UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS◆

JUDUL: **DEVELOPMENT OF SOLAR BATTERY INDICATOR**

SESI PENGAJIAN: **2006/2007**

Saya **AHMAD FADZLI BIN AHMAD TARMUGI (870307-23-5357)**
(HURUF BESAR)

mengaku membenarkan tesis (Sarjana Muda/~~Sarjana~~ /~~Doktor Falsafah~~)* ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hakmilik Universiti Malaysia Pahang (UMP).
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

[ ]	**SULIT**	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
[ ]	**TERHAD**	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
[√]	**TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS) (TANDATANGAN PENYELIA)

Alamat Tetap:

C01/06 RUMAH KAKITANGAN FELDA
BUKIT KEPAYANG, 28300, TRIANG,
PAHANG

RUHAIZAD BIN ISHAK
(Nama Penyelia)

Tarikh: **23 NOVEMBER 2009** Tarikh: : **23 NOVEMBER 2009**

CATATAN:
* Potong yang tidak berkenaan.
** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh tesis ini perlu dikelaskan sebagai atau TERHAD.
◆ Tesis dimaksudkan sebagai tesis bagi Ijazah doktor Falsafah dan Sarjana secara Penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).

"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Power System)"

Signature : ______________________

Name : RUHAIZAD BIN ISHAK

Date : 23 NOVEMBER 2009

DEVELOPMENT OF SOLAR BATTERY INDICATOR

AHMAD FADZLI BIN AHMAD TARMUGI

This thesis is submitted as partial fulfillment of the requirement for the award of the Bachelor Degree of Electrical Engineering (Power Systems)

Faculty of Electrical & Electronics Engineering

Universiti Malaysia Pahang

NOVEMBER, 2009

"All the trademark and copyrights use herein are property of their respective owner. References of information from other sources are quoted accordingly; otherwise the information presented in this report is solely work of the author."

Signature :

Author : AHMAD FADZLI BIN AHMAD TARMUGI

Date : 23 NOVEMBER 2009

Special dedicated to

My beloved family and those people who have guided and inspired me throughout my journey of education

ACKNOWLEGEMENT

In The Name of God, The Most Beneficent The Most Gracious

First and foremost, I would like to express my heartily gratitude to my supervisor, Mr. Ruhaizad Bin Ishak for the guidance and enthusiasm given throughout the progress of this project and I am deeply in debt. I have learned a great deal from him in moral and academic matters, in improving my written documentation skill and in wide variety of area through his consistent mentoring as my project adviser.

My appreciation also goes to my family who has been so tolerant and supports me all this years. Their always encouraged me to ask questions, to curious about how things work. Thanks for their encouragement, love and emotional supports that they had given to me.

Nevertheless, I would like to thank my entire group members for their strong support and helping me to finish this project. There is no such meaningful word than.....Thank You So Much.

ABSTRACT

The objective of this project is to create or design the solar battery indicator to monitor the percentage capacity of the battery. The purpose of the use solar energy in this project is to replace the existing energy by use the solar energy to charge the battery using the charging circuit and to improve the solar energy to a new application. This project design is separated into two basic parts which are the charging circuit which is solar charging circuit and the solar battery indicator circuit. The main task of charging circuit use in this project is to charge and store the sun energy from solar panel into the battery. The battery use in this project is 12V 7A lead-acid battery which is fit for storing the energy from the solar panel. The solar battery indicator circuit using as the load for the 12V 7A lead-acid battery. Main task of this circuit is to check the capacity of the battery when the battery is charging and when the battery is use. The circuit will display the percentage of the voltage capacity in the battery by using the seven-segment display and the range of the voltage charge and discharge will use LED as monitoring display.

ABSTRAK

Objektif projek ini adalah untuk membina pemapar bateri solar untuk memapar peratusan kapasiti sesebuah bateri. Tujuan penggunaan tenaga suria ini adalah untuk menggantikan tenaga yang sedia ada bagi mengecas bateri disamping menggunakan litar pengecas dan menambah baik penggunaan tenaga suria untuk kegunaan aplikasi baru. Projek ini dapat dibahagikan kepada dua bahagian dimana bahagian pertama ialah pengecas suria manakala bahagian kedua meliputi litar pemapar. Tugas utama litar pengecas dalam projek ini adalah untuk mengecas dan menyimpan tenaga daripada tenaga suria melalui panel suria kedalam bateri. Bateri yang digunakan dalam projek ini adalah 12 V 7A bateri asid sulfurik yang mana telah disesuaikan untuk menyimpan tenaga daripada panel suria. Litar pemapar bateri akan digunakan sebagai beban untuk bateri ini. Tugas utama litar pemapar ini adalah untuk menyemak kapasiti bateri semasa bateri dicas dan dinyahcas. Litar ini akan memaparkan peratusan voltan yang terdapat dalam bateri dengan menggunakan pemapar seven-segmen dan julat semasa bateri dicas dan dinyahcas akan dipaparkan melalui LED.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

A	-	Ampere
Ah	-	Ampere per hours
R	-	Resistor
kWh	-	kilowatts per hours
W	-	Watts
m^2	-	meter square
m	-	mili
V	-	Voltage
u	-	mikro
F	-	Farad

LIST OF ABBREVIATION

DC	-	Direct Current
PWM	-	Pulse Width Modulation
IC	-	Integrated Circuit
AC	-	Alternating Current
Ni-Cd	-	Nickel-Cadmium
DP	-	Decimal Point
Q	-	Transistor
LED	-	Light Emitting Diode
BCD	-	Binary Code Decimal
SC	-	Short Circuit
PV	-	Photo Voltaic

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 Overview

Solar energy is the light and radiant heat from the Sun that influence Earth's climate and weather sustains life. Solar power is synonym to solar energy or more specifically to refer the electricity generated from solar radiation. Solar energy technologies can provide electrical generation by heat engine or photovoltaic means; space heating and cooling in active and passive solar buildings, day lighting, hot water, thermal energy for cooking, and high temperature process heat for industrial purposes. Since this technology is still new in Malaysia, so the using of solar as electric source is limited. So, in this case, solar energy is use to replace the existing power supply because solar energy is the renewable energy and can minimize the pollution to the earth.

This project is use the solar energy as the main supply and applies the existing solar energy to a new application. To supply the required voltage to the battery indicator, a voltage regulator needed to reduce the voltage from the solar panel which is up to 20 VDC depend on the sunlight energy to 5 VDC. The first step to start this project is to make a research and thorough analysis about the panel solar that will be used for this project. After obtaining the data needed, a charger circuit must be design to charge the battery. This will ensure that the charger which will be charge the battery are functioning and will be able to supply the battery indicator circuits which have function as a load. Besides that, the battery indicator needs to be design as the monitor to the battery capacity. This battery indicator will use seven – segment and light emitting diode (LED) as the display.

1.2 Objective

The aim of this project is to design or invent the solar battery indicator which uses the solar energy using solar cell to produce the electric energy. On the other hand, this project wants to implement the renewable energy to replace the permanent energy such as oil or charcoal. The objective of this project is to:

i. To use a renewable energy in order to replace the existing supply.

ii. To charge and stored solar energy in the battery using the charging circuit.

iii. To design the battery indicator to monitor the percentage capacity of the battery.

1.3 Scope of Project

These projects obviously focus on hardware implementation. This project is divided into two parts of hardware implementation which are solar charger circuit and the battery indicator circuit. Several scopes need to be proposed in these projects which are:

i. Solar panel will produce up to 20V DC from sun energy depend on sunlight.

ii. The output from the solar panel will use to give supply to the battery 12V DC 7Ah by using the charger circuit.

iii. Voltage regulator will reduce the voltage from battery which is from 12V DC 7Ah to 5V DC to the battery indicator.

iv. Battery indicator will use seven – segment and LED as monitoring display.

v. Charged battery will use when the solar supply cannot operate.

1.4 Problem Statement

Nowadays, there are many type of energy that can be used as a power supply by using the equipment that can convert it to into electricity. Solar energy is the renewable energy that not be commercialize as a supply than other energy such as hydro energy and charcoal energy and not many appliances use this solar energy. So this project main objective is to use the solar energy as main supply and implement it to other electrical appliances. On the other hand, the battery use cannot display the percentage of the capacity of the battery when it in use or charge. Hopefully, this battery monitoring circuit will overcome the problem by display the capacity of the voltage by using the percentage of use and discharged of the battery.

1.4 Thesis Organization

Including this chapter, it consist of 5 chapter altogether. Chapter 1 is contained full description of the project, chapter 2 is article review, chapter 3 consists of the project methodology, mostly about the project flow and how it's organized. Chapter 4 presents the expected result, while the conclusion in chapter 5.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A review of the article was performed to identify studies that relevant to the topic. A combination of the following keywords was used to identify relevant material. In this chapter, the researcher reviews article and past research about the component and device used to make this project a reality. Literature review has been made from various sources like journals, books, articles and others. A study about this project had being identified which are solar battery indicator which is integrated with the solar panel to produces power supply from sun energy, voltage regulator to give the suitable voltage to the solar battery indicator, solar charger to charge the battery, suitable battery specification use for this project and seven-segment and LED display to monitoring the capacity of the battery.

2.2 Solar Energy

A solar cell or photovoltaic cell is a device that converts sunlight directly into electricity by the photovoltaic effect. Photovoltaic are the field of technology and research related to the application of solar cells in producing electricity for practical use [1] means that the electric energy can be produce by the solar energy by using the solar panel and output energy from solar panel can be used for the domestic use. Solar power technologies provide electrical generation by means of heat engines or photovoltaic [2] that means the solar energy can provide the electric energy by using the suitable technology to convert the sun energy to the electric energy. Solar panel which is also known as photovoltaic is a device that is capable to converting at least a portion of solar light incident thereon into electrical energy [3]. It means that solar energy can convert its energy into the electric energy which we need to use solar energy as main supply to the project. The wind and solar power constitute the primary power generation system and diesel generators act as backup.

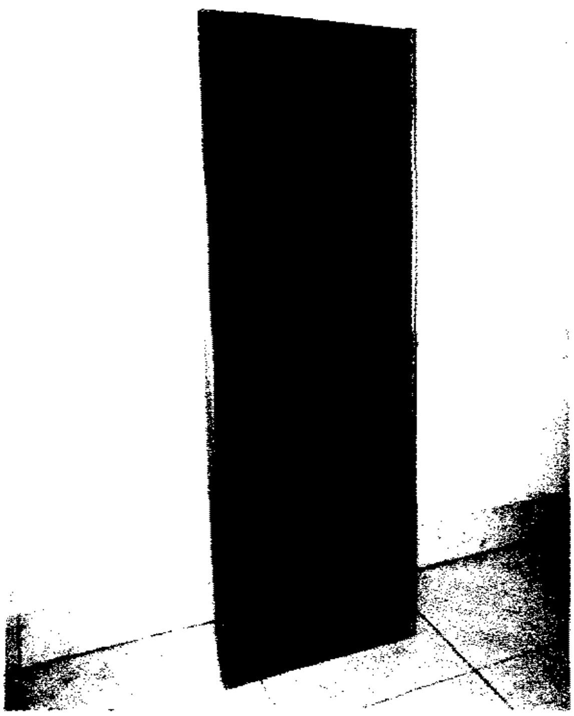


Figure 2.1: Solar Panel

Model	Sunmodule SW80 mono/RSE
Rated Max. Power, P_{max}(W)	80(±5%)
Open Circuit Voltage, Vsc(V)	21.9
Rated Voltage, Vrated(V)	17.5
Short Circuit Current, Isc(A)	5
Rated Current, Irated(A)	4.58
Maximum System Voltage, (V)	715AC

Table 2.0: Solar Panel Specification

2.3 Voltage Regulator

Voltage regulator which is has a function to fix the output voltage in certain value will play important role. It includes a capacitor to provide a regulated voltage and a regulation circuit for closing the regulation switch when the regulated voltage is below reference voltage [4]. This is because every appliance must get stable voltage to operate. In this case, a voltage regulator needs to be design in case to get appropriate value of voltage. Voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. Depending on the design, it may be used to regulate one or more AC or DC voltages [5] means that the main function of the regulator is to give the maintain voltage and it convert the AC or DC voltage according to the system design of the regulator.

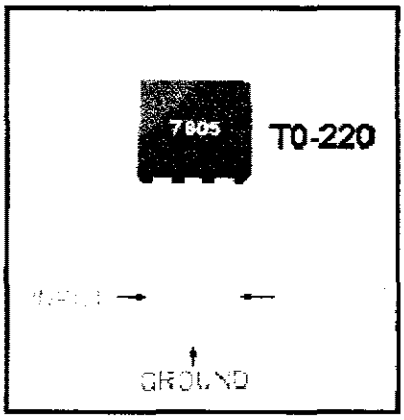


Figure 2.2: Voltage Regulator

2.4 Solar Charger

A solar charger employs solar energy. They are generally portable. Solar chargers are also used for charging of lead acid or Ni-Cd battery bank up to 48 V & hundreds Ampere-Hours (up to 400Ah) capacity. For such type of solar chargers, generally intelligent charge controllers are used. A series of solar cell array plates are installed separately on roof top of buildings & can be connected to battery bank through intelligent charge controllers. As solar chargers are good source of green energy, such arrangement can also be used in addition to mains supply chargers for energy saving during day times [6].

2.5 Lead-Acid Battery

Knowledge of the charge efficiency of lead-acid batteries near top-of-charge is important to the design of small photovoltaic systems. In order to know how much energy is required from the photovoltaic array in order to accomplish the task of meeting load, including periodic full battery charge, a detailed knowledge of the battery charging efficiency as a function of state of charge is required, particularly in the high state-of-charge regime, as photovoltaic systems are typically designed to operate in the upper 20 to 30% of battery state-of-charge [7]. It means we have to know the energy produce by the solar panel to ensure the lead/acid battery is charge.

Figure 2.3: Lead-acid battery

2.6 Seven-segment

A seven segment display, as its name indicates, is composed of seven elements. The seven segments are arranged as a rectangle of two vertical segments on each side with one horizontal segment on the top and bottom. Additionally, the seventh segment bisects the rectangle horizontally [8]. There are 2 type of seven-segment which are common anode which is the supply from the positive supply and seven-segment connected to negative supply is called common cathode. The segments of a 7-segment display are referred to by the letters A to G, where the optional DP decimal point is used for the display of non-integer numbers.

Figure 2.4: Seven-Segment Displays

2.7 Types of Charger

There are various types of battery chargers like mobile battery charger, car battery charger and etc. The duty of all the chargers is the same, that is, to basically charge a battery. With many types of chargers out in the market, it is essential to find out which would suit ones' requirement and necessity, so that the chargers can be of maximum use to the user.

2.7.1 Switch Mode Regulator

Also called as a Switcher, these regulators use the modulation of pulse width for controlling the voltage. The power wastage is also comparatively less in this type of charging. The size of the whole component can be reduced with the help of using high switch frequency [9].

2.7.2 Series Regulator or Linear Regulator

This type of charging is less complex but the power wastage is more here. Here the load current moves through the regulating transistor, which is usually a device of high power. Due to the unavailability of switching, the current produced is pure DC type and so there is no need of an output filter. It is very suitable for low noise producing devices [9].

2.7.3 Shunt Regulators

They are common photo-voltaic systems as they are quite inexpensive to build and easy to design. This type of charging does not allow over-charging, as the PV output is shunted when the voltage reaches the correct level, and hence the name [9].

2.7.4 Buck Regulator

This is a switching type of charger that uses a step-down DC-DC converter. Here the heat loss is very less and the efficiency is also very high. Also these types of chargers can handle high current-outputs [9].

2.7.5 Pulse Charging

These types of chargers make use of a series transistor, which has the facility of being switched as well. Part of the cycle it acts as a switch regulator and so less wastage of power and heat is maintained. When the charger is at rest, the polarization is reduced as well. These types of chargers require current limiting in its input sources, for safety features and reasons.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will discuss on the methods that will be use to ensure the project could achieve the objective and scope of the project. Thus, all the methods need to be done as in schedule so that this project could be completed within the time. There are several steps to be applied in designing a solar battery indicator. Most of the electronics devices are sold in the stores that require designing the solar battery indicator. This project will be able to monitor the capacity of the battery which use in this project. The battery use in this project is 12V DC lead-acid battery. The relevant information is gathered through literature review. Figure 1 shows the block diagram of whole system that has been applied.

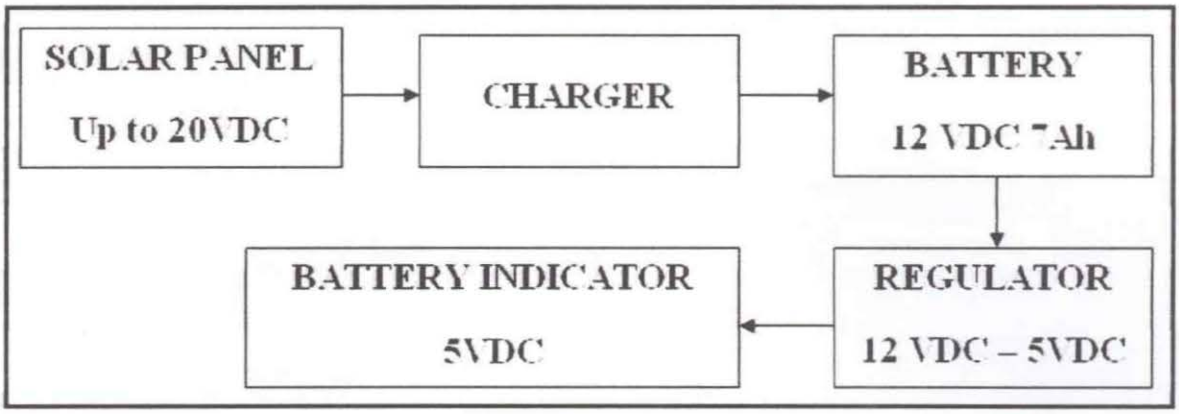


Figure 3.1: Block Diagram of the Solar Battery Indicator

Figure 3.1 shows that's the solar panel will produce the energy from the sunlight which is up to 20 VDC to supply the solar charger which use the 12 VDC. The solar charger will charge the battery during day time and store the energy in the battery for night use or when there is no sunlight energy. The voltage regulator will convert the voltage from the battery for suitable use of the solar battery indicator which is 5VDC.

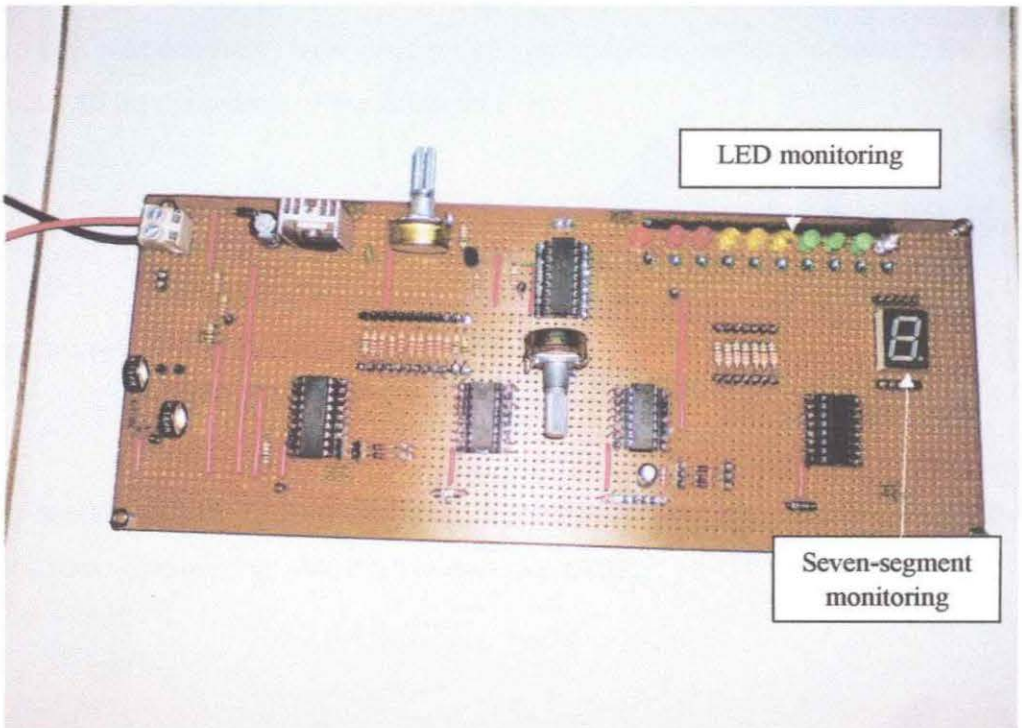


Figure 3.2: Develop Monitoring Circuit

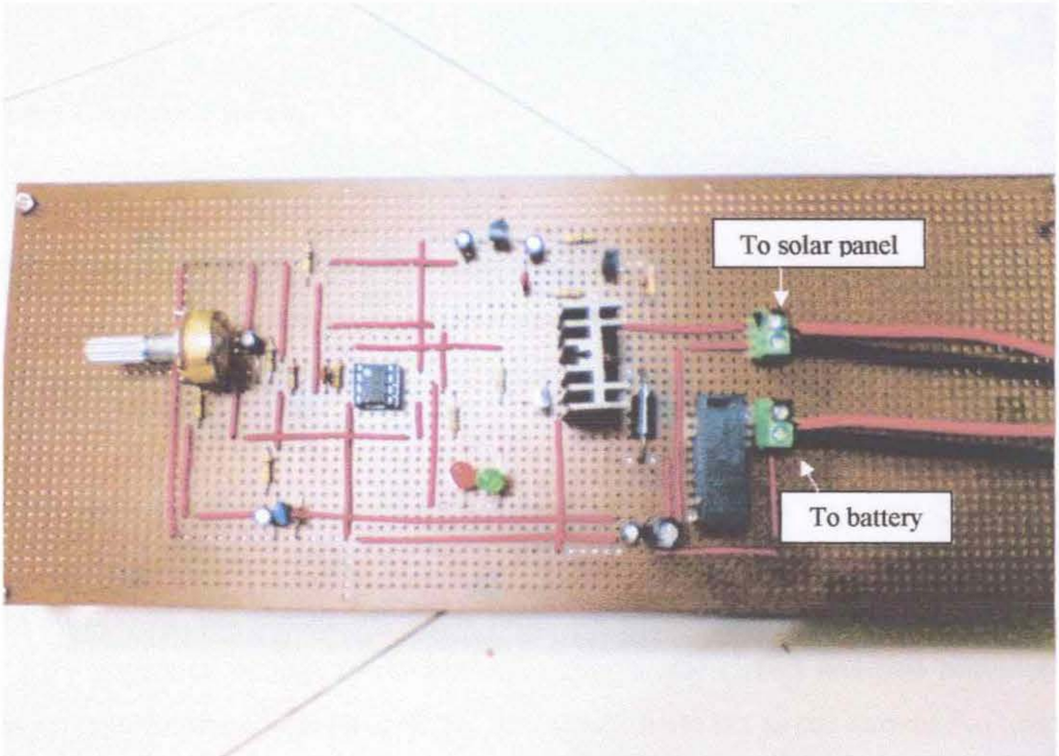


Figure 3.3: Develop Solar Charger Circuit

Figure 3.2 and figure 3.3 show the picture of the project. The project circuits divided into two parts namely, solar charger circuit and solar battery indicator. Each part of the project will be discussed in the following section.

3.2 Hardware Implementation

This section will discuss about the components and the concept of both hardware part which is solar charger and the solar battery indicator.

3.3 Solar Charger Circuit

This solar charger it fit with the source energy use which is solar energy. The solar charger circuit will use the rechargeable battery which is 12V. The medium power solar system can be built with the 12V solar panel up to 10A and a lead acid rechargeable battery which is up to a few 100Ah.

By theory method, the zener diode will conducts and turn on transistor Q2 when there is enough photovoltaic voltage to charge the battery and will switch on the rest of the circuit to operate the circuit. At night time, the circuit will switch off and IC2 provides a 5V regulated voltage to the power to comparator circuit and also provides references voltage for the comparator IC 1a. The zener diode act as the current limiting flow back to the solar panel during the night time.

When the battery is below the desire full voltage and needs charging, comparator IC 1a will activates the Q1 and Q3 to on and allow the solar charging current to flow into the battery. The Q3 will allow the circuit to be connected to the common ground for the solar panel and the battery.

IC 1a operates as a comparator based schmidt trigger oscillator when the battery is reaches the full charge point and it will switch the solar current off and on. The switching will cause the battery voltage to oscillate a few 10mV above and below desired set point of the battery voltage charge.

The green LED will act the display of the solar charger when the battery is fully charged. IC 1b only needs an approximate center point to work as the on-off comparator and it is connected to the varying IC 1a so that it does not require another reference divider circuit.

The resistor on the input side of the IC 1a forms a resistive bridge circuit that is used to compare the battery voltage to a reference voltage coming from IC2, R8 and R9.R7 will adds positive feedback to IC 1a for a Schmidt trigger characteristic.

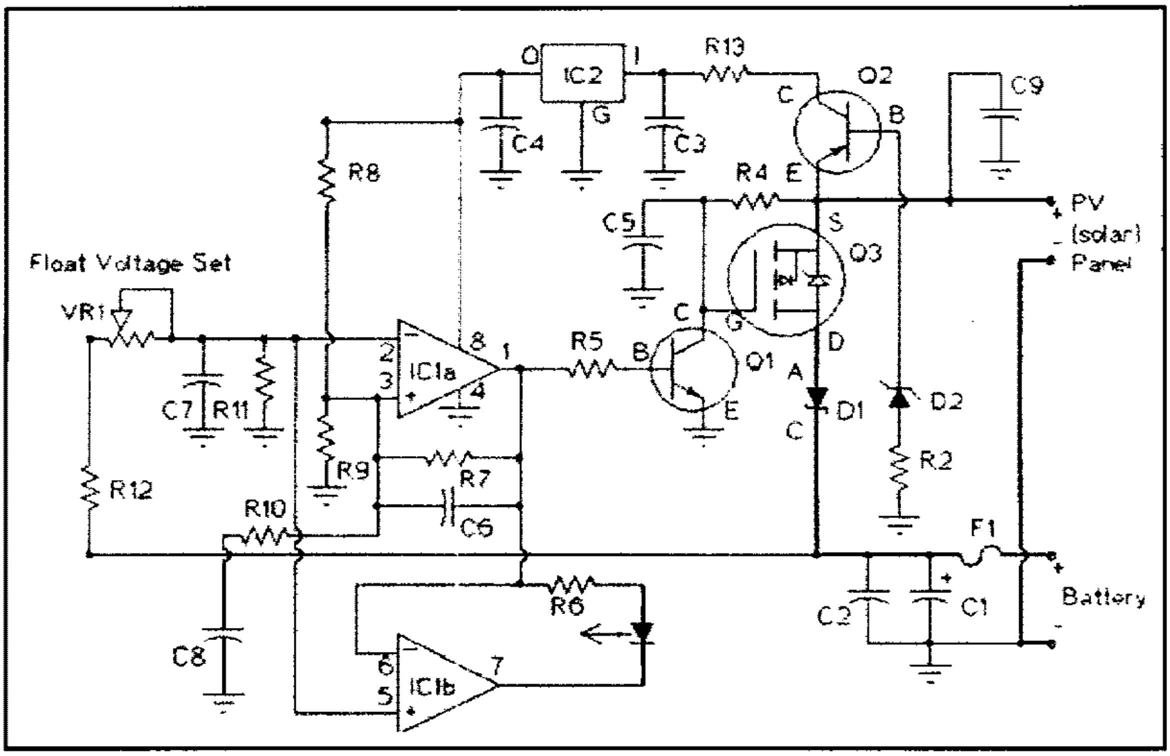


Figure 3.4: Schematic Diagram for Solar Charger

3.4 Solar Battery Indicator

3.4.1 Seven – Segment Monitoring Circuit

This circuit main function is to show the capacity of the battery for this project. The seven-segment will use as display to show the capacity of the battery. The 12V DC rechargeable lead-acid battery use should be operated within 0V and 12V. When the battery charges higher than 12V it is said to be overcharged, and when it discharges below 1.50V it can be deeply discharged.

Input from the battery is applied to IC LM3914. The IC 74LS147 is a decimal-to-BCD priority encoder which converts the output of IC LM3914 into its BCD complement. The true BCD is obtained by using the hex inverter IC 74LS04. This BCD output is displayed as a decimal digit after conversion using IC5 (74LS247), which is a BCD-to-seven-segment decoder/driver. The seven-segment LED display (LTS-542) is used because it is easy to read compared to a bar graph or, for that matter, an analogue meter. The charge status of the battery can be quickly calculated from the display. For instance, if the display shows 4, it means that the battery is charged to 40 per cent of its maximum value of 12V.

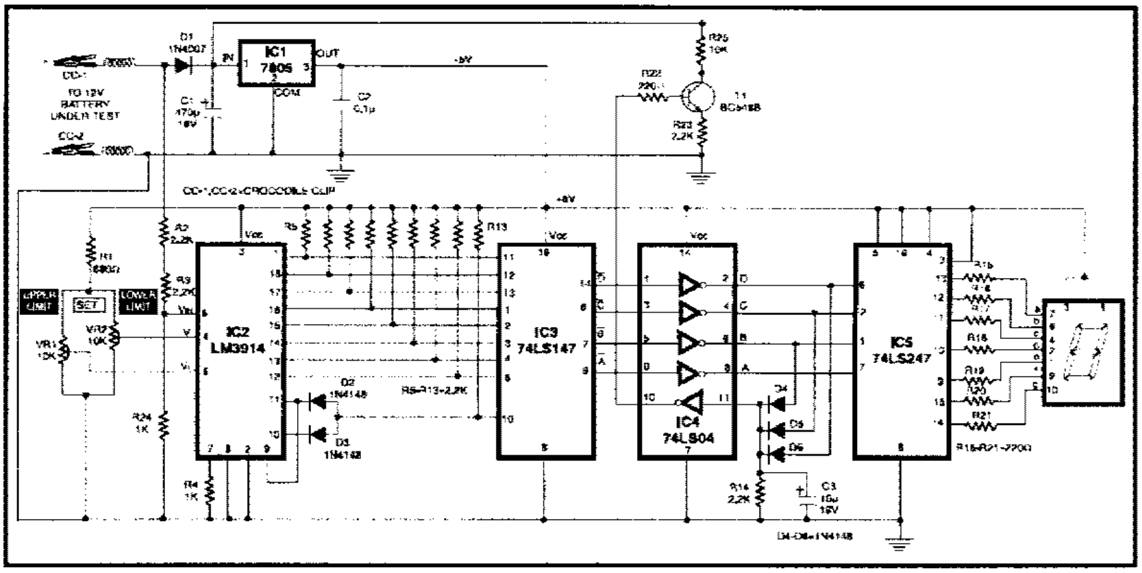


Figure 3.5: Schematic Diagram for Seven-segment Monitor

3.4.2 LED Monitoring Circuit

These circuits operating by place the battery to the terminal positive and negative terminal of the circuit. The purpose of the variable resistor, R2 is to set the voltage divisor of the battery to set it into the range of the voltage. This solution is better than letting the internal voltage regulator set the 12V sample voltage to be feed into the internal voltage divider simply because it cannot regulate 12V when the voltage drops lower. The build in voltage regulator of the IC LM3914 provide the stable voltage which is fed up into the precision internal resistor cascade to generate sample voltage for the internal comparator which is use LED as the output display. The variable resistor, R3 is set as the offset trimmer of the voltage range that needs to be checking the voltage of the battery.

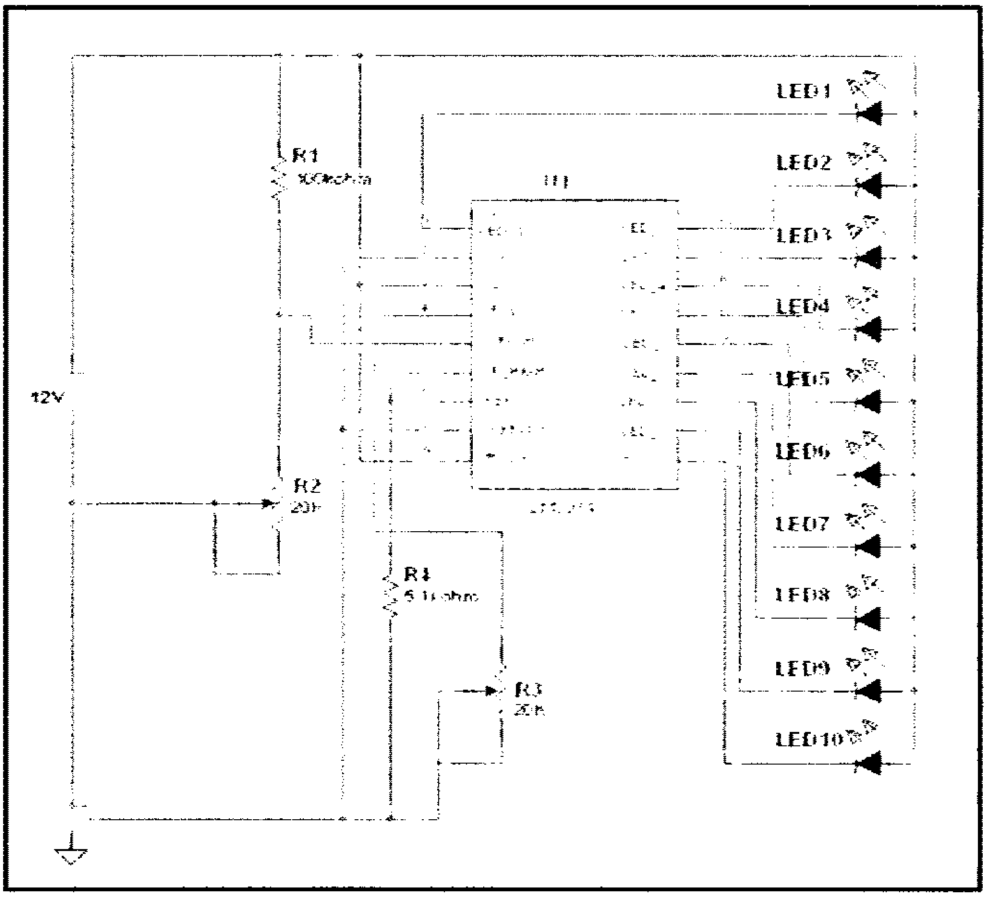


Figure 3.6: Diagram of LED Monitoring Circuit

3.5 Regulated Voltage

The components used mostly need a constant DC voltage supply of 5V. To meet these requirements, a DC regulator, IC 7805 is used. The IC is build to regulate DC input and provide a constant DC output of 5VDC.

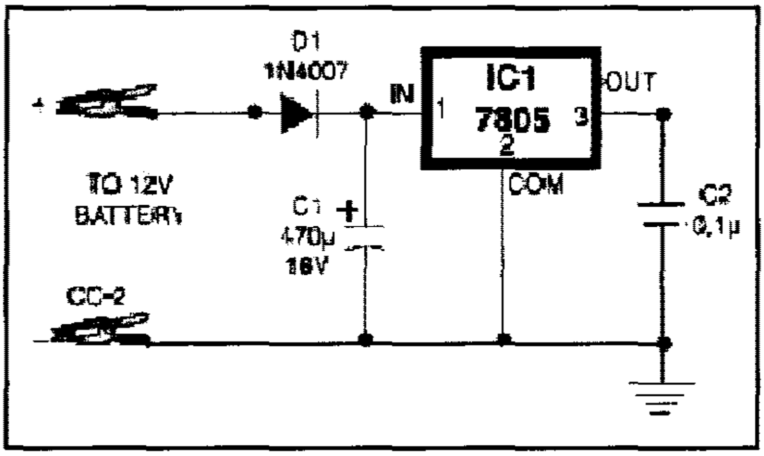


Figure 3.7: Volt Voltage Regulator

3.6 Solar Panel

The main source of this project is use the solar energy to supply the energy to the charger circuit and monitoring circuit. The specification of the solar panel need to be consider to these project. This solar irradiation data consist of the solar system information, sun energy information and the irradiation of the sun energy at the working project places.

Model	Sunmodule SW80 mono/RSE
Rated Max. Power, Pmax(W)	80(±5%)
Open Circuit Voltage, Vsc(V)	21.9
Rated Voltage, Vrated(V)	17.5
Short Circuit Current, Isc(A)	5
Rated Current, Irated(A)	4.58
Maximum System Voltage, (V)	715AC

Table 3.0: Solar Panel Specification

Your location:	26300 Gambang, Pahang, Malaysia
Using data from **Kuantan (AFB) weather station**	
Min. solar irradiation per day	3.58 kWh / m^2
Average solar irradiation per day	5.19 kWh / m^2
Max. solar irradiation per day	5.97 kWh / m^2

Table 3.1: Solar Irradiation Data

Energy usage (per day)	0.003 kWh
Maximum (Peak) load	35 W
Power from other sources (wind, hydro, etc)	0 Ah a day at 12 V

Table 3.2: Sun Energy Data

System voltage	12 V
Current required (factoring loss)	21 Ah at 12 V
Solar Panels	5 × Suntech Solar Panel 20Watt 12Volt (Multi-crystalline Solar Panel)
Solar Charge Controller	1 × Morningstar 12Volt 6Amp DC Solar Controller
Days of battery backup	3 days
Battery depth of discharge	50%
Battery bank required	312 Ah
(factoring loss)	1 × Fullriver Sealed Lead Acid AGM Battery 12Volt
	2.3Ah HGL

Table 3.3: Solar System Information

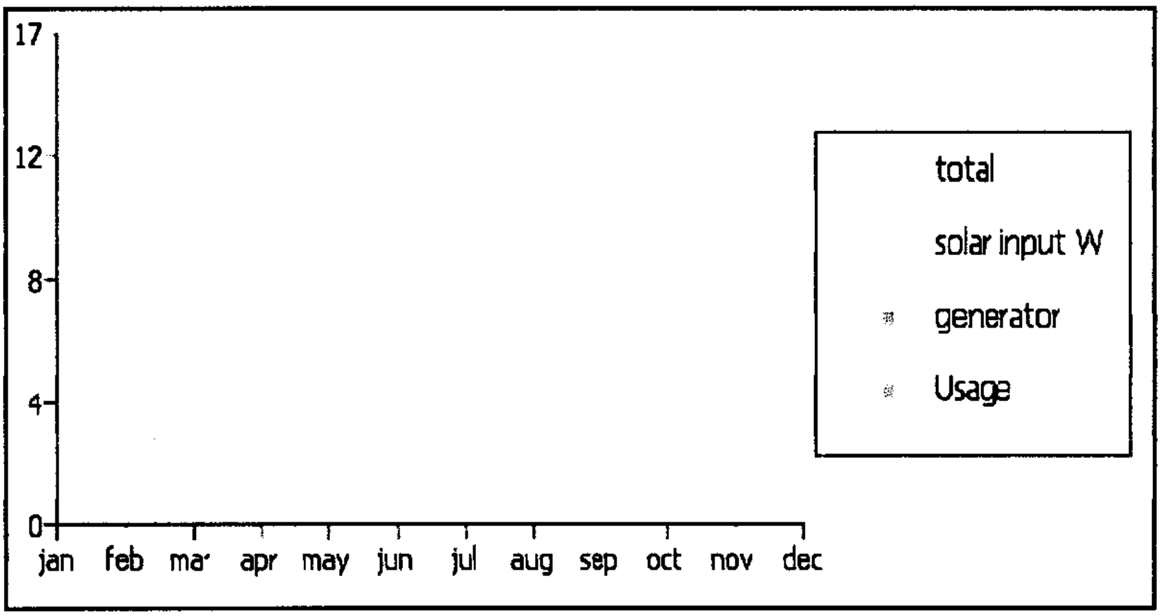


Figure 3.8: Graph of Annual System Performance of the Project

3.7 Load Calculation

Component	Power, (P) = Current, (I) x Voltage, (V)	Quantity	Power Rating (W)
LM3914	0.2mA x 5V	2	2.00m
74LS147	0.4mA x 5V	1	2.00m
74LS247	50μA x 5V	1	0.25m
74LS04	0.4mA x 5.25V	1	2.10m
LTS-542	40mW	1	40.00m
TOTAL POWER (W)			46.35mW

Table 3.4: Total Power Consumption

Total load per day

Load battery indicator = 46.35mW

Unit= 1

Total power = 1 x 46.35m x 24 hour per day

= 1.1124Wh per day

Energy loss =20%

Total load power = total power + 20% Energy loss

= 1.33488Wh per day

Sizing Solar Panel

5 hour peak sunshine for Malaysia

Solar panel input = 1.33488/5 hour peak sunshine

= 266.976mW

Select solar panel and regulator

Solar panel in lab = 12Watt

Unit of Solar = 266.976m/12 ...... solar panel input divide by solar panel used

= 0.022 unit

= ≈1 unit

Short Circuit Current, Isc = 5.00A*

Regulator must can handle 5.00A Isc

Sizing Battery

Load = 1.1124Wh per day

Ampere hour per day = total load per day divide by Rated Voltage*

= 1.1124/17.5

= 63.57mAh

Energy loss = 20%

Ampere hour per day = 63.57m + 20%

= 76.284mAh per day

Battery required = 76.284m/0.2 Energy loss

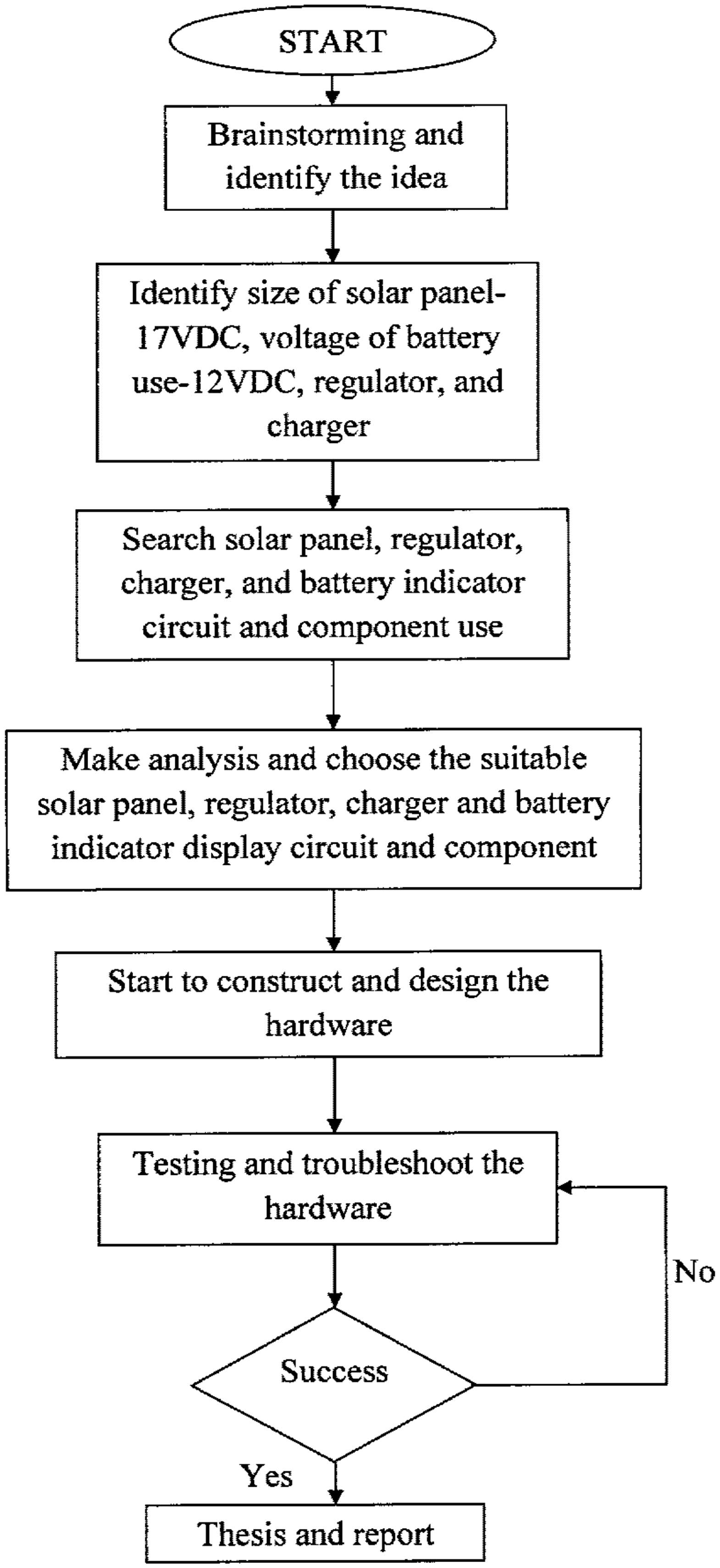
= 0.38142Ah x 7 days backup no sun light

= 2.66994 Ah for seven days

Selected of battery = 12V 7Ah Lead Acid Battery

Unit of battery = 1 units

3.8 Flow Diagram of the Project



CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

The charging design circuit has been successful in achieving one of the main objectives of the project. On the other hand, the monitoring percentage of the battery using the solar battery indicator been successfully display on the display component which is seven-segment component. A comparison of the solar panel and the battery specification have take place in order to distinguish the voltage charging and discharging over time taken to store the energy from the solar panel use. This chapter consist of the discussion on the result from the outputs of the charging process occur. Monitoring circuit of the battery is use to monitor the capacity of the battery.

4.2 Result of Experiment

4.2.1 Solar Panel

The reading of solar panel during the open circuit which is not connected to any load is taken. The reading is take again during the solar panel is connected to the load to check the voltage drop.

Battery Capacity	Reading (Volts, V)
Open circuit	21.9
Connected to load	19.7

Table 4.0: Data reading of Battery

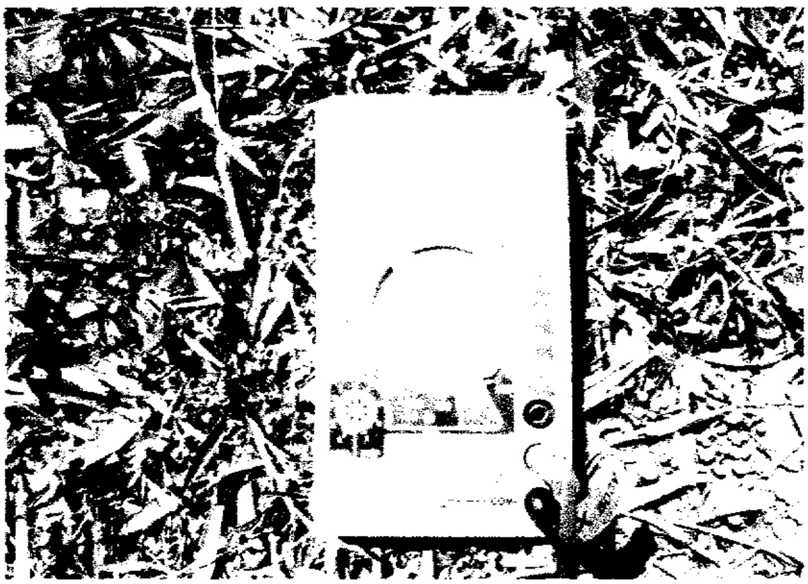


Figure 4.1: Data reading of solar panel during open circuit

From table 4.0 and figure 4.1, we can see that there is voltage drop after the solar panel was connected to the load which is battery. The voltage drop reading is 2.2V DC.

These cases occur because of the current produce from solar panel is not maintaining same and it can cause the voltage drop when the solar panel is connected to the load.

4.2.2 Charger Circuit

This solar charger main task is to charge the battery during the daytime so that the charge battery can be use in the diffuse weather or in night time. The measurement data of the charging circuit is taken when the design of circuit is finished. The data taken based on the voltage capacity of the battery during charging process. Table 4.1, table 4.2 and figure 4.4 show the result of the experiment.

Battery Condition	Capacity of the Battery (Volts, V)
Before charge	4.52
After 10 minutes charge	10.28

Table 4.1: Battery Capacity

Duration (Min)	Battery Capacity (Volts, V)
0	4.52
10	10.28
20	11.39
30	11.47
40	11.49
50	11.51
60	11.54
70	11.59
80	11.65
90	11.67
100	11.78
110	11.87
120	11.96

Table 4.2: Times Taken to Fill the 12V Battery

Figure 4.2: Data reading of battery capacity before charging

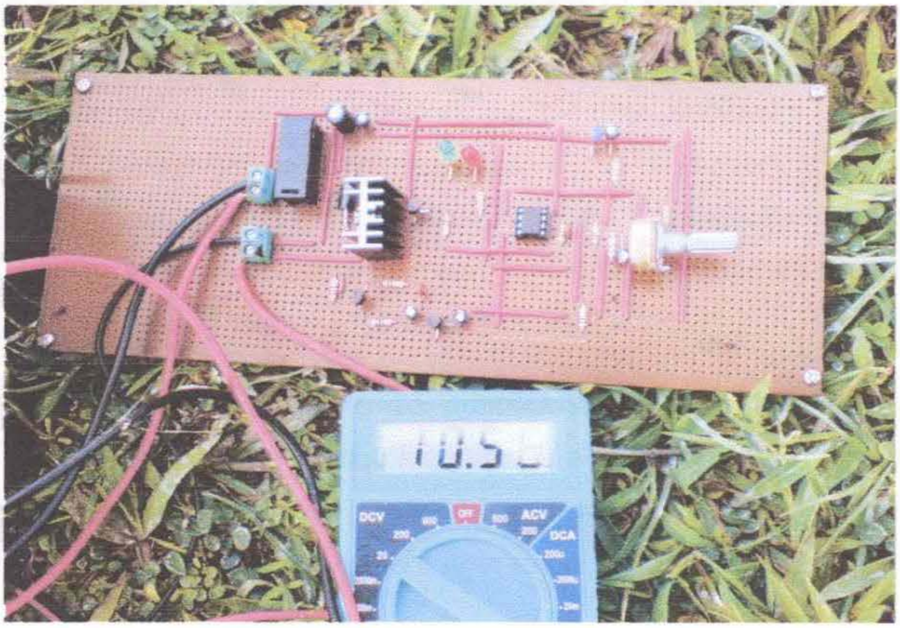


Figure 4.3: Reading of battery capacity after 10 minutes charging

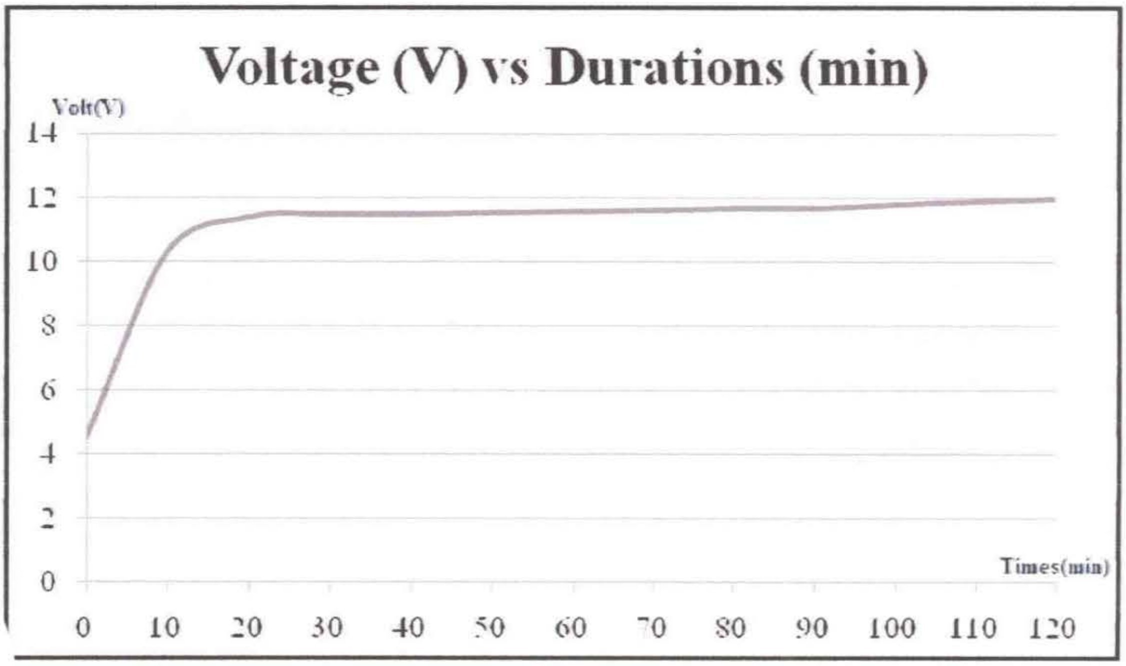


Figure 4.4: Graph Voltage versus Time taken to charge the battery in minutes

From figure 4.4, the process of charging the 12 V battery need 2 hours to fully charge the battery. At the first 10 minutes, the charging process is fast according to the current sent to the battery. At this time, maximum current from the solar panel through the solar charger to store it at the battery is sent in safe rate of current. Then, the voltages will rise near to the full capacity of the battery which is 75% to 90% of the battery capacity. At this level, usually the range of the voltage in the battery is from 10.5V DC to 15 V DC.

At the duration time from 25 minutes to 100 minutes, the voltages remains in the constant value and increase slowly according to the internal resistance of the battery during the charging process. This level is called an absorption charge because of the current flow to the battery is limit.

When the battery is nearly to reach the fully charge, charging process voltage is reduce to the lower lever usually is 12.5V DC to 13.8V DC. This happens to prevent the reliability of the battery and the battery lifetime.

4.2.2 Monitoring Circuit

This monitoring circuit is the combination of the seven-segment monitoring circuit and the LED monitoring circuit. Both of the circuits have the same purpose which is to check the capacity of the battery. The data taken several times to get the precise voltage range with the percentage monitoring display.

Range of the Voltage (volt, V)	No. of LED Display	7-segment Display
0.00-1.50	LED 1	1
1.50-2.50	LED 2	2
2.50-3.50	LED 3	3
3.50-4.80	LED 4	4
4.80-6.10	LED 5	5
6.10-7.50	LED 6	6
7.50-8.70	LED 7	7
8.70-9.50	LED 8	8
9.50-11.00	LED 9	9
11.00-12.00	LED 10	9

Table 4.3: Display Result of the Battery Monitoring

From table 4.0 above, we can see that the range of the voltage is directly proportional to the display percentage of the seven – segment monitoring but have slightly different in the voltage divisor. The seven-segment display monitoring is not accurate likes LED display because of the there are some charge is capacitor (10uF/16V) are not fully spread into the BCD to seven-segment decoders IC which is 74LS247. So, some of the display of seven-segment cannot display the integer of the battery capacity. To overcome this problem, some changers have been made by replace the 10uf/16V capacitor with higher value of capacitor which is 470uF/16V.The display of battery capacity of 6V and 12V are shown below.

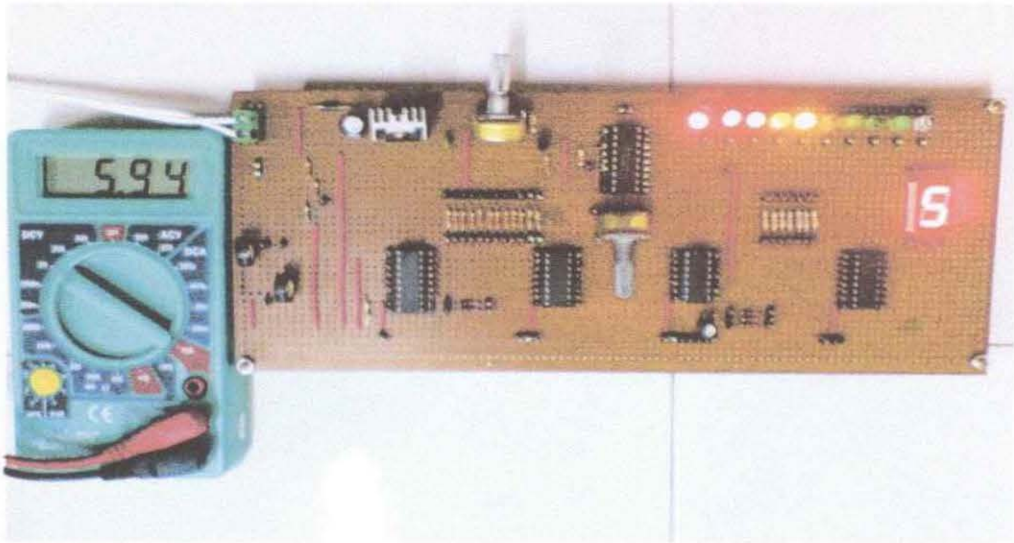


Figure 4.5: Monitoring display of battery capacity of 6V

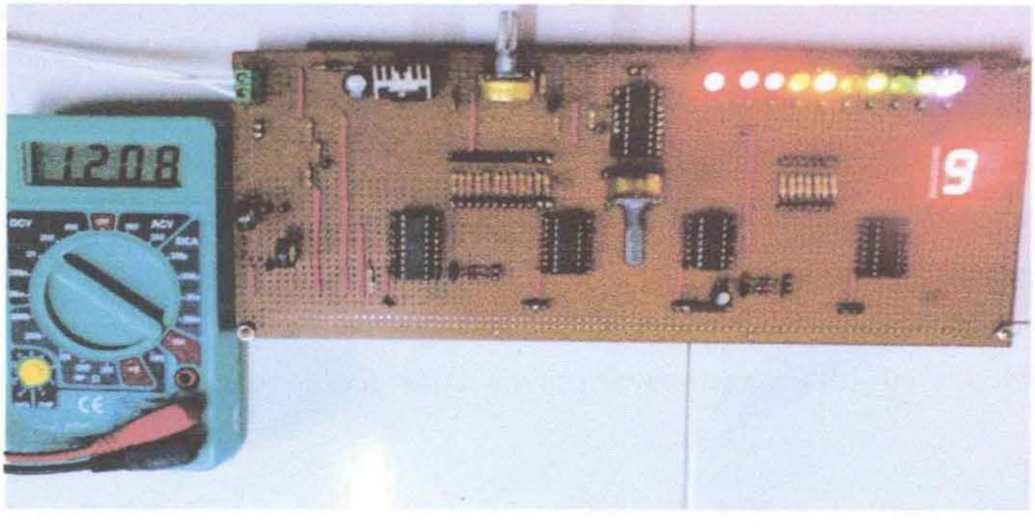


Figure 4.6: Monitoring display of battery capacity of 12V

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

These thesis views about the projects that had been designed and implement it of the solar battery charger and the solar battery indicator. The project is divided into two part of hardware which are the solar battery charger and the solar battery indicator. The solar battery charger is consisted the solar charger circuit which is integrated with the solar panel to supply the energy to battery and store the energy