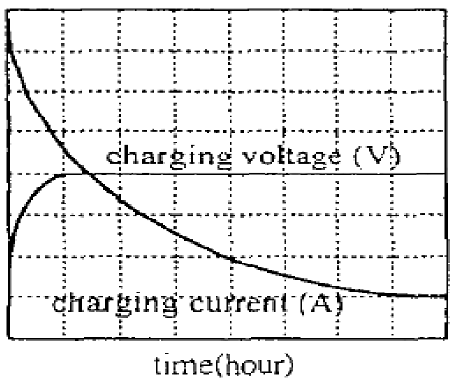


Figure 2.1: Constant voltage charging curves for batteries [3].

2.4.2 Constant Current Charging

The simple charging method, the constant current charging use currents to charge the battery and the charging currents for the series connected batteries are equal. However, overcharging the battery will result in the degradation of the battery life. Small charging current will prolong the charging time. The charging curve for constant current charging is shown in Figure 2.2 [3].

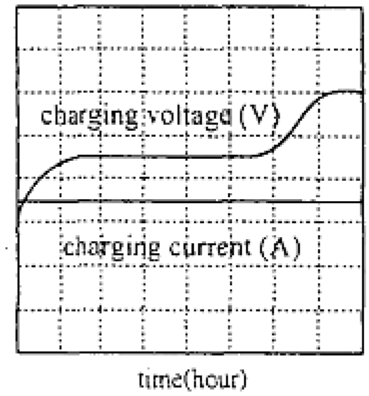


Figure 2.2: Constant current charging curves for batteries [3].

2.4.3 Two-step Charging

For the two-step charging method, it is the combination of the constant current and constant voltage charging. At the first stage of charging, the batteries are charged by a constant current until the battery voltage reaches a pre-set voltage. In the second stage, a constant voltage is applied for battery charging. The curve for the two-step charging is shown in Figure 2.3 [3].

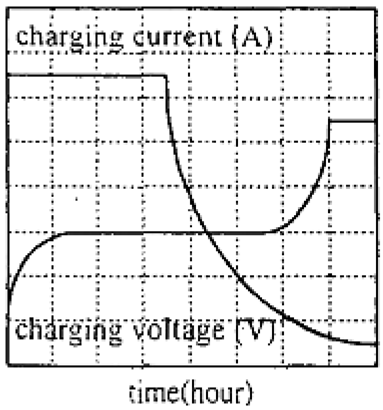


Figure 2.3: Two-step charging curves for batteries [3].

2.5 State Of Charge (SOC) Monitoring

Battery SOC is very important information to make sure that the user knows the remaining energy. The battery monitoring procedures to compute battery SOC is not something new, but until now, we are far away from the final solution. There are three different SOC monitoring methods are evaluated and compared. They are based on Ah (Ampere hours) counter, open circuit voltage and artificial neural network. The first one is very effective for constant current discharge but, it is very sensible to error when several charge/discharge is executed in a row. The open circuit voltage can be effectively adopted when the open circuit voltage, after battery resting period, is not a problem. The third method is based on using an artificial neural network. It is well known that an artificial neural network can be very effective when data for its training are reliable. Assuming that Ah counter and open circuit voltages are easily formulated, but more details will be provided only by using the third method [4]. The state of charge of the battery is conventionally monitored by means of voltage measurement or integrating the current, both the methods introduce by a certain approximation [10].

State of charge of the battery is the amount of available energy expressed in percentage of the rated energy. The variation in the battery voltage from charged to discharged state is very small. Hence the state of charge of battery can be defined as the available capacity (AHr) expressed as the percentage of the rated capacity (AHr) [11].

$$SOC \ = \left(\frac{Avaiable\ Capacity\ (AHr)}{Rated\ Capacity\ (AHr)}\right) \times 100$$

2.6 PIC Simulator IDE

PIC Simulator IDE is powerful application that supplies PIC developers with user-friendly graphical development environment for Windows with integrated simulator (emulator), Basic compiler, assembler, disassembler and debugger. PIC

Simulator IDE currently supports the microcontrollers from the Microchip PIC micro 12F and 16F product lines.

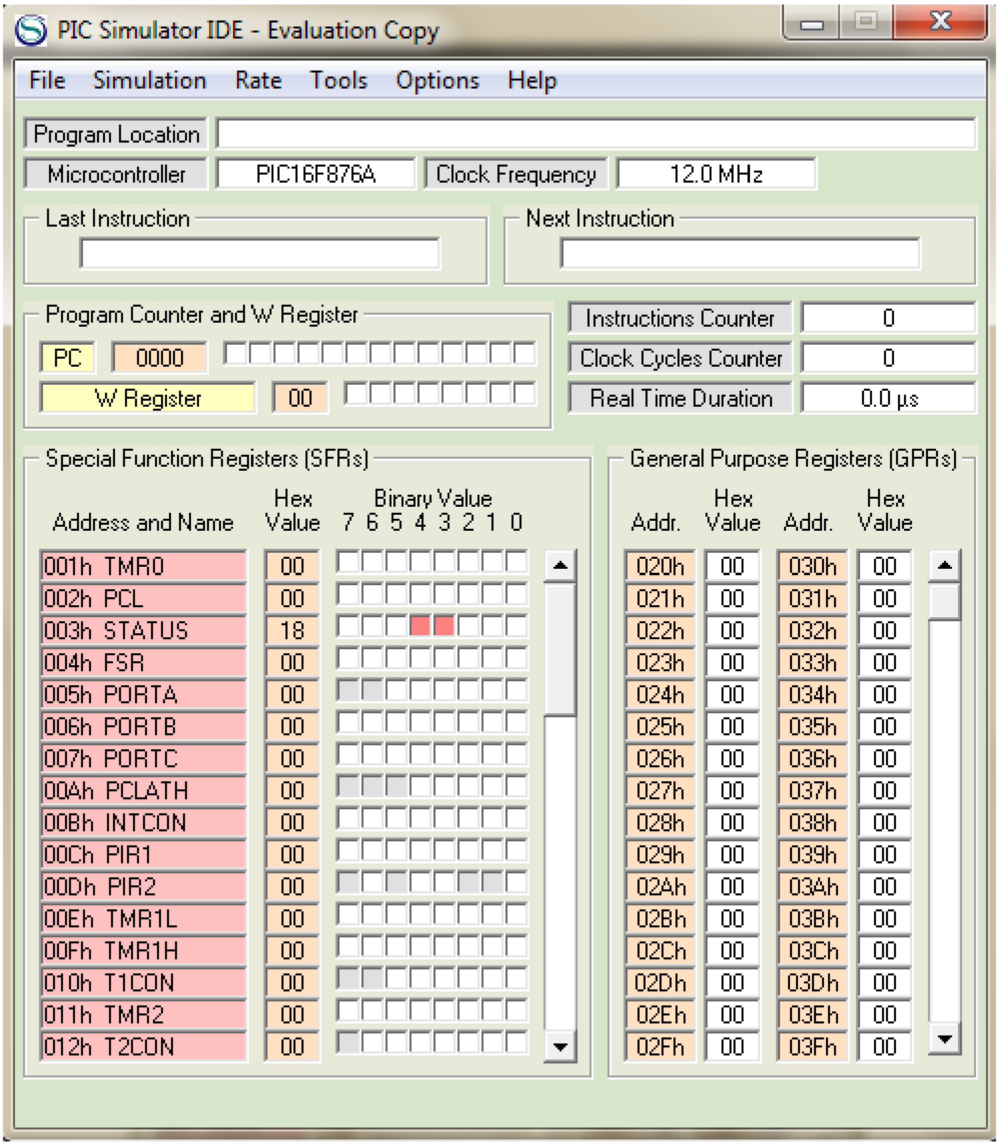


Figure 2.4: PIC Simulator IDE.

2.6.1 PIC Simulator IDE main features

The PIC Simulator IDE main features are the simulation interface shows the internal architecture of microcontroller. The FLASH program memory editor, EEPROM data memory editor, and hardware stack viewer also available in the PIC Simulator IDE. There is also microcontroller pin out interface for simulation of digital I/O and analogue inputs. It also has a variable simulation rate and simulation statistic. Besides that, there is also breakpoints manager for code debugging with breakpoints support. Other than that, there are also PIC assembler, interactive assembler editor for beginners and PIC disassembler. It also features a powerful PIC Basic compiler with smart Basic source editor.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This project consists of hardware and software development. The software is the programming for the hardware. The hardware is developing the circuit operations that consist of charging, and monitoring the battery levels. The controller for this project is the microcontroller as the central processing unit for the charging and displaying the battery level on the LCD screen. Figure 3.1 below is the block diagram for this system.

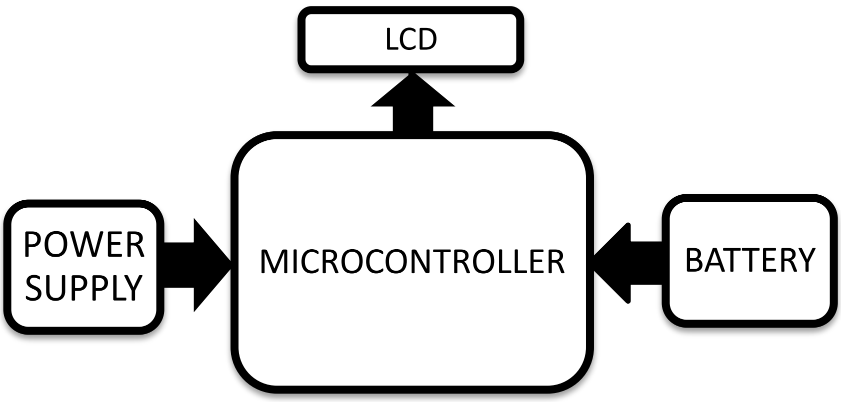


Figure 3.1: Battery Level Monitoring System Block Diagram.

From Figure 3.1 above, this project consists of microcontroller, battery and LCD screen as the main components. The microcontroller is the central processing unit that will display the state of charge and voltage value of the battery, when the battery is charged and discharge.

3.2 Hardware Implementation

This section will discuss about components that had been used including 12 V Sealed Lead Acid battery, DC Power Supply, microcontroller PIC 16F877A, Analogue to Digital Converter (ADC), Voltage Regulator, Mosfet, and 16x2 Alphanumeric LCD Modules.

3.2.1 Sealed Lead Acid Battery

The battery used for this project is a 12 Volt 12 Ah Sealed lead acid battery. Figure 3.2 below shows the picture of the battery. Table 3.1 is the specification of the battery.

Figure 3.2: 12 Volt 12 Ah Sealed Lead Acid Battery.

Table 3.1: The Sealed Lead Acid Battery specifications.

Specifications:	
BM Part #:	SLA-12V12
Voltage:	12 Volt
Capacity:	12 Ah
Type:	Sealed Lead Acid Battery
Warranty:	1 Years
Shipping Weight:	10.00 Pounds
Length:	5.95"
Width:	3.91"
Height:	3.71"

3.2.2 DC Power Supply

The DC power supply is an AC powered unregulated power supply usually uses a transformer to convert the voltage from the mains to DC power supply with variable and lower voltage. It used a rectifier to convert alternating voltage to a pulsating direct voltage, followed by a filter, comprising one or more capacitors, resistors, and sometimes inductors, to filter out (smooth) most of the pulsation

Figure 3.3: DC Power Supply.

3.2.3 Voltage Regulator LM317 and LM7805

LM7805 is a voltage regulator integrated circuit. Member of 78xx series is a fixed linear voltage regulator ICs. The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. The voltage regulator IC maintains the output voltage at a constant value. 7805 is designed to provide +5V regulated power supply. Capacitors of suitable values can be connected at the input and output pins depending upon the respective voltage levels.

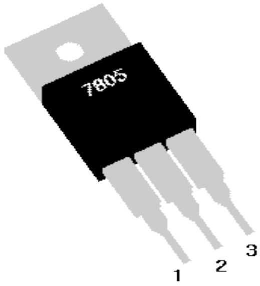


Figure 3.4: Voltage Regulator LM7805.

A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. LM317 is a type of Adjustable voltage regulator that also available in circuit configurations that allow the user to set the output voltage to a desired regulated value.

The regulated output voltage is given by:

$$V_{out} = V_{ref}\left(1 + \frac{R2}{R1}\right) + I_{Adj}R2$$

Since I_{adj} is controlled less than 100µA the error associated with this term is negligible in most applications. Thus:

$$V_{out} = V_{ref}\left(1 + \frac{R2}{R1}\right)$$

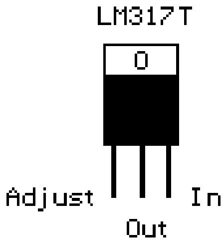


Figure 3.5: Voltage Regulator LM317.

3.2.4 Microcontroller

PIC16F876A devices are available in 28-pin packages. All devices in the PIC16F87XA family share common architectures. It has 5 ports for I/O ports, 15 interrupts, 8 ports of 10-bit A/D input channels and a Parallel Slave Port. The Figure 3.6 shows the pin diagram for PIC16F876A.

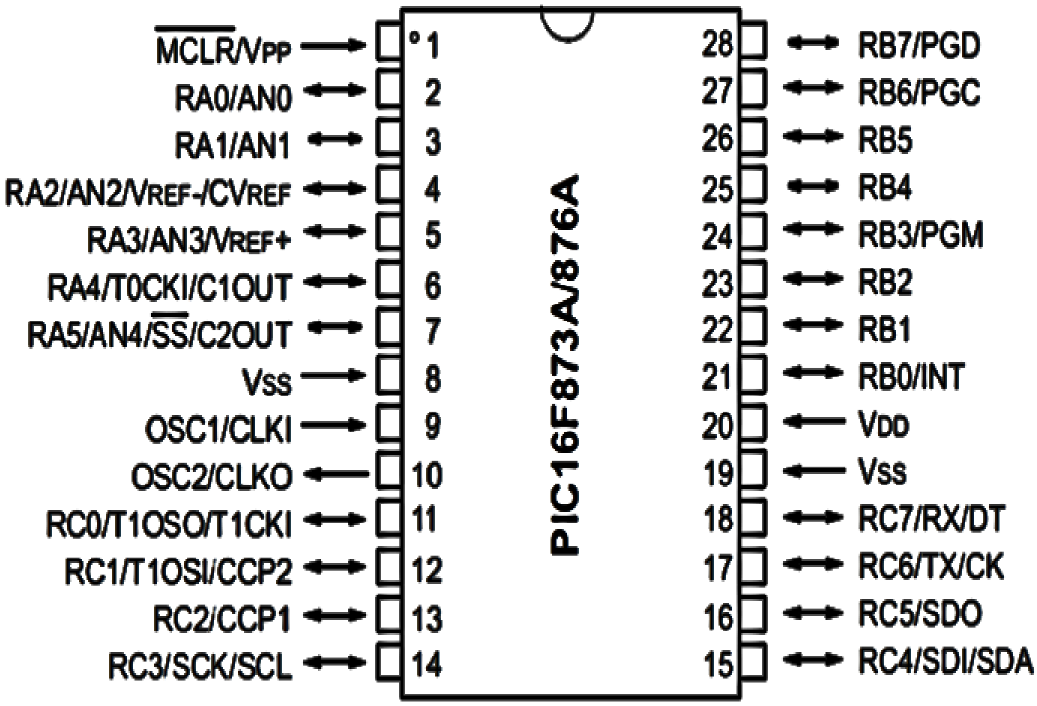


Figure 3.6: PIC16F876A Pin Diagram.

Table 3.2: Pin connection of PIC16F876A for the battery level monitoring system.

Pin Name	Pin Number	Description	Application
V_{DD}	20	Positive Supply (+5V)	Power Supply for PIC
V_{SS}	8, 19	Ground Reference	Ground Reference
OSC1	9	For oscillator or resonator	Connected to resonator 12MHz with 22pF
OSC2	10		
MCLR\	1	Reset Input	Connected to +5V
AN0	2	Analog Input	Connected to Voltage Cell
RB4 – RB7	25 – 28	Input/output	Connected to the LCD
RB0 – RB3	21 – 24	Input/output	Connected to Push Button
RC1 & RC2	12, 13	Input/output	Connected to Charging Circuit

3.2.4.1 Analogue to Digital Converter (ADC)

The ADC is important to convert an analogue signal to an accurate digital number proportional to its amplitude and vice versa. In the applications in which analogue information is converted to an intermediate digital form of error and noise-free transmission makes heavy use of an analogue / digital converter [6]. The ADC applications are also one of the PIC16F876A features.

3.2.5 Mosfet

The metal–oxide–semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) is a device used to amplify or switch electronic signals. It is by far the most common field-effect transistor in both digital and analogue circuits. The MOSFET is composed of a channel of n-type or p-type semiconductor material.

In MOSFET, the gate is separated from the channel by an insulating silicon dioxide (SiO2) layer. The charge carriers the conducting channel constitute an inversion charge, that is, electrons in the case of a p-type substrate (n-channel device) or holes in the case of an n-type substrate (p-channel device), induced in the semiconductor at the silicon-insulator interface by the voltage applied to the gate electrode. The electrons enter and exit the channel at n + source and drain contacts in the case of an n-channel MOSFET, and at p+ contacts in the case of a p-channel MOSFET.

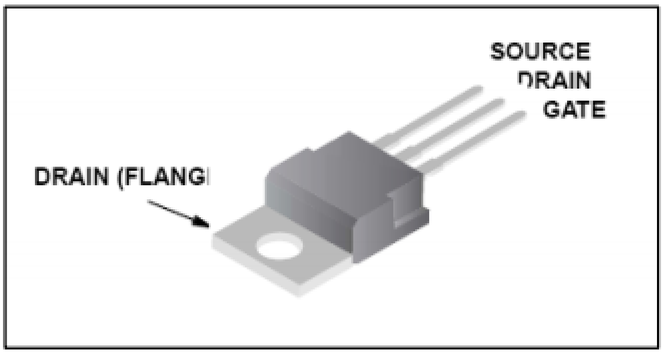


Figure 3.7: Mosfet.

3.2.6 16 x 2 Alphanumeric LCD Module

LCD or liquid crystal display is an electro-optical amplitude modulator realized as a thin, flat display device made up of any number of colour or monochrome pixels arrayed in front of a light source or reflector. It is often utilized in battery powered electronic devices because it uses very small amounts of electric power [12].

The LCD screen is used to display the charging state and the voltage value in this project. The LCD screen use is the 16 x 2 Alphanumeric LCD Modules. For the display on the LCD screen, programming must be developed. Figure 3.8 are the Alphanumeric LCD Module.

Figure 3.8: Alphanumeric LCD Module.

3.2.6.1 16 x 2 Alphanumeric LCD Module Features

Below are the 16 x 2 Alphanumeric LCD Module Features:

i. Intelligent, with built-in Hitachi HD44780 compatible LCD controller and RAM provides simple interfacing
ii. 61 x 15.8 mm viewing area
iii. 5 x 7 dot matrix format for 2.96 x 5.56 mm characters, plus cursor line
iv. Can display 224 different symbols
v. Low power consumption (1 mA typical)
vi. Powerful command set and user-produced characters
vii. TTL and CMOS compatible
viii. Connector for standard 0.1-pitch pin headers

Alphanumeric LCD module outline dimension are as in the Figure 3.9.

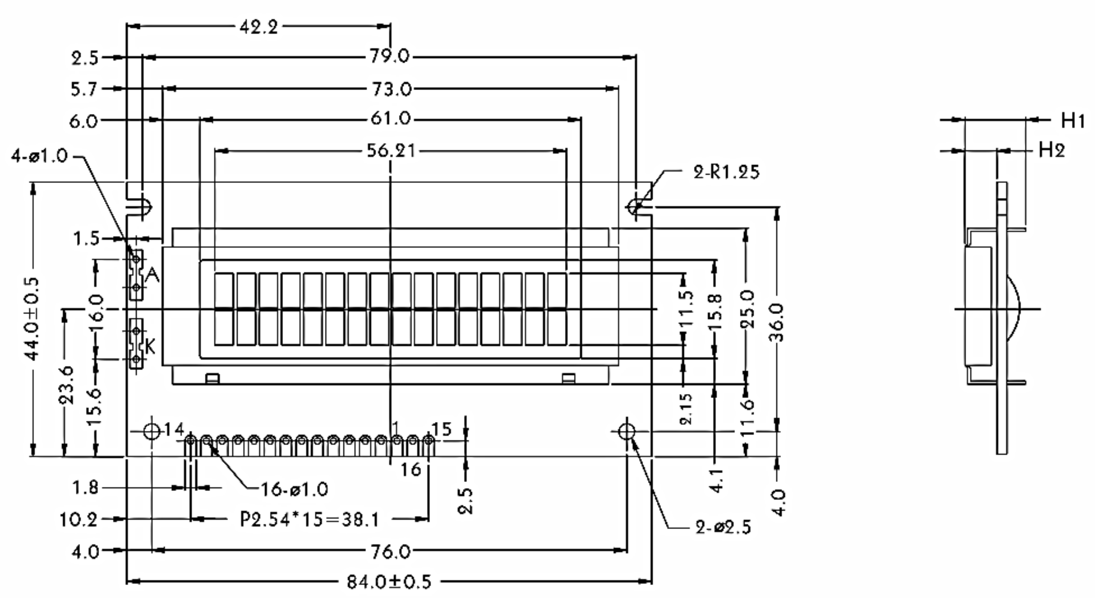


Figure 3.9: 16 x 2 Alphanumeric LCD Module outline dimension.

The Table 3.2 shows the 16 x 2 Alphanumeric LCD Module pins and functions.

Table 3.3: 16 x 2 Alphanumeric LCD Module Pin and functions.

Pin	Symbol	Level	Function
1	V_{SS}	-	Power, GND
2	V_{DD}	-	Power, 5V
3	V_O	-	Contrast Adjust
4	RS	H/L	Register Select Signal
5	R/W	H/L	Data Read/write
6	E	H, H→L	Enable Signal
7 - 14	DB0 – DB7	H/L	Data Bus line
15	A	-	Power Supply for LED (+)
16	K	-	Power Supply for LED (-)

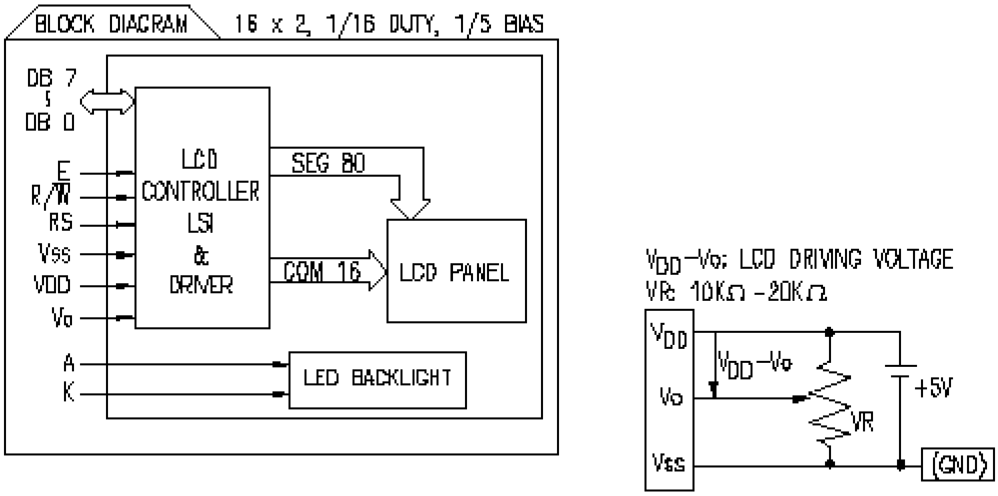


Figure 3.10: Alphanumeric LCD Module Block Diagram.

3.2.7 Charging the Lead Acid Battery

PbSO4 or Lead Acid batteries are usually charged either by the current-limited method or by the more common and generally simpler voltage-limited method. The voltage-limited charging method is similar to that used for Li+ cells, but high precision isn't as critical. It requires a current-limited voltage source set at a level somewhat higher than the cell's float voltage (about 2.45V) [13].

After a preconditioning operation that ensures that the battery will take a charge, the charger begins the fast charge and continues until it reaches a minimum charging current. (This procedure is similar to that of a Li+ charger). Fast charge is then terminated, and the charger applies a maintenance charge of V FLOAT (usually about 2.2V). PbSO4 cells allow this float-voltage maintenance for indefinite periods in Figure 3.11 [13].

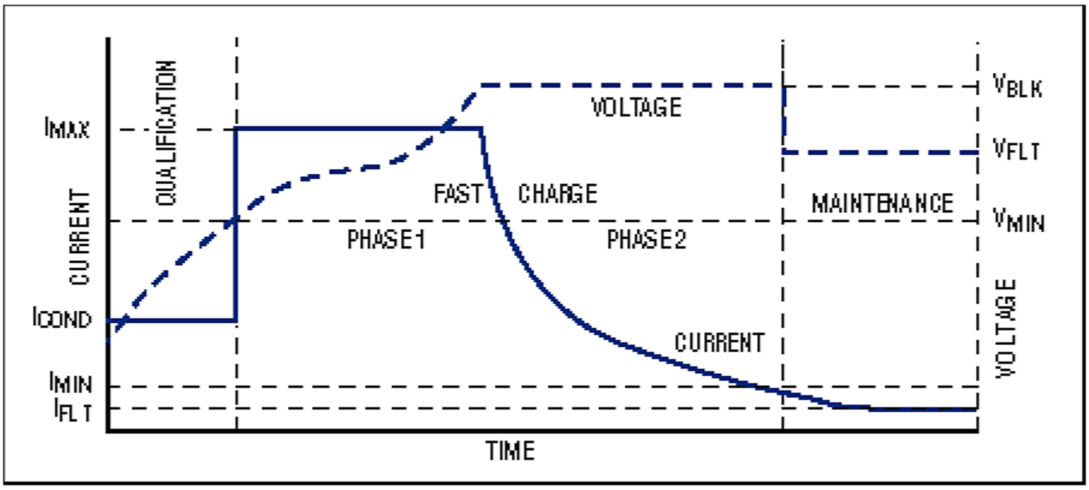


Figure 3.11: Lead Acid Battery Charging-Profile. [13]

For the sealed lead acid (SLA) the charging time is 12 to 16 hours. With higher charge currents and multi-stage charge methods, charge time can be reduced to 10 hours or less. SLAs cannot be fully charged as quickly as nickel-based systems. To correctly set the cell-voltage limit is critical. A typical voltage limit is from 2.30V to 2.45V. If a slow charge is acceptable, or the room temperature may exceed 30°C, the recommended voltage limit is 2.35V/cell. If a faster charge is required, and the room temperature will remain below 30° C, 2.40 to 2.45V/cell may be used [6].

Table 3.4: Recommended voltage limit on recharge and float charge of SLA [6].

	0°C	25°C	40°C
Voltage limit on recharge	2.55V/cell	2.45V/cell	2.35V/cell
Continuous float voltage	2.35V/cell or lower	2.30V/cell or lower	2.25V/cell or lower

3.2.8 Charging Circuit.

Developing a charging circuit is one of the objectives for this project. The schematic diagram in Figure 3.12 is the developed charging circuit. This charging circuit consist of two Mosfet, IRF540, an adjustable voltage regulator, LM317 and also a diode.

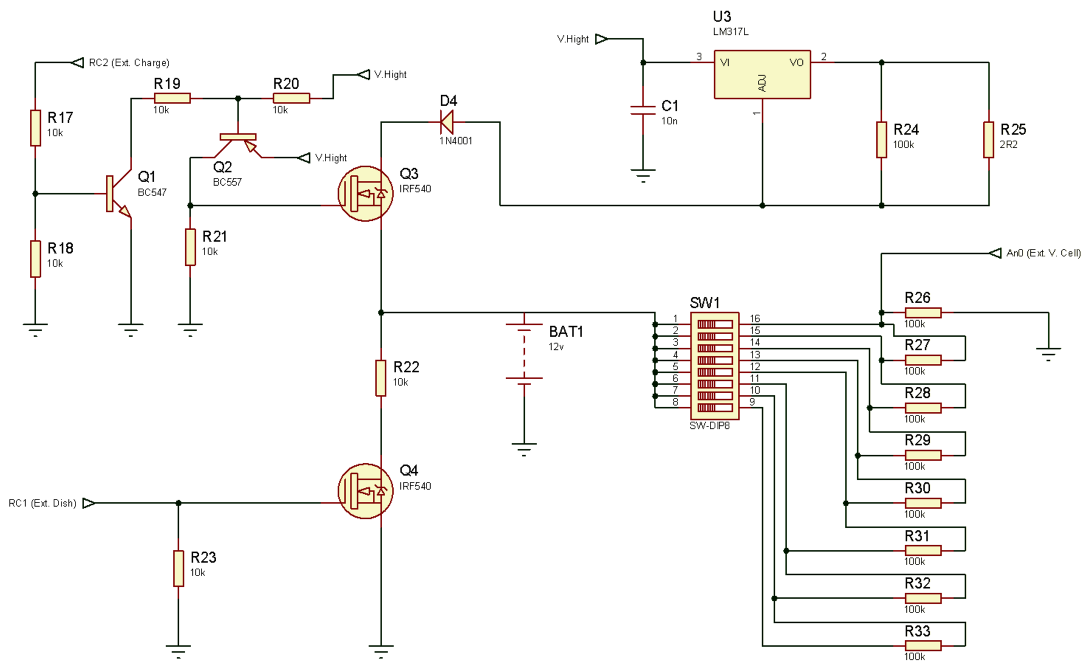


Figure 3.12: Schematic Diagram for Charging Circuit.

From the charging circuit in the Figure 3.13, a voltage regulator is used. The voltage regulator, (LM317) allows constant current flow in the circuit. This adjustable voltage regulator supports input voltage of 3 V to 40 V and the output voltage between 1.25 V to 37 V.

The Mosfet in the charging circuit is used as a switch to turn on and turn off. The switching of Mosfet is activated when the Gate is receiving voltage from the source. As for this circuit, it will be switched automatically. This is because of the Mosfet's Gate are connected to a transistor that receive voltage from PIC. When the Mosfet is activated, the current will flow through the Mosfet then it will charge the battery.

The diode that connected at the voltage regulator is used to allow the current to flow in one direction only. It is also functioning to ensure the current is not drained after it completely charged.

The Dip. switch is filtered by a series of resistor before the current is flow to the PIC. The Dip. switch is a set of manual switch. The function of this filtered is to decrease the voltage value that is sent to PIC. The filter is used because pin AN0 at the PIC can only read analog input from 0 V to 5 V only.

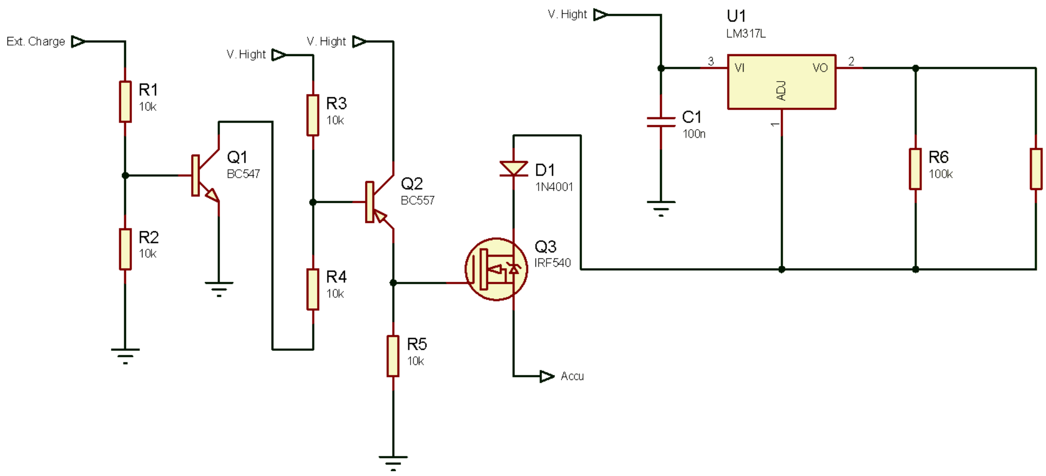


Figure 3.13: Charging

The charge ranges for this charging circuit is 1 V to 16 V. This range exceeds the requirement. Thus, when charging process, overheats will happen occasionally due to the output exceed the rated current. To resolve this problem the adjustable voltage regulator is used, that is LM317. This adjustable voltage regulator functions as current limiter and will automatically reduce the output current if overheat occurs under load.

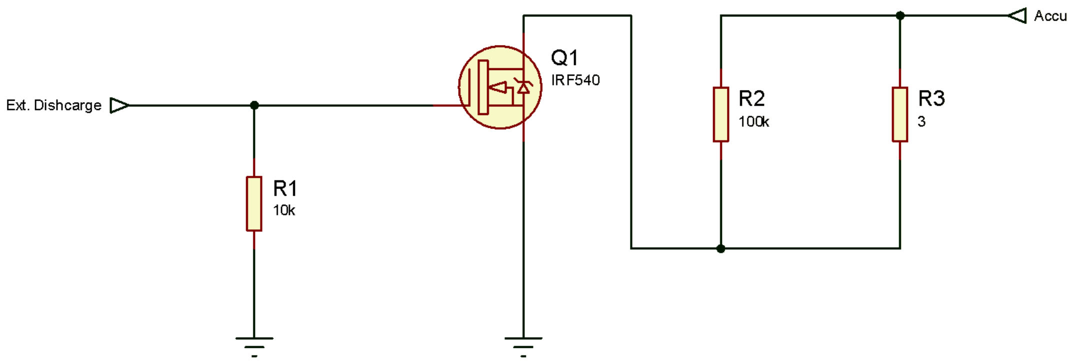


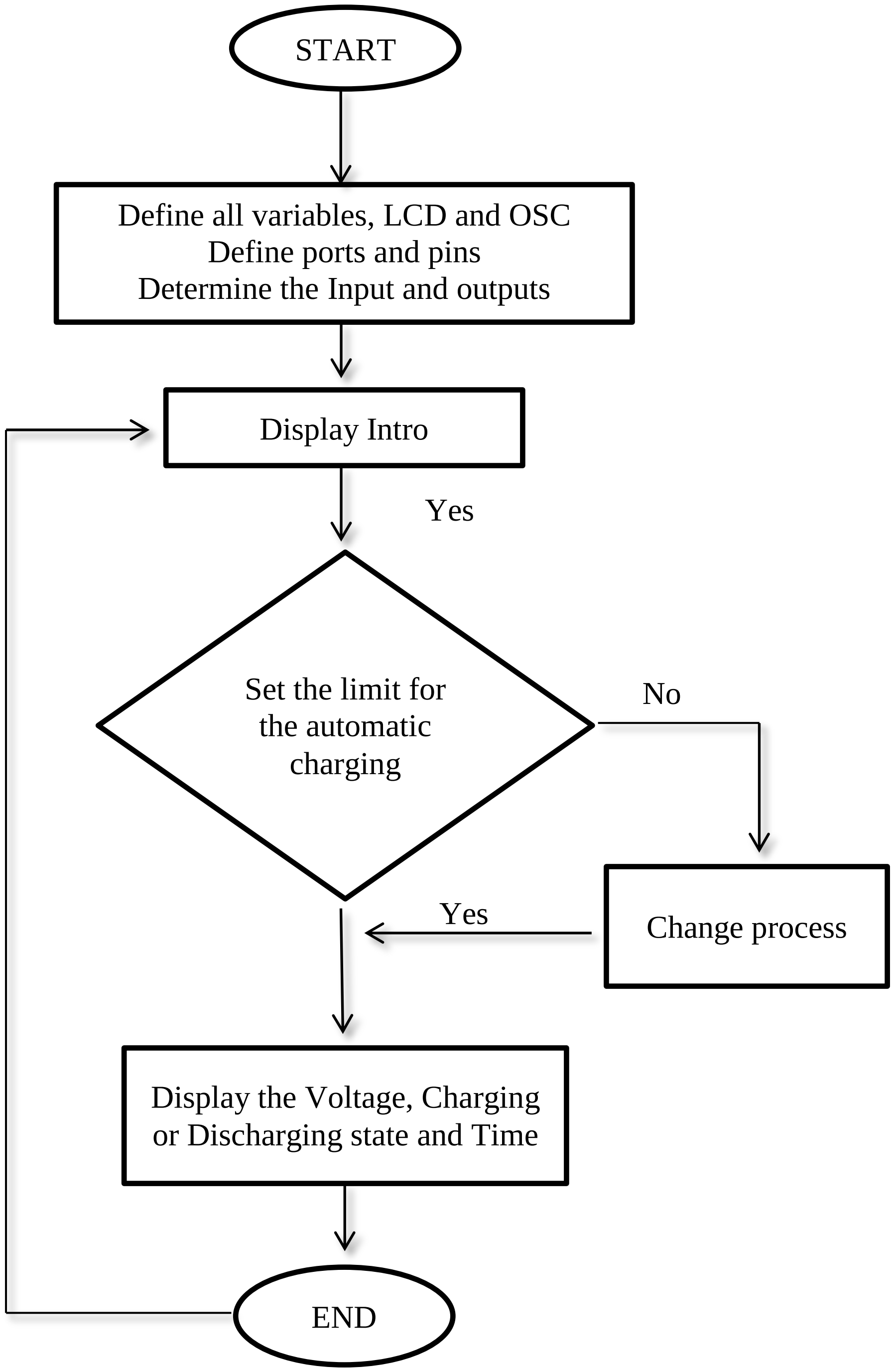
Figure 3.14: Discharging

In the Figure 3.14 shows the discharging part of the charging circuit. The testing for discharging circuit is experimented by using a lamp as a load to discharge the battery.

3.3 Software Implementation

The software used for this project is the PIC Simulator IDE and PROTEUS. PIC Simulator IDE is used to develop the programming for microcontroller for this project. PROTEUS is the software used to construct a circuit and run simulation to make sure the circuit designed is functioning for safety reason.

3.3.1 Flow Chart of the programming



3.3.2 Burning Hex file Into PIC by using PIC USB programmer

When a program is compiled it will be saved as hex file. The hex file is the file used to be read in the microcontroller. The hex file is burned into the microcontroller by using a PIC USB programmer. The device is connected to the computer and burned into the microcontroller. The PIC USB programmer is as in the Figure 3.15.

Figure 3.15: PIC USB Programmer

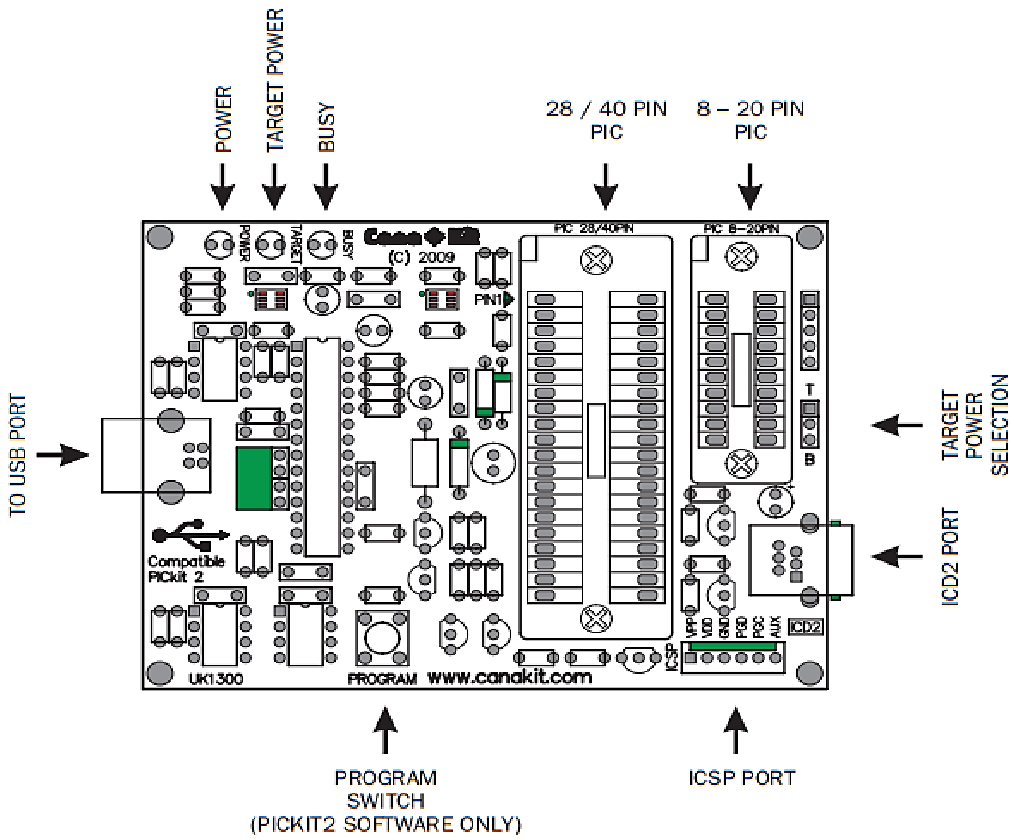


Figure 3.16: Programmer Overview [14].

The PIC programmer offers In-circuit programming with a wide range of optional adapters is available for all DIP sizes from 8 to 40 pins, together with a program-run switch for direct in-circuit program execution [14].

The PIC programmer is 100% compatible with PICkit 2 interface as in Figure 3.17, with the added advantage that it incorporates a ZIF socket for easy insertion and removal of the PIC and therefore can be used as a production programmer as well as an experimental programmer. It is also fully compatible with Microchip's MPLAB IDE software and therefore can program practically any PIC microcontroller including the PIC16F84, PIC16F628, PIC 18F458, and many more [14]. The PICkit 2

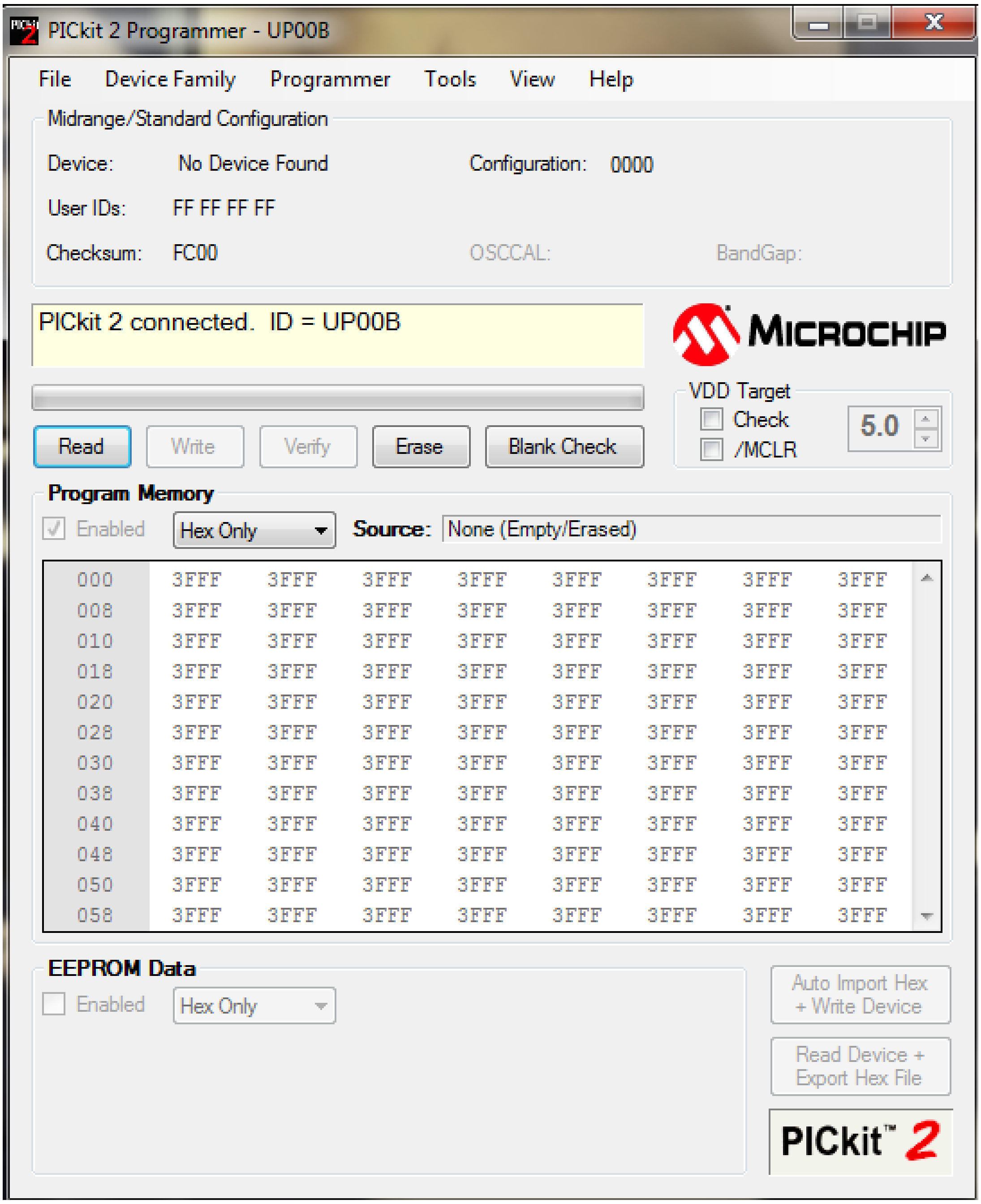


Figure 3.17: The PICkit 2 programmer [14].

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

Some testing has been conducted for the project. Firstly, the testing of the power circuit has been conducted to find out whether that the circuit is working properly and to make sure that the output is 5 V to be supplied to the PIC. Then, LEDs are used to test the circuit. After that, the LED programming is tested. Lastly the analyses are made.

4.2 Power Circuit

The power circuit in Figure 4.1 is the tested circuit. The power circuit is converting 12 V or 24 V to 5 V to be used for the PIC input supply. From the testing of the hardware, the output voltage is 5.03 V, so comparing the result from the hardware testing and simulation it is similar.

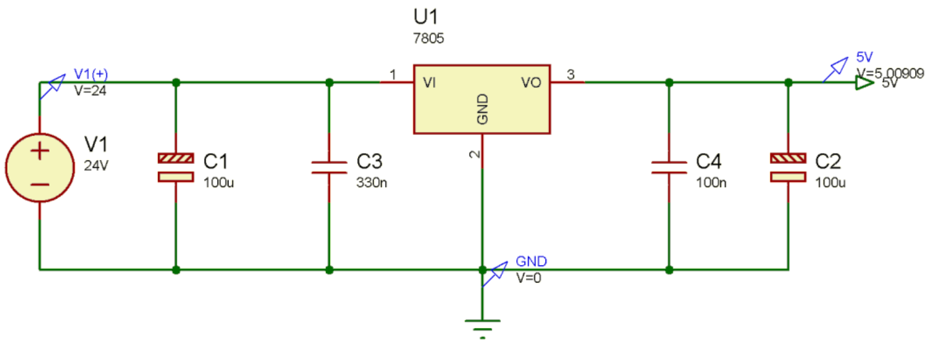


Figure 4.1: Power Circuit

4.3 Circuit Testing

This circuit is tested by using LED to make sure that the power circuit output in the hardware is 5 V, to be supplied to the PIC. If the LED is switched on, then the circuit is functioning. The program below is to turn on the LED on the circuit. Before it is tested on the hardware the program is tested by using software; PROTEUS in Figure 4.2. Figure 4.3, is the picture when the hardware is tested.

```
Define CONF_WORD = 0x3f72
Define CLOCK_FREQUENCY = 12

Symbol s1 = PORTA.0
Symbol led1 = PORTB.0

Dim phase As Byte
Dim key As Byte

PORTA = 0
PORTB = 0
PORTC = 0
TRISA.1 = 0
TRISA.5 = 0
TRISC.2 = 0
TRISC.1 = 0
AllDigital
ADCON1 = 0x0f
WaitMs 1000
```

```
newprogram:
Gosub welcome
End

welcome
If key = s1 Then
        phase = phase + 1
        If phase = 5 Then phase = 1
        Goto loop1

Loop1:
Led1 = 1
WaitMs 3000
End
```

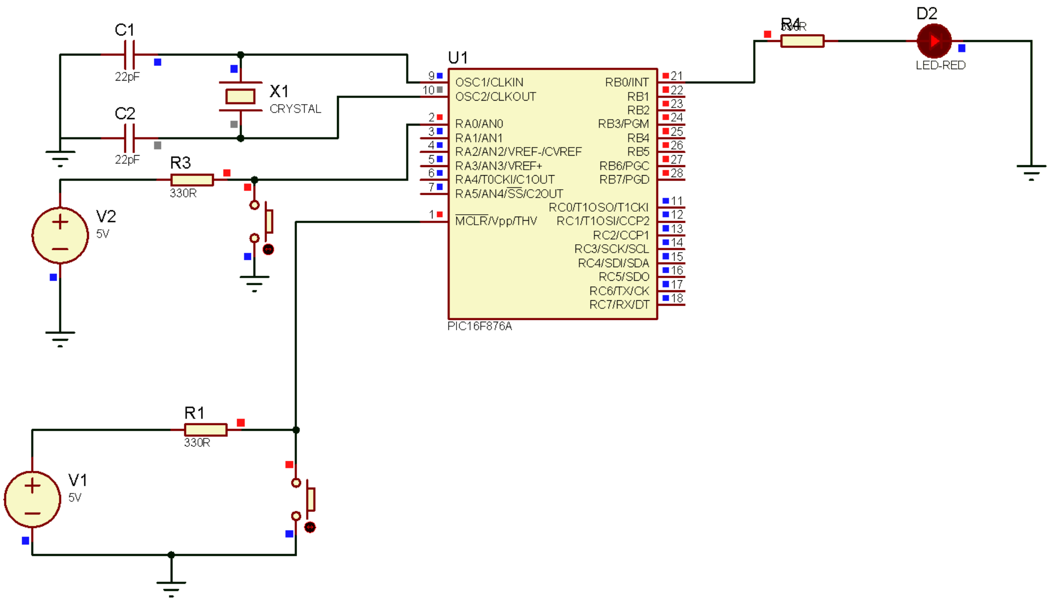


Figure 4.2: The simulation in PROTEUS.

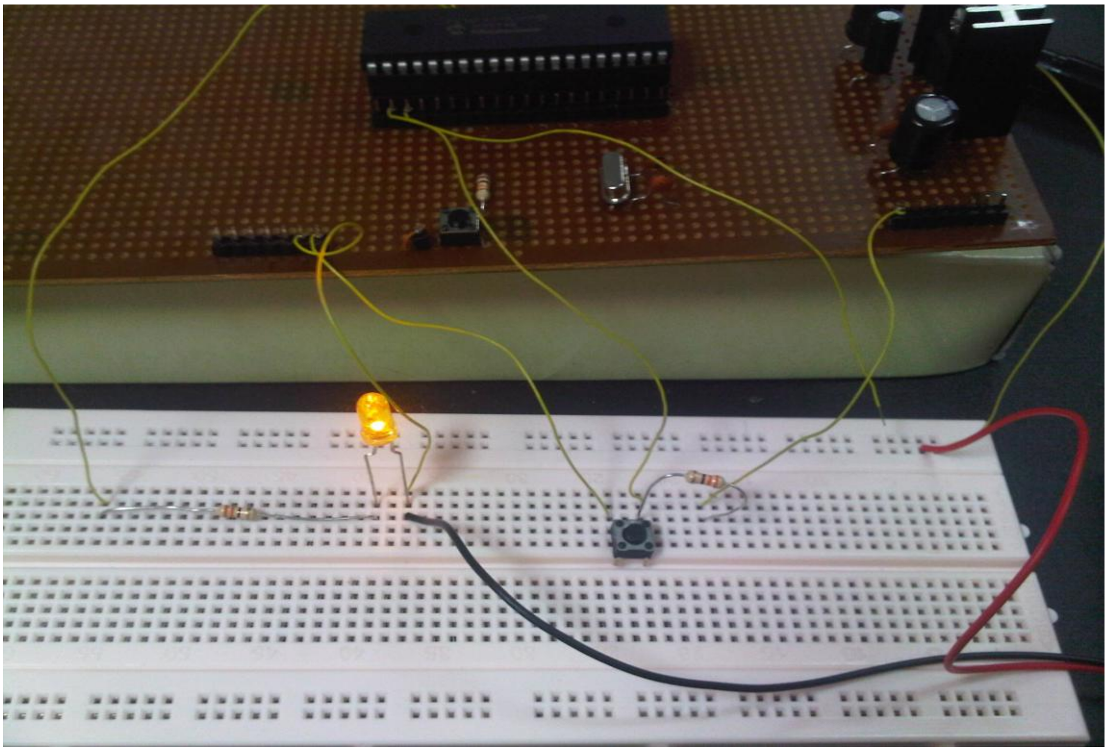


Figure 4.3: The hardware testing.

4.4 LCD Testing

The LCD testing is conducted to make sure the program for LCD is functioning well. Below is the programming for the LCD. The LCD will display "LCD display" when the button is pressed. The result of the LCD testing of hardware is in Figure 4.4. Figure 4.5 is the simulation tested in PROTEUS.

```
Define CONF_WORD = 0x3f72
Define CLOCK_FREQUENCY = 12

Symbol t_right = PORTB.3
Symbol t_down = PORTB.2
Symbol t_up = PORTB.1
Symbol t_left = PORTB.0
Symbol i2cclock = PORTC.3
Symbol i2cdata = PORTC.4

Define LCD_BITS = 4
Define LCD_DREG = PORTB
Define LCD_DBIT = 4
Define LCD_RSREG = PORTC
Define LCD_RSBIT = 0
Define LCD_EREG = PORTC
```

```
Define LCD_EBIT = 5

PORTA = 0
PORTB = 0
PORTC = 0
TRISA.1 = 0
TRISA.5 = 0
TRISC.2 = 0
TRISC.1 = 0
AllDigital
ADCON1 = 0x0f
Lcdinit
WaitMs 1000
newprogram:
Gosub welcome
End

welcome:
Lcdcmdout LcdClear
Lcdout "LCD display"
WaitMs 3000
End
```

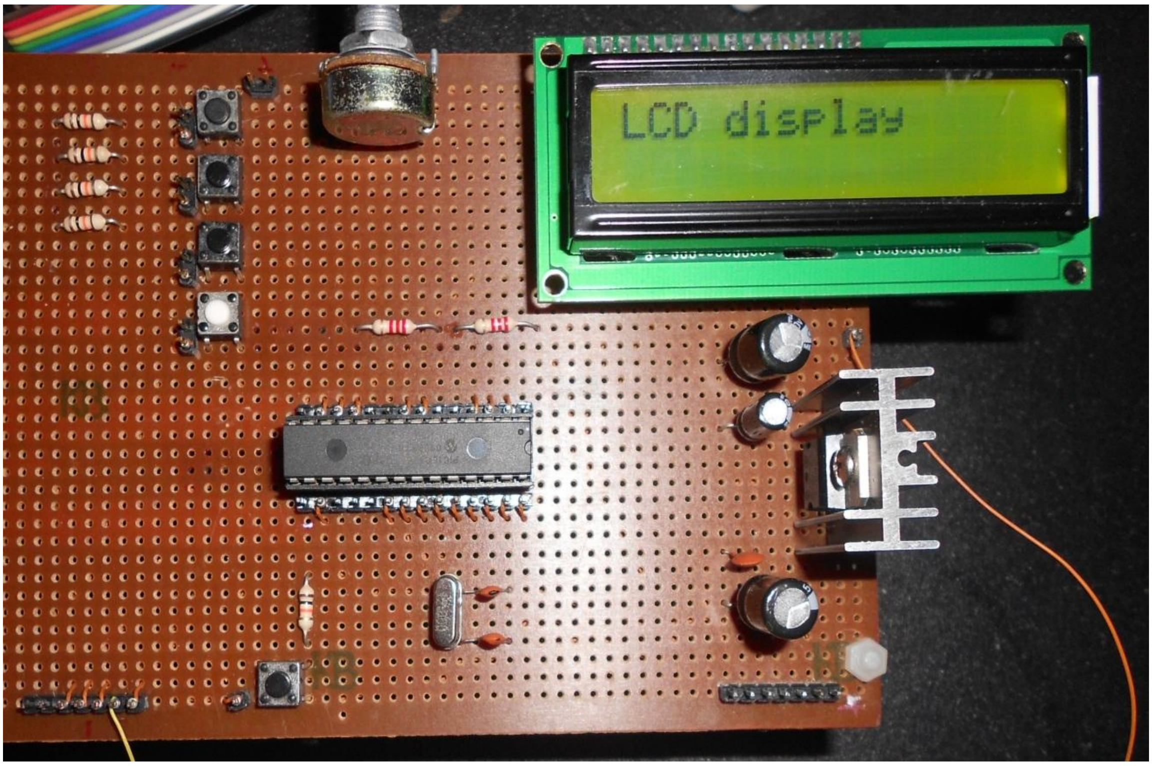


Figure 4.4: The tested LCD at hardware.

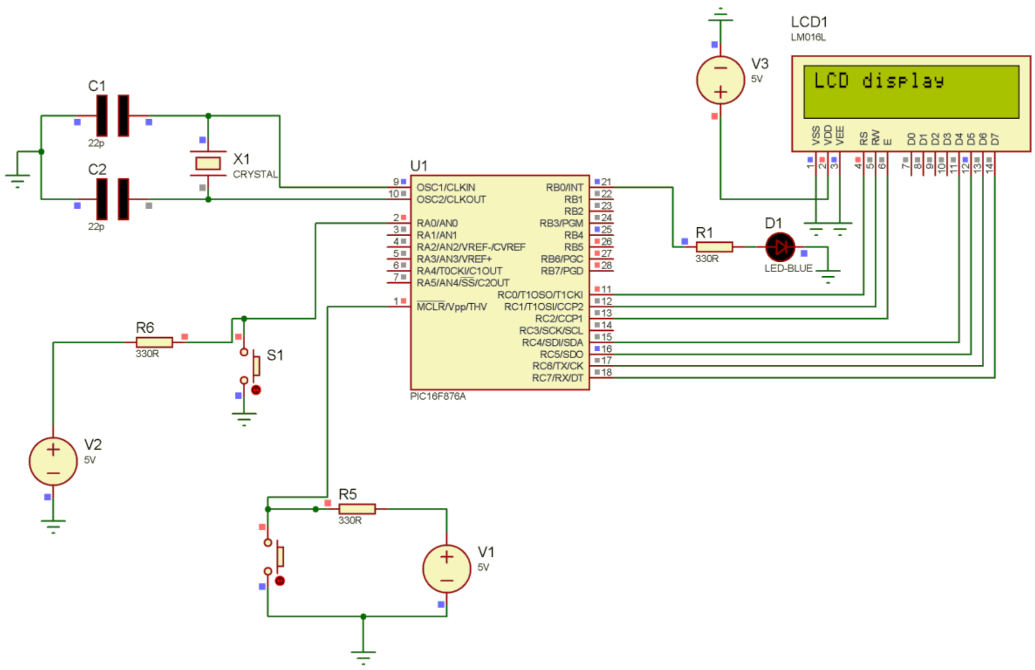


Figure 4.5: Simulation in PROTEUS.

4.5 Charging Circuit Testing.

As in the objectives the charging circuit is one of the objectives to be fulfilled. For charging circuit testing, the testing is by collecting the data from charging as in the Table 4.1.

Table 4.1: Charging circuit testing.

Input Voltage	Output Voltage
1 V	0.0 V
3 V	0.0 V
5 V	2.2 V
6 V	3.0 V
7 V	3.9 V
9 V	6.0 V
12 V	8.9 V
14 V	10.7 V
16 V	12.7 V
18 V	14.7 V
20 V	16.6 V
22 V	18.7 V
24 V	20.6 V

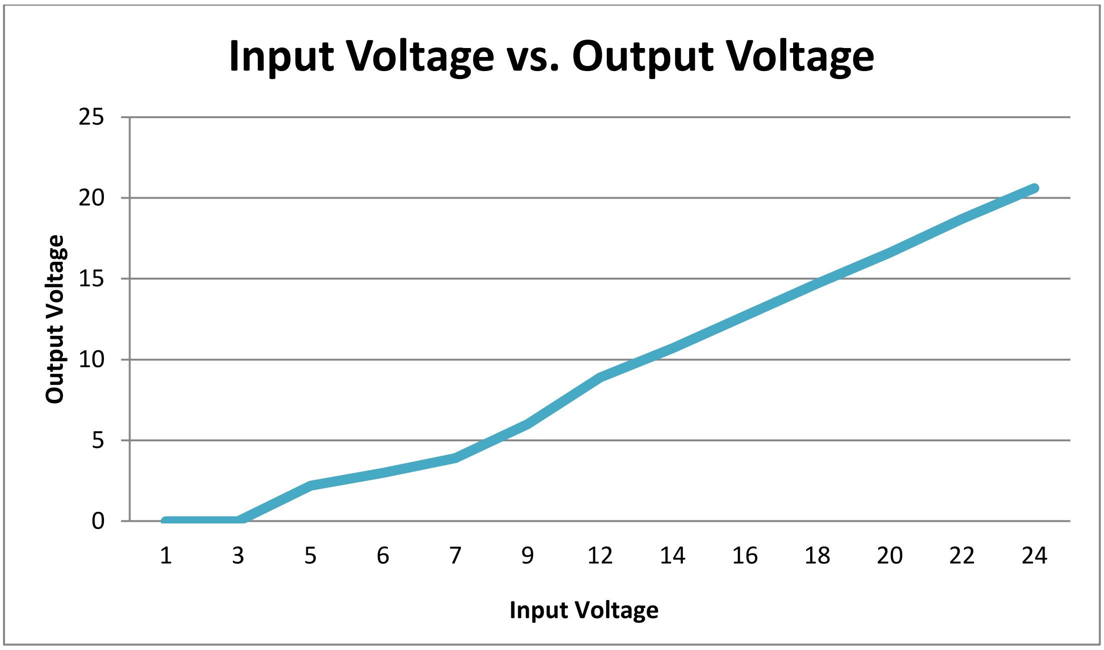


Figure 4.6: Graph Input Voltage vs. Output Voltage

The output voltages of the charging circuit are as in the Table 4.1 above. The output voltage shows that the input voltages are regulated by the voltage regulator LM317. To charge a 12 V Sealed Lead Acid it needs more than 12 V to charge the battery of 12 V. The battery charger is able to regulate the output of 37 V and with a 40 V input maximum. However if the voltage used to charge is too high it will shorten the battery life.

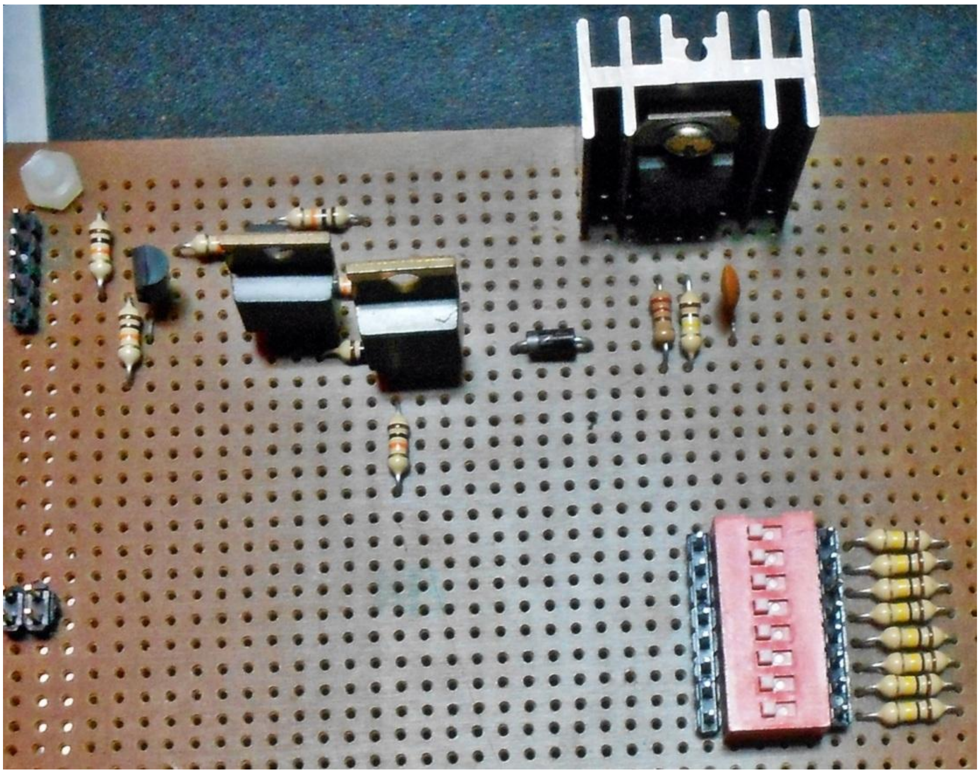


Figure 4.7: Charging Circuit

4.6 Charging Circuit Result

The charging circuit is connected to the controller circuit, where the PIC is controlling the charging start. The charging is start by pressing a push button to select the menu charge from the LCD screen as in Figure 4.8.

Figure 4.8: Selecting Program on LCD display.

The input voltage to charge the battery is 16 V. Meanwhile the current is about 0.05 A. The battery voltage changes from 10.76 V to 10.77 V within 22 minutes as in Figure 4.9 and Figure 4.10.

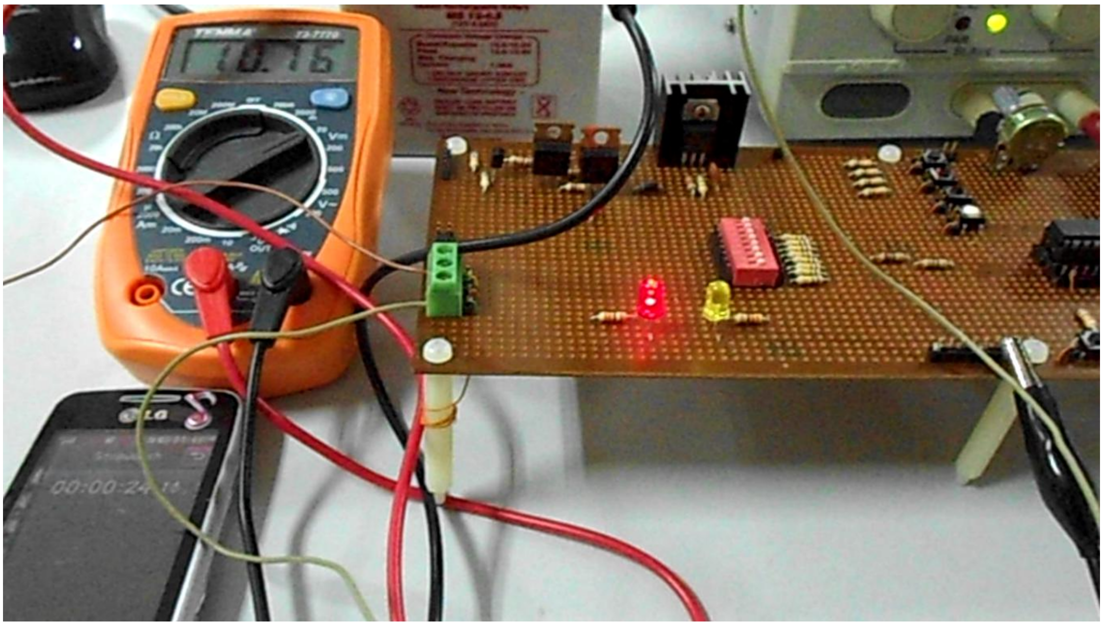


Figure 4.9: The voltage charge is up to 10.76.

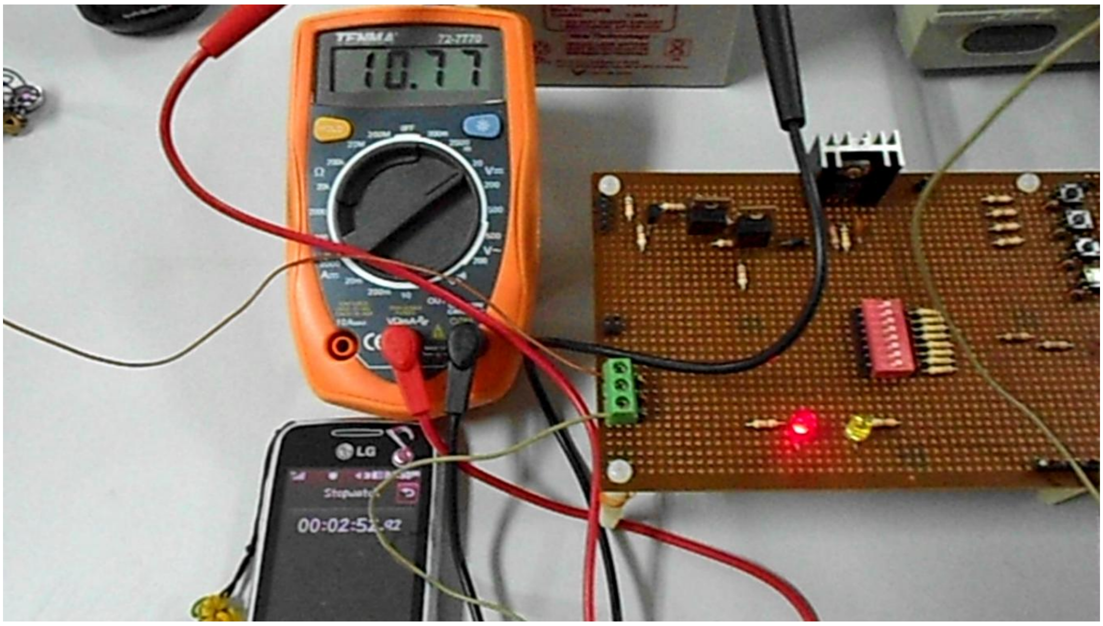


Figure 4.10: The voltage value is 10.77 V after 22 minutes.

The charging will stop when reset button is pressed and the charging can be continued by pressed the select button to charge from the menu on the LCD screen.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The battery level monitoring system is a project that displays the charging and discharging of a 12 V Sealed Lead Acid battery. This project also helps the user to monitor the voltage value and the charging and discharge state of the battery. The purpose of this application is to monitor the voltage, charging and discharging. Besides that, a battery charger circuit is developed to charge the battery.

This project includes three parts. The first part is the charging circuit. The charging circuit of this project should be able to charge a 12 V Sealed Lead Acid battery. The circuit should stop charging when the charging is almost full to make sure it will not damage the battery.

The second part of this project is the controller circuit. The controller circuit is the brain of this project. In this controller circuit contains the PIC or the microcontroller. This microcontroller needs a program to be operated.

The last but not least is the monitoring circuit. The monitoring circuit is to display the charging and discharging state of the battery and also the voltage value of the battery.

5.2 Problem

During the project there should be some certain problems occur during the progress of this project. The problems can be resolved by many certain ways, so the purpose of this problem discussed is to provide information for others to resolve when the problems occur.

One of the problems is during developing the power circuit. The power circuit in this project should be providing a +5 V power to supply to the microcontroller. The solution for this problem is by troubleshooting the connection in the circuit. There is some error in the connection.

Besides that, during the testing of the circuit some problems occur to activate the LED with a functional programming. The programming develops is not functioning well so the LED in the circuit is not activated. When the programming is tested in the software, PROTEUS the programming shows no problem to activate the LED. The solution that came across is to troubleshoot the programming. It seems that the programming will be functioning well in the software but not in the hardware. To solve the problem due to this is by adding a device to be defined in the programming.

Other than that, during developing the charging circuit there are some spark happens occurred during the test. Thus, the problem is solved by troubleshooting the circuit to make sure the connection is correct. The problem causing this case is because of the ground and +5 V is short circuit.

5.3 Recommendation

For the future used on this project, some recommendation is provided to improve the project performances and functions.

This project monitors the battery charging and discharging state and also the voltage value. There are many other parameters that can be monitored to make sure the battery is in a good condition. For example of the parameter is the temperature. The importance of monitoring the temperature is because the battery performance will change dramatically with temperature.

Other than that, this project also can be done with wireless monitoring. The advantage of wireless monitoring is the battery can be stored at a place that is hazardous, and the battery level can be monitored from afar.

When the charging is complete the charging will be automatically stop, to indicate the charging is complete is by adding a buzzer. When, a buzzer is added the user will be notify by the sound of the buzzer instead of light indicator.

REFFERENCE

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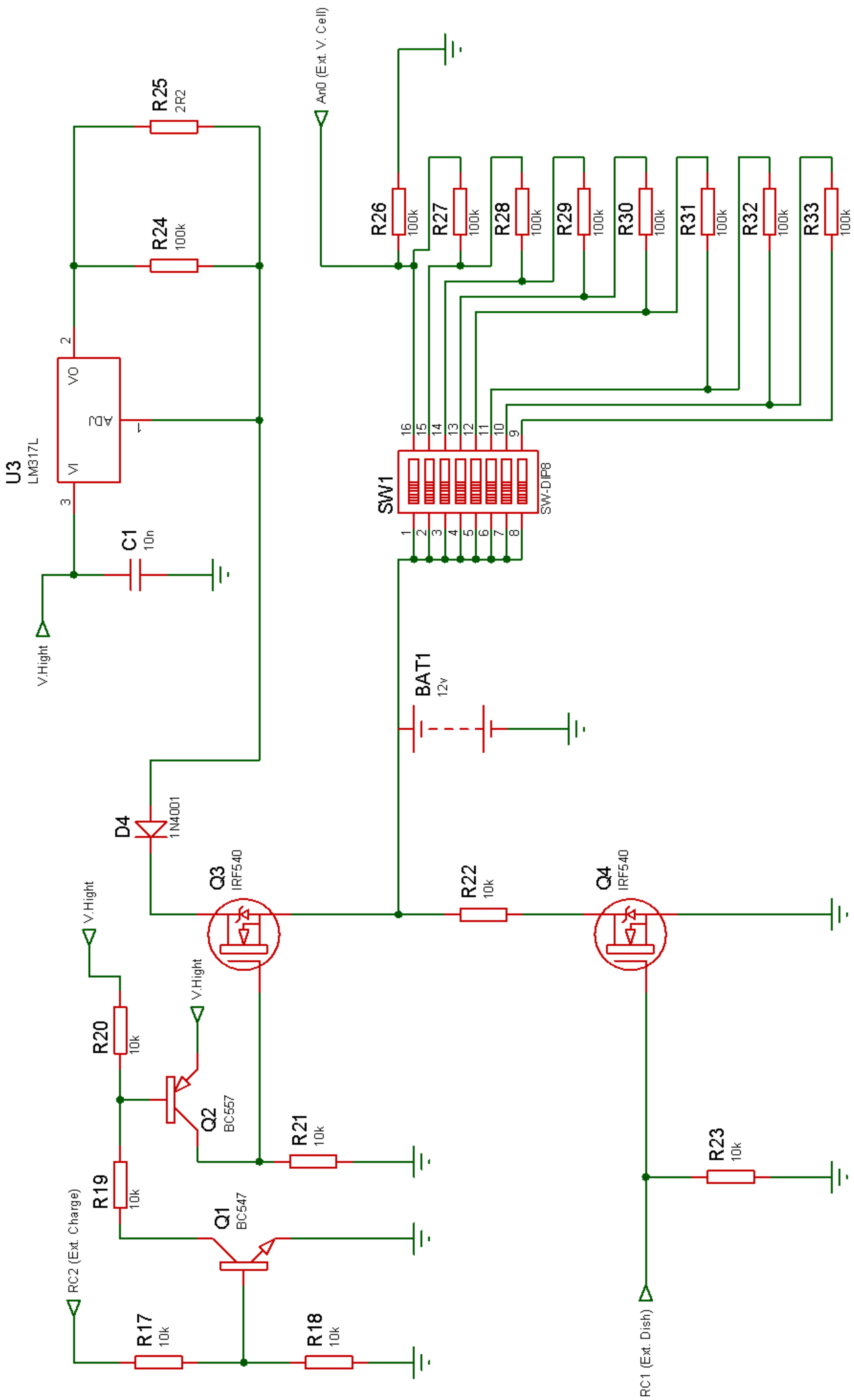
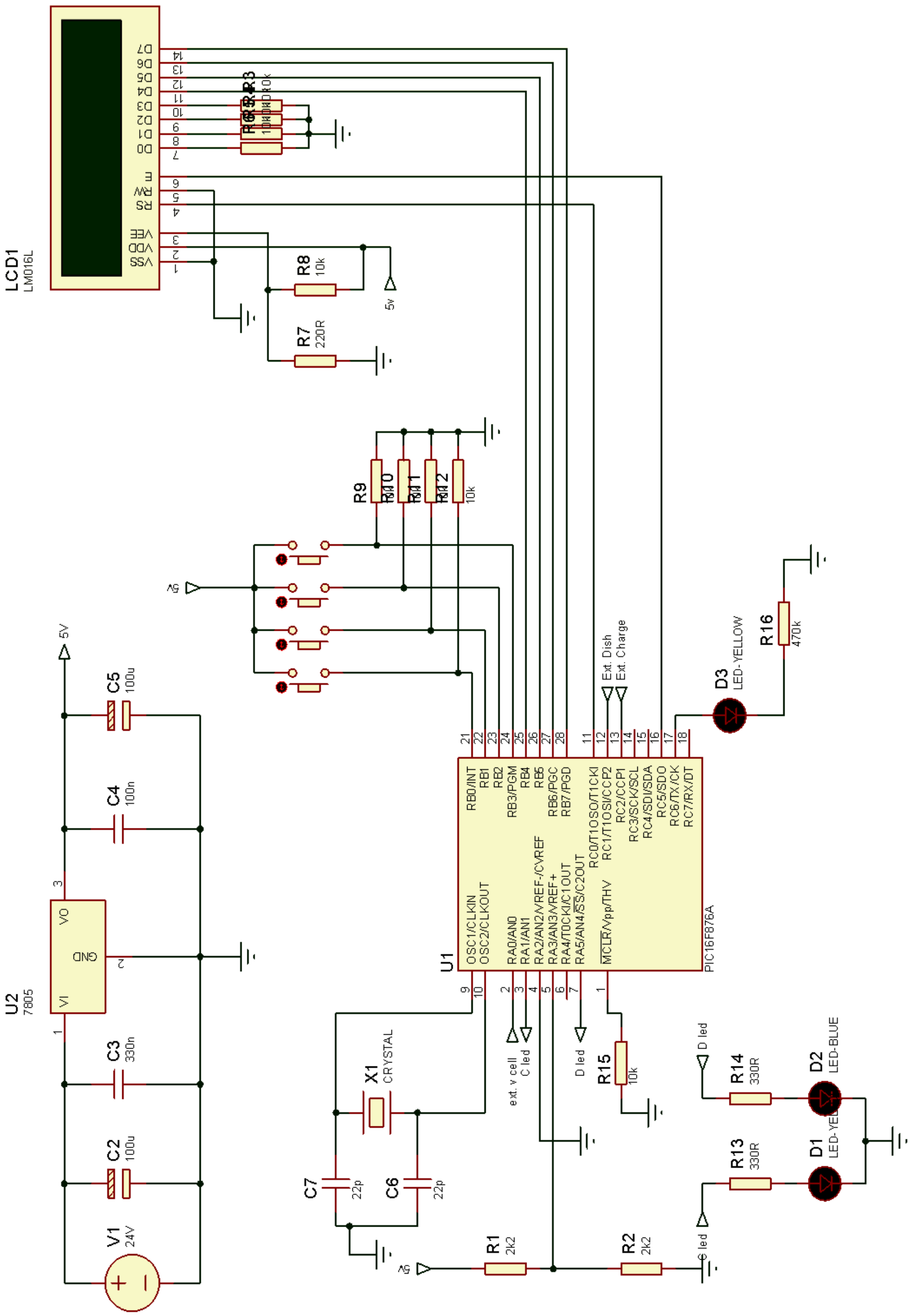
APPENDIX A

Schematic Circuit Diagram



APPENDIX A

Schematic Circuit Diagram



APPENDIX B

Project Coding

```
Define CONF_WORD = 0x3f72
Define CLOCK_FREQUENCY = 12

Symbol t_right = PORTB.3
Symbol t_down = PORTB.2
Symbol t_up = PORTB.1
Symbol t_left = PORTB.0
Symbol ledcharge = PORTA.1
Symbol leddischarge = PORTA.7
Symbol charge = PORTC.2
Symbol discharge = PORTC.1
Symbol i2cclock = PORTC.3
Symbol i2cdata = PORTC.4

Define LCD_BITS = 4
Define LCD_DREG = PORTB
Define LCD_DBIT = 4
Define LCD_RSREG = PORTC
Define LCD_RSBIT = 0
Define LCD_EREG = PORTC
Define LCD_EBIT = 5

Const c_right = 1
Const c_up = 2
Const c_down = 3
Const c_left = 4

Dim vin As Word
Dim i As Byte
Dim j As Byte
Dim an0 As Word
Dim vmod As Word
Dim vfinal As Word

Dim v(13) As Word
Dim vmax As Word
Dim vmaxdelay As Byte
Dim vmaxnum As Byte

Dim finish As Bit
Dim address As Word
Dim seconds As Byte
Dim minutes As Word
Dim hours As Byte

Dim voltage As Word
Dim voltage1 As Word
Dim voltage2 As Word
Dim cnt As Word
```

APPENDIX B

Project Coding

```
Dim sample As Word

Dim program As Byte
Dim phase As Byte
Dim key As Byte

Dim dischargelimit As Word
Dim signalfiltertype As Byte
Dim mintime As Byte
Dim minvalue As Word
Dim maxtime As Word

PORTA = 0
PORTB = 0
PORTC = 0
TRISA.1 = 0
TRISA.5 = 0
TRISC.2 = 0
TRISC.1 = 0
AllDigital
ADCON1 = 0x0f
Lcdinit
WaitMs 1000

newprogram:
Gosub welcome
Gosub selectprogram
If program = 1 Then Gosub prog_charge
If program = 2 Then Gosub prog_discharge
If program = 3 Then Goto prog_combine
If program = 4 Then Goto prog_features
Goto newprogram
End

welcome:
Lcdcmdout LcdClear
Lcdout "PSM Project 2012"
Lcdcmdout LcdLine2Home
Lcdout "Loading..."
WaitMs 3000
Return

selectprogram:
phase = 1
Lcdcmdout LcdClear
Lcdout "Select Program:"
loop1:
Lcdcmdout LcdLine2Clear
If phase = 1 Then Lcdout "1-Charge"
```

APPENDIX B

Project Coding

```
If phase = 2 Then Lcdout "2-Discharge"
If phase = 3 Then Lcdout "3-Combine"
If phase = 4 Then Lcdout "4-Features"
Gosub waitkey
If key = c_down Then
        phase = phase + 1
        If phase = 5 Then phase = 1
        Goto loop1
Endif
If key = c_up Then
        phase = phase - 1
        If phase = 0 Then phase = 4
        Goto loop1
Endif
If key = c_right Then program = phase
If key = c_left Then program = 0
Return

waitkey:
key = 0
If t_right = 1 Then key = c_right
If t_up = 1 Then key = c_up
If t_down = 1 Then key = c_down
If t_left = 1 Then key = c_left
If key = 0 Then Goto waitkey
Gosub debounce
Return

getkey:
key = 0
If t_right = 1 Then key = c_right
If t_up = 1 Then key = c_up
If t_down = 1 Then key = c_down
If t_left = 1 Then key = c_left
If key > 0 Then Gosub debounce
Return

debounce:
If t_right = 1 Then i = 0
If t_up = 1 Then i = 0
If t_down = 1 Then i = 0
If t_left = 1 Then i = 0
i = i + 1
WaitMs 10
If i < 10 Then Goto debounce
Return

scankey:
If t_right = 1 Then key = c_right
```

APPENDIX B

Project Coding

```
If t_up = 1 Then key = c_up
If t_down = 1 Then key = c_down
If t_left = 1 Then key = c_left
Return

initroutine:
Lcdcmdout LcdClear
Lcdout "Starting..."
WaitMs 3000
Gosub getvin
For i = 1 To 12
	v(i) = vin
Next i
vmax = 0
vmaxdelay = 0
vmaxnum = 0
finish = 0
seconds = 251
minutes = 0
hours = 0
key = 0

Lcdcmdout LcdClear
Return

prog_discharge:
discharge = 1
leddischarge = 1
Gosub initroutine
Lcdout "Discharging..."
Lcdcmdout LcdLine2Home
Signalfiltertype = 1
Dischargelimit = 290
While finish = 0
	If signalfiltertype = 1 Then Gosub getvfinal1
	If vfinal <= dischargelimit Then finish = 1
	Gosub settime
	Gosub showvoltage
	If key = c_left Then finish = 1
	key = 0
Wend
Lcdcmdout LcdLine1Clear
Lcdout "Completed!"
discharge = 0
leddischarge = 0
WaitMs 3000
Return

prog_charge:
```

APPENDIX B

Project Coding

```
charge = 1
ledcharge = 1
Gosub initroutine
Lcdout "Charging..."
Lcdcmdout LcdLine2Home
While finish = 0
	If signalfiltertype = 1 Then Gosub getvfinal1
	If vfinal > vmax Then vmaxdelay = vmaxdelay + 1
	If vmaxdelay = 5 Then
		If vmaxnum < 5 Then vmaxnum = vmaxnum + 1
		vmax = vfinal
		vmaxdelay = 0
	Endif
	If peakdetect = 1 Then
		vfinal = vfinal + peakgap
		If vfinal <= vmax Then finish = 1
		vfinal = vfinal - peakgap
		If vmaxnum < 5 Then finish = 0
	Endif
	If minutes < mintime Then
		finish = 0
		vmax = vfinal
		vmaxdelay = 0
	Endif
	If vfinal < minvalue Then
		finish = 0
		vmax = vfinal
		vmaxdelay = 0
	Endif
	If minutes >= maxtime Then finish = 1
	Gosub settime
	Gosub showvoltage
	If key = c_left Then finish = 1
	key = 0
Wend
Lcdcmdout LcdLine1Clear
Lcdout "Completed!"
charge = 0
ledcharge = 0
WaitMs 3000
Return

prog_combine:
Gosub prog_discharge
WaitMs 10000
Gosub prog_charge
Goto newprogram
Return
```

APPENDIX B

Project Coding

```
prog_features:
Lcdcmdout LcdClear
Lcdout "PSM Project 2012"
Lcdcmdout LcdLine2Home
Lcdout "FKEE"
WaitMs 3000

Lcdcmdout LcdClear
Lcdout "Aiesyah"
Lcdcmdout LcdLine2Home
Lcdout "EC08027"
WaitMs 3000

Lcdout "Supervisor"
Lcdcmdout LcdLine2Home
Lcdout "Ms.Nor Laili"
WaitMs 3000
Return

getvin:
vin = 0
For i = 1 To 60
        Adcin 0, an0
        Vin = vin + an0
Gosub scankey
WaitMs 83
Next i
vmod = vin Mod 60
vin = vin / 60
If vmod >= 30 Then vin = vin + 1
Return

getvfinal1:
For i = 1 To 11
        J = i + 1
        V(i) = v(j)
Next i
Gosub getvin
v(12) = vin
vfinal = 0
For i = 1 To 12
        Vfinal = vfinal + v(i)
Next i
vmod = vfinal Mod 12
vfinal = vfinal / 12
If vmod >= 6 Then vfinal = vfinal + 1
Return

showvoltage:
```

APPENDIX B

Project Coding

```
'0V=0 2.5V=1023 2500/1023=2.444
voltage = (vfinal * 2) + (vfinal * 4 / 10)
voltage = voltage +(vfinal * 4 / 100) + (vfinal * 4 / 1000)
voltage1 = voltage / 1000
voltage2 = voltage Mod 1000
Lcdcmdout LcdLine2Clear
Lcdout #voltage1, "."
If voltage2 < 100 Then Lcdout "0"
If voltage2 < 10 Then Lcdout "0"
Lcdout #voltage2, "V "
hours = minutes / 60
If hours < 10 Then Lcdout "0"
Lcdout #hours, ":"
hours = minutes Mod 60
If hours < 10 Then Lcdout "0"
Lcdout #seconds
Return

settime:
seconds = seconds + 5
if seconds >= 60 Then
        seconds = 0
        minutes = minutes + 1
Endif
Return
```

APPENDIX C

Datasheet PIC16F877A

MICROCHIP

PIC16F87XA

28/40/44-Pin Enhanced Flash Microcontrollers

Devices Included in this Data Sheet:

- PIC16F873A
- PIC16F874A
- PIC16F876A
- PIC16F877A

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 other 28-pin or 40/44-pin PIC16CXXX and PIC16FXXX microcontrollers

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
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I^2C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) – 8 bits wide with external $\overline{RD}$, $\overline{WR}$ and $\overline{CS}$ controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

Analog Features:

- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- Brown-out Reset (BOR)
- Analog Comparator module with:
  - Two analog comparators
  - Programmable on-chip voltage reference (VREF) module
  - Programmable input multiplexing from device inputs and internal voltage reference
  - Comparator outputs are externally accessible

Special Microcontroller Features:

- 100,000 erase/write cycle Enhanced Flash program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory typical
- Data EEPROM Retention > 40 years
- Self-reprogrammable under software control
- In-Circuit Serial Programming™ (ICSP™) via two pins
- Single-supply 5V In-Circuit Serial Programming
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving Sleep mode
- Selectable oscillator options
- In-Circuit Debug (ICD) via two pins

CMOS Technology:

- Low-power, high-speed Flash/EEPROM technology
- Fully static design
- Wide operating voltage range (2.0V to 5.5V)
- Commercial and Industrial temperature ranges
- Low-power consumption

Device	Program Memory		Data SRAM (Bytes)	EEPROM (Bytes)	I/O	10-bit A/D (ch)	CCP (PWM)	MSSP		USART	Timers 8/16-bit	Comparators
	Bytes	# Single Word Instructions						SPI	Master I^2C			
PIC16F873A	7.2K	4096	192	128	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F874A	7.2K	4096	192	128	33	8	2	Yes	Yes	Yes	2/1	2
PIC16F876A	14.3K	8192	368	256	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F877A	14.3K	8192	368	256	33	8	2	Yes	Yes	Yes	2/1	2

APPENDIX C

Datasheet PIC16F877A

1.0 DEVICE OVERVIEW

This document contains device specific information about the following devices:

- PIC16F873A
- PIC16F874A
- PIC16F876A
- PIC16F877A

PIC16F873A/876A devices are available only in 28-pin packages, while PIC16F874A/877A devices are available in 40-pin and 44-pin packages. All devices in the PIC16F87XA family share common architecture with the following differences:

- The PIC16F873A and PIC16F874A have one-half of the total on-chip memory of the PIC16F876A and PIC16F877A
- The 28-pin devices have three I/O ports, while the 40/44-pin devices have five
- The 28-pin devices have fourteen interrupts, while the 40/44-pin devices have fifteen
- The 28-pin devices have five A/D input channels, while the 40/44-pin devices have eight
- The Parallel Slave Port is implemented only on the 40/44-pin devices

The available features are summarized in Table 1-1. Block diagrams of the PIC16F873A/876A and PIC16F874A/877A devices are provided in Figure 1-1 and Figure 1-2, respectively. The pinouts for these device families are listed in Table 1-2 and Table 1-3.

Additional information may be found in the PICmicro® Mid-Range Reference Manual (DS33023), which may be obtained from your local Microchip Sales Representative or downloaded from the Microchip web site. The Reference Manual should be considered a complementary document to this data sheet and is highly recommended reading for a better understanding of the device architecture and operation of the peripheral modules.

TABLE 1-1: PIC16F87XA DEVICE FEATURES

Key Features	PIC16F873A	PIC16F874A	PIC16F876A	PIC16F877A
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 (bytes)	128	128	256	256
Interrupts	14	15	14	15
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
Analog Comparators	2	2	2	2
Instruction Set	35 Instructions	35 Instructions	35 Instructions	35 Instructions
Packages	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN

APPENDIX C

Datasheet PIC16F877A

17.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Ambient temperature under bias .... -55 to +125°C
Storage temperature .... -65°C to +150°C
Voltage on any pin with respect to VSS (except VDD, $\overline{MCLR}$, and RA4) .... -0.3V to (VDD + 0.3V)
Voltage on VDD with respect to VSS .... -0.3 to +7.5V
Voltage on $\overline{MCLR}$ with respect to VSS **(Note 2)** .... 0 to +14V
Voltage on RA4 with respect to Vss .... 0 to +8.5V
Total power dissipation **(Note 1)** 1.0W
Maximum current out of VSS pin .... 300 mA
Maximum current into VDD pin .... 250 mA
Input clamp current, IIK (VI < 0 or VI > VDD) .... ± 20 mA
Output clamp current, IOK (VO < 0 or VO > VDD) .... ± 20 mA
Maximum output current sunk by any I/O pin .... 25 mA
Maximum output current sourced by any I/O pin .... 25 mA
Maximum current sunk by PORTA, PORTB and PORTE (combined) **(Note 3)** .... 200 mA
Maximum current sourced by PORTA, PORTB and PORTE (combined) **(Note 3)** .... 200 mA
Maximum current sunk by PORTC and PORTD (combined) **(Note 3)** .... 200 mA
Maximum current sourced by PORTC and PORTD (combined) **(Note 3)** .... 200 mA

Note 1: Power dissipation is calculated as follows: Pdis = VDD x {IDD - Σ IOH} + Σ {(VDD - VOH) x IOH} + Σ(VOl x IOL)

2: Voltage spikes below VSS at the $\overline{MCLR}$ pin, inducing currents greater than 80 mA, may cause latch-up. Thus, a series resistor of 50-100Ω should be used when applying a "low" level to the $\overline{MCLR}$ pin rather than pulling this pin directly to VSS.

3: PORTD and PORTE are not implemented on PIC16F873A/876A devices.

† NOTICE: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

APPENDIX D

Datasheet MOSFET IRF540

FAIRCHILD SEMICONDUCTOR®

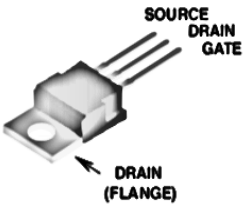
IRF540N

Data Sheet **January 2002**

33A, 100V, 0.040 Ohm, N-Channel, Power MOSFET

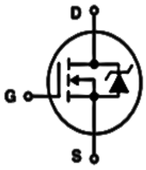
Packaging

JEDEC TO-220AB



IRF540N

Symbol



Features

- Ultra Low On-Resistance
  - $r_{DS(ON)} = 0.040\Omega$, $V_{GS} = 10V$
- Simulation Models
  - Temperature Compensated PSPICE™ and SABER© Electrical Models
  - Spice and SABER© Thermal Impedance Models
  - www.fairchildsemi.com
- Peak Current vs Pulse Width Curve
- UIS Rating Curve

Ordering Information

PART NUMBER	PACKAGE	BRAND
IRF540N	TO-220AB	IRF540N

Absolute Maximum Ratings $T_C = 25^oC$, Unless Otherwise Specified

		IRF540N	UNITS
Drain to Source Voltage (Note 1)	V_{DSS}	100	V
Drain to Gate Voltage ($R_{GS} = 20k\Omega$) (Note 1)	V_{DGR}	100	V
Gate to Source Voltage	V_{GS}	±20	V
Drain Current			
Continuous ($T_C = 25^oC$, $V_{GS} = 10V$) (Figure 2)	I_D	33	A
Continuous ($T_C = 100^oC$, $V_{GS} = 10V$) (Figure 2)	I_D	23	A
Pulsed Drain Current	I_{DM}	Figure 4	
Pulsed Avalanche Rating	UIS	Figures 6, 14, 15	
Power Dissipation	P_D	120	W
Derate Above 25^oC		0.80	$W/^oC$
Operating and Storage Temperature	T_J, T_{STG}	-55 to 175	^oC
Maximum Temperature for Soldering			
Leads at 0.063in (1.6mm) from Case for 10s	T_L	300	^oC
Package Body for 10s, See Techbrief TB334	T_{pkg}	260	^oC

NOTES:

1. $T_J = 25^oC$ to 150^oC.

***CAUTION:** Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.*

APPENDIX D

Datasheet MOSFET IRF540

IRF540N

Electrical Specifications $T_C = 25^oC$, Unless Otherwise Specified

PARAMETER	SYMBOL	TEST CONDITIONS		MIN	TYP	MAX	UNITS
OFF STATE SPECIFICATIONS							
Drain to Source Breakdown Voltage	BV_{DSS}	$I_D = 250\mu A$, $V_{GS} = 0V$ (Figure 11)		100	-	-	V
Zero Gate Voltage Drain Current	I_{DSS}	$V_{DS} = 95V$, $V_{GS} = 0V$		-	-	1	µA
		$V_{DS} = 90V$, $V_{GS} = 0V$, $T_C = 150^oC$		-	-	250	µA
Gate to Source Leakage Current	I_{GSS}	$V_{GS} = \pm 20V$		-	-	±100	nA
ON STATE SPECIFICATIONS							
Gate to Source Threshold Voltage	$V_{GS(TH)}$	$V_{GS} = V_{DS}$, $I_D = 250\mu A$ (Figure 10)		2	-	4	V
Drain to Source On Resistance	$r_{DS(ON)}$	$I_D = 33A$, $V_{GS} = 10V$ (Figure 9)		-	0.033	0.040	Ω
THERMAL SPECIFICATIONS							
Thermal Resistance Junction to Case	$R_{\theta JC}$	TO-220		-	-	1.25	$^oC/W$
Thermal Resistance Junction to Ambient	$R_{\theta JA}$			-	-	62	$^oC/W$
SWITCHING SPECIFICATIONS ($V_{GS} = 10V$)							
Turn-On Time	t_{ON}	$V_{DD} = 50V$, $I_D = 33A$, $V_{GS} = 10V$, $R_{GS} = 9.1\Omega$ (Figures 18, 19)		-	-	100	ns
Turn-On Delay Time	$t_{d(ON)}$			-	9.5	-	ns
Rise Time	t_r			-	57	-	ns
Turn-Off Delay Time	$t_{d(OFF)}$			-	40	-	ns
Fall Time	t_f			-	55	-	ns
Turn-Off Time	t_{OFF}			-	-	145	ns
GATE CHARGE SPECIFICATIONS							
Total Gate Charge	$Q_{g(TOT)}$	$V_{GS} = 0V$ to $20V$	$V_{DD} = 50V$, $I_D = 33A$, $I_{g(REF)} = 1.0mA$ (Figures 13, 16, 17)	-	66	79	nC
Gate Charge at 10V	$Q_{g(10)}$	$V_{GS} = 0V$ to $10V$		-	35	42	nC
Threshold Gate Charge	$Q_{g(TH)}$	$V_{GS} = 0V$ to $2V$		-	2.4	2.9	nC
Gate to Source Gate Charge	Q_{gs}			-	5.4	-	nC
Gate to Drain "Miller" Charge	Q_{gd}			-	13	-	nC
CAPACITANCE SPECIFICATIONS							
Input Capacitance	C_{ISS}	$V_{DS} = 25V$, $V_{GS} = 0V$, f = 1MHz (Figure 12)		-	1220	-	pF
Output Capacitance	C_{OSS}			-	295	-	pF
Reverse Transfer Capacitance	C_{RSS}			-	100	-	pF

Source to Drain Diode Specifications

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Source to Drain Diode Voltage	V_{SD}	$I_{SD} = 33A$	-	-	1.25	V
		$I_{SD} = 17A$	-	-	1.00	V
Reverse Recovery Time	t_{rr}	$I_{SD} = 33A$, $dI_{SD}/dt = 100A/\mu s$	-	-	112	ns
Reverse Recovered Charge	Q_{RR}	$I_{SD} = 33A$, $dI_{SD}/dt = 100A/\mu s$	-	-	400	nC

APPENDIX D

Datasheet MOSFET IRF540

Typical Performance Curves (Continued)

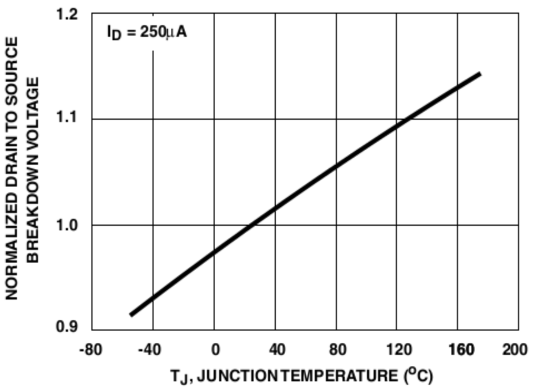


FIGURE 11. NORMALIZED DRAIN TO SOURCE BREAKDOWN VOLTAGE vs JUNCTION TEMPERATURE

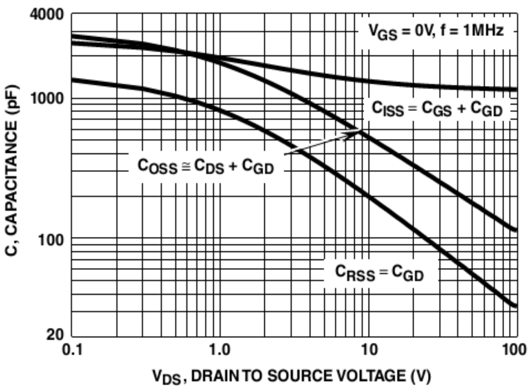
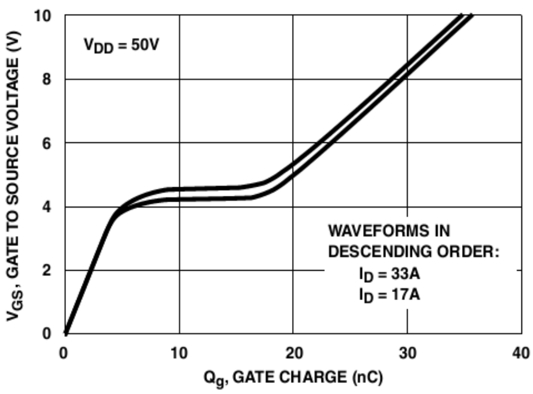


FIGURE 12. CAPACITANCE vs DRAIN TO SOURCE VOLTAGE



NOTE: Refer to Application Notes AN7254 and AN7260.

FIGURE 13. GATE CHARGE WAVEFORMS FOR CONSTANT GATE CURRENT

Test Circuits and Waveforms

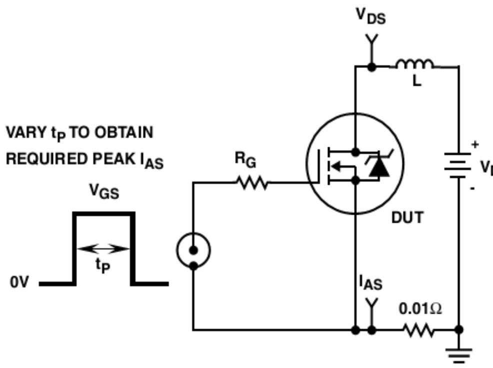


FIGURE 14. UNCLAMPED ENERGY TEST CIRCUIT

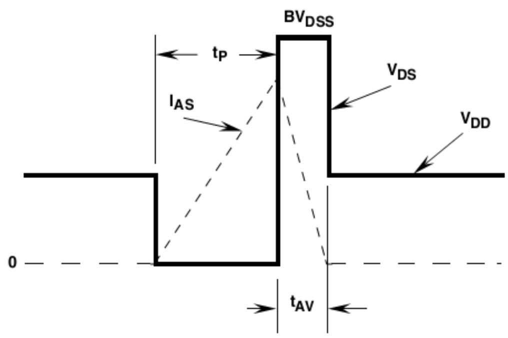


FIGURE 15. UNCLAMPED ENERGY WAVEFORMS

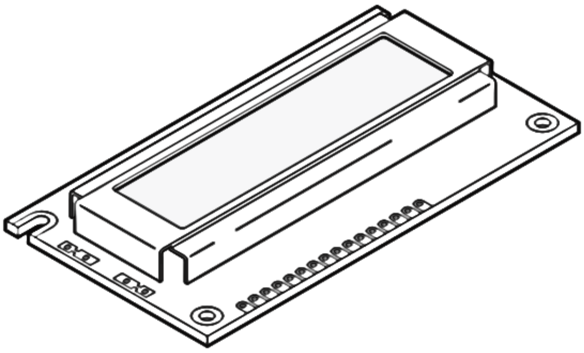
APPENDIX E

Datasheet 16x2 Alphanumeric LCD Module

ALPHANUMERIC LCD DISPLAY (16 x 2)

Order Code

LED008 16 x 2 Alphanumeric Display
FRM010 Serial LCD Firmware (optional)



Contents

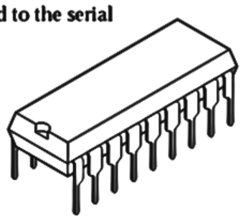
1 x 16x2 Alphanumeric Display
1 x data booklet

Introduction

Alphanumeric displays are used in a wide range of applications, including palmtop computers, word processors, photocopiers, point of sale terminals, medical instruments, cellular phones, etc. The 16 x 2 intelligent alphanumeric dot matrix display is capable of displaying 224 different characters and symbols. A full list of the characters and symbols is printed on pages 7/8 (note these symbols can vary between brand of LCD used). This booklet provides all the technical specifications for connecting the unit, which requires a single power supply (+5V).

Further Information

Available as an optional extra is the Serial LCD Firmware, which allows serial control of the display. This option provides much easier connection and use of the LCD module. The firmware enables microcontrollers (and microcontroller based systems such as the PICAXE) to visually output user instructions or readings onto an LCD module. All LCD commands are transmitted serially via a single microcontroller pin. The firmware can also be connected to the serial port of a computer.



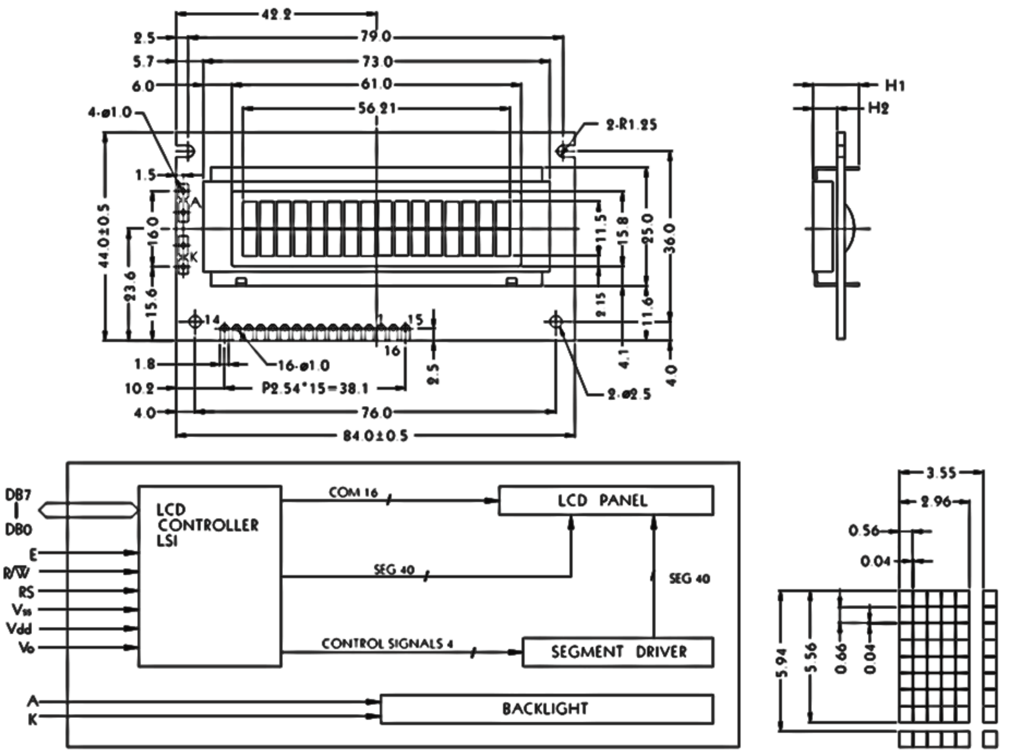
An example PICAXE instruction to print the text 'Hello' using the **serout** command is as follows:

```
serout 7,T2400,("Hello")
```

APPENDIX E

Datasheet 16x2 Alphanumeric LCD Module

Outline Dimension and Block Diagram



The tolerance unless classified ±0.3mm

MECHANICAL SPECIFICATION			
Overall Size	84.0 * 44.0	Module	H2 / H1
View Area	61.0 * 15.8	W/O B/L	5.1 / 9.7
Dot Size	0.56 * 0.66	EL B/L	5.1 / 9.7
Dot Pitch	0.60 * 0.70	LED B/L	9.4 / 14.0

PIN ASSIGNMENT

Pin no	Symbol	Function
1	Vss	Power supply (GND)
2	Vdd	Power supply (+5V)
3	Vo	Contrast Adjust
4	RS	Register select signal
5	R/W	Data read /write
6	E	Enable signal
7	DB0	Data bus line
8	DB1	Data bus line
9	DB2	Data bus line
10	DB3	Data bus line
11	DB4	Data bus line
12	DB5	Data bus line
13	DB6	Data bus line
14	DB7	Data bus line
15	A	Power supply for LED B/L (+)
16	K	Power supply for LED B/L (−)

ABSOLUTE MAXIMUM RATING

Item	Symbol	Conditions	Min.	Max.	Unit
Power Supply Voltage	Vdd—Vss	—	0	7	V
LCD Driving Supply Voltage	Vdd—Vee	—	0	13	V
Input Voltage	Vin	—	−0.3	Vdd+0.3	V
Operating Temperature	Topr	Nor.	0	50	°C
Storage Temperature	Tstg	Nor.	−20	+70	°C

ELECTRICAL CHARACTERISTICS (Vdd = +5V, Ta = 25°C)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Logic Supply Voltage	Vdd	—	4.5	5	5.5	V
"H" Input Voltage	V_{IH}	—	2.2	—	—	V
"L" Input Voltage	V_{IL}	—	—	—	0.6	V
"H" Output Voltage	V_{OH}	—	2.4	—	—	V
"L" Output Voltage	V_{OL}	—	—	—	0.4	V
Supply Current	Idd	—	2	—	—	mA
LCD Driving Voltage	V_{LCD}	Vdd—Vo	4.3	—	4.8	V

APPENDIX E

Datasheet 16x2 Alphanumeric LCD Module

Electrical Characteristics

Vdd = 5V±5%
Vss = 0V

Item	Symbol	Condition	Standard value			Unit	Applicable terminal
			Min.	Typ.	Max.		
Power voltage	Vdd		4.5	5.00	5.5	V	Vdd
Input H- level voltage	VIH		2.2	—	Vdd	V	RS, R/$\overline{W}$, E DB0~DB7
Input L - level voltage	VIL		−0.3	—	0.6	V	
Output H - level voltage	VOH	−IOH = 0.205mA	2.4	—	—	V	DB0~DB7
Output L - level voltage	VOL	IOL = 1.2mA	—	—	0.4	V	
I/O leakage current	IIL	Vin = 0~Vdd	−1	—	1.0	μA	RS, R/$\overline{W}$, E DB0~DB7
Supply current	Idd	Vdd = 5V	2	—	—	mA	Vdd
LCD operating voltage	VLCD	Vdd—V0	3.0	—	11.0	V	V0

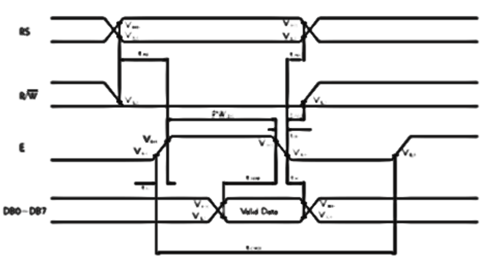
Timing Characteristics

Vdd = 5V±5%
Vss = 0V

Item		Symbol	Min.	Max.	Unit
Enable cycle time		TCYCE	500	—	ns
Enable pulse width	"High" level	PWEH	220	—	ns
Enable rise / fall time		TER, TEF	—	25	ns
Set-up time	RS, R/$\overline{W}$, E	TAS	40	—	ns
Address hold time		TAH	10	—	ns
Data set-up time		TDSH	60	—	ns
Data delay time		TDDR	60	120	ns
Data hold time (writing)		TH	10	—	ns
Data hold time (reading)		TDHR	20	—	ns
Clock oscillating frequency		TOSC	270(TYP)		KHz

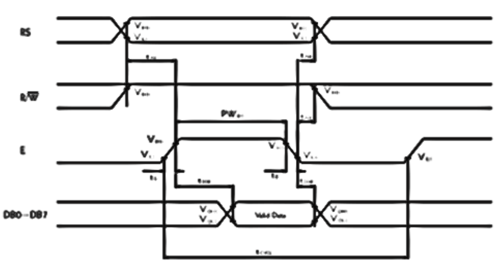
Timing Chart

◆ FIG.1 WRITE OPERATION



(Write Data from MPU to MODULE)

◆ FIG.2 READ OPERATION



(Read Data from MODULE to MPU)

APPENDIX F

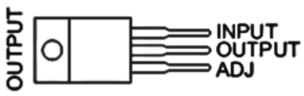
Datasheet LM 317

LM317
3-TERMINAL ADJUSTABLE REGULATOR

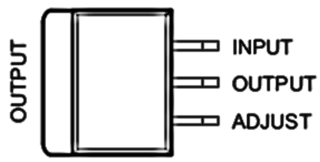
SLVS044O – SEPTEMBER 1997 – REVISED JULY 2003

- **Output Voltage Range Adjustable From 1.25 V to 37 V**
- **Output Current Greater Than 1.5 A**
- **Internal Short-Circuit Current Limiting**
- **Thermal Overload Protection**
- **Output Safe-Area Compensation**

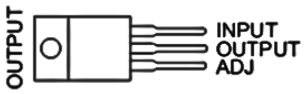
KC (TO-220) PACKAGE
(TOP VIEW)



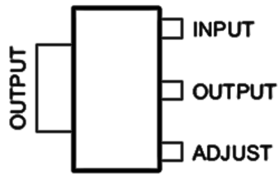
KTE PACKAGE
(TOP VIEW)



KCS (TO-220) PACKAGE
(TOP VIEW)



DCY (SOT-223) PACKAGE
(TOP VIEW)



description/ordering information

The LM317 is an adjustable three-terminal positive-voltage regulator capable of supplying more than 1.5 A over an output-voltage range of 1.25 V to 37 V. It is exceptionally easy to use and requires only two external resistors to set the output voltage. Furthermore, both line and load regulation are better than standard fixed regulators.

ORDERING INFORMATION

T_J	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 125°C	POWER-FLEX (KTE)	Reel of 2000	LM317KTER	LM317
	SOT-223 (DCY)	Tube of 80	LM317DCY	L3
		Reel of 2500	LM317DCYR	
	TO-220 (KC)	Tube of 50	LM317KC	LM317
	TO-220, short shoulder (KCS)	Tube of 20	LM317KCS	

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

APPENDIX F

Datasheet LM 317

recommended operating conditions

		MIN	MAX	UNIT
$V_I - V_O$	Input-to-output voltage differential	3	37	V
I_O	Output current		1.5	A
T_J	Operating virtual junction temperature	0	125	°C

electrical characteristics over recommended ranges of operating virtual junction temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			MIN	TYP	MAX	UNIT
Line regulation‡	$V_I - V_O$ = 3 V to 40 V		T_J = 25°C		0.01	0.04	%/V
			T_J = 0°C to 125°C		0.02	0.07	
Load regulation	I_O = 10 mA to 1500 mA	C_{ADJ} = 10 μF§, T_J = 25°C	$V_O \le 5$ V			25	mV
			$V_O \ge 5$ V		0.1	0.5	$\%V_O$
		T_J = 0°C to 125°C	$V_O \le 5$ V		20	70	mV
			$V_O \ge 5$ V		0.3	1.5	$\%V_O$
Thermal regulation	20-ms pulse,	T_J = 25°C			0.03	0.07	$\%V_O$/W
ADJUST terminal current					50	100	μA
Change in ADJUST terminal current	$V_I - V_O$ = 2.5 V to 40 V, $P_D \le 20$ W, I_O = 10 mA to 1500 mA				0.2	5	μA
Reference voltage	$V_I - V_O$ = 3 V to 40 V, $P_D \le 20$ W, I_O = 10 mA to 1500 mA			1.2	1.25	1.3	V
Output-voltage temperature stability	T_J = 0°C to 125°C				0.7		$\%V_O$
Minimum load current to maintain regulation	$V_I - V_O$ = 40 V				3.5	10	mA
Maximum output current	$V_I - V_O \le 15$ V,	$P_D < P_{MAX}$ (see Note 1)		1.5	2.2		A
	$V_I - V_O \le 40$ V, $P_D < P_{MAX}$ (see Note 1), T_J = 25°C			0.15	0.4		
RMS output noise voltage (% of V_O)	f = 10 Hz to 10 kHz,	T_J = 25°C			0.003		$\%V_O$
Ripple rejection	V_O = 10 V,	f = 120 Hz	C_{ADJ} = 0 μF§		57		dB
			C_{ADJ} = 10 μF§	62	64		
Long-term stability	T_J = 25°C				0.3	1	%/1k Hrs

† Unless otherwise noted, the following test conditions apply: $|V_I - V_O|$ = 5 V and I_{OMAX} = 1.5 A, T_J = 0°C to 125°C. Pulse testing techniques are used to maintain the junction temperature as close to the ambient temperature as possible.

‡ Line regulation is expressed here as the percentage change in output voltage per 1-V change at the input.

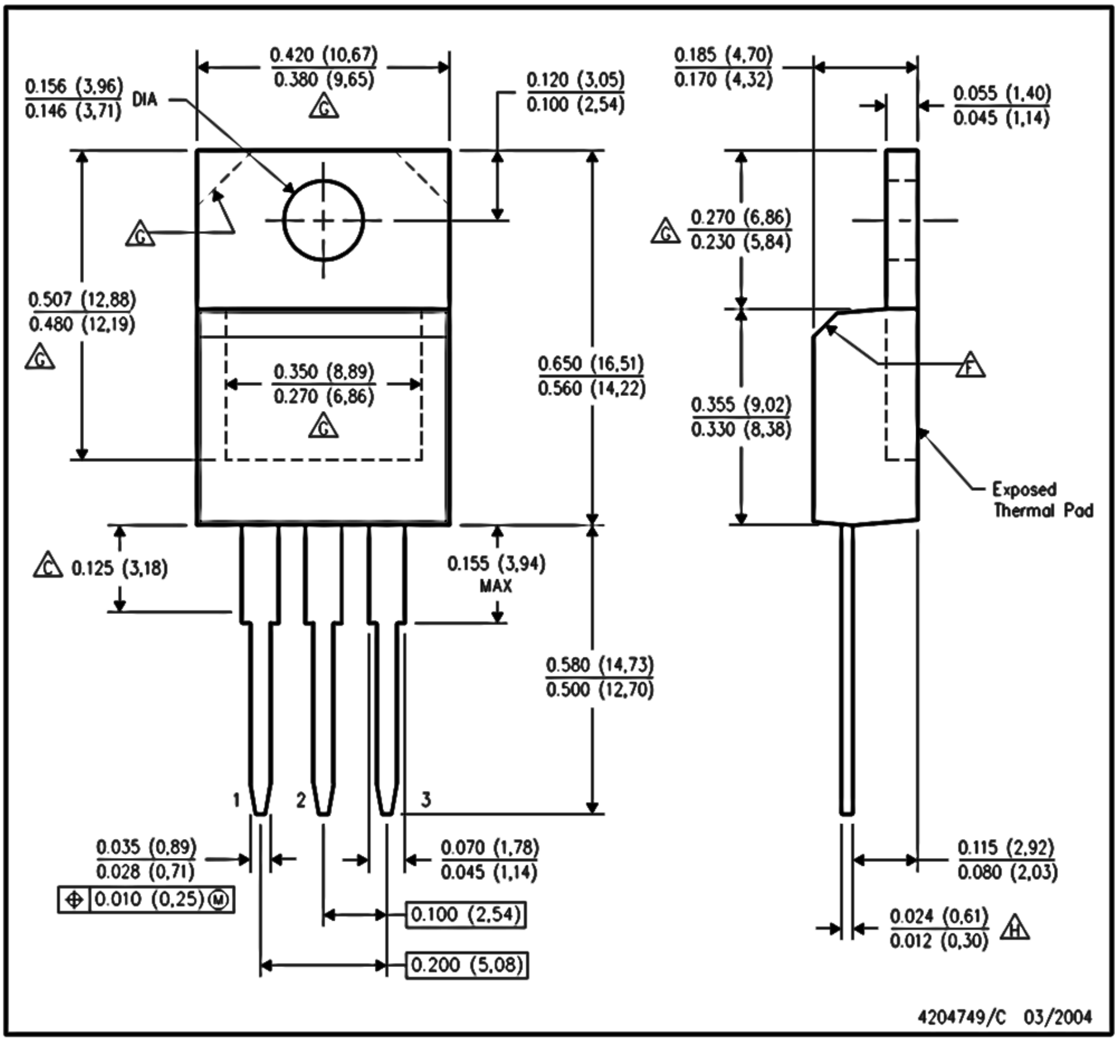
§ C_{ADJ} is connected between the ADJUST terminal and GND.

NOTE 1: Maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.

APPENDIX F

Datasheet LM 317

KCS (R-PSFM-T3) PLASTIC FLANGE-MOUNT PACKAGE



NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Lead dimensions are not controlled within this area.
- D. All lead dimensions apply before solder dip.
- E. The center lead is in electrical contact with the mounting tab.
- F. The chamfer is optional.
- G. Thermal pad contour optional within these dimensions.
- H. Falls within JEDEC TO-220 variation AB, except minimum lead thickness.

APPENDIX G

Cost of Project

FKEE/PSM/3(A)

FAKULTI KEJURUTERAAN ELEKTRIK & ELEKTRONIK
UNIVERSITI MALAYSIA PAHANG (UMP)
BORANG PEMBELIAN KOMPONEN/BAHAN PSM

Sila isi secara **bertaip** dalam **3** salinan dan hantar bersama **1** salinan litar projek berkaitan
Komponen yang rosak kerana kecuaian pelajar tidak boleh diganti

Nama Pelajar:	**AIESYAH GHAZALI**	**Nama Penyelia: NOR LAILI ISMAIL**	
ID No:	**EC08027**	**Tajuk Projek: BATTERY LEVEL MONITORING SYSTEM**	**PSM 1/ PSM 2** (tanda yang berkenaan)

Bil	Bahan/Komponen	Spesifikasi	Anggaran Harga / unit	Kuantiti	Anggaran Harga
1	Resistor	10K	RM 0.04	16	RM 0.64
2		100K	RM 0.04	10	RM 0.40
3		100	RM 0.04	1	RM 0.04
4		220	RM 0.04	1	RM 0.04
5		330	RM 0.04	2	RM 0.08
6		2.2K	RM 0.04	2	RM 0.08
7	Electrolyte Capacitor	100u	RM 0.25	2	RM 0.50
8	Capacitor	330n	RM 0.12	1	RM 0.12
9		100n	RM 0.30	3	RM 0.90
10		100u	RM 0.25	2	RM 0.50
11		22p	RM 0.08	2	RM 0.16
12	Voltage Regulator	7805	RM 0.90	1	RM 0.90
13		LM317		1	
14	LED	Red	RM 0.12	1	RM 0.12
15		Yellow	RM 0.12	1	RM 0.12
16	Switch	ON/OFF	RM 0.50	1	RM 0.50
17	Crystal	12MHZ	RM 1.90	1	RM 1.90
18	MOSFET	IRF540	RM 2.10	2	RM 4.20
19	IC Base	28 PIN	RM 0.60	2	RM 1.20
20	Switch Push Button		RM 0.60	4	RM 2.40
21	Transistor	BC557	RM 1.00	1	RM 1.00
22		BC547	RM 0.50	1	RM 0.50
23	PIC16F876A	MICROCONTROLLER	RM 25.00	1	RM 25.00
24	Diode	1N4001	RM 0.50	1	RM 0.50
25	LCD	16X2	RM 20.00	1	RM 20.00
26	Independent Board			1	
27	Soldering Lead			1	
28	Wraping Wire		RM 13.50	1	RM 13.50
29	Header		RM 0.80	4	RM 3.20
30	Crocodile Clip			2	
31	Female Header			1	
32	Heat Sink		RM 0.70	2	RM 1.40
33	Potentiometer	5K	RM 2.30	1	RM 2.30

APPENDIX G

Cost of Project

FKEE/PSM/3(A)

34	Stand			4	
35	Jumper				
36	Connector	3 way	RM 1.20	1	RM 1.20
JUMLAH ANGGARAN HARGA					RM 92.40

Catatan
Penyelia: ....

Pengesahan Penyelia:

NOR LAILI BINTI ISMAIL
PENSYARAH
FAKULTI KEJURUTERAAN ELEKTRIK & ELEKTRONIK
UNIVERSITI MALAYSIA PAHANG
26600 PEKAN
PAHANG DARUL MAKMUR
09-4242100 FAKS : 09-4242032

8/3/2012

....

Tarikh: ....

Pengesahan Juruteknik/Pembantu Makmal:

....

Tarikh: ....

* satu salinan bagi penyelia, pelajar dan makmal

APPENDIX H

Project Circuit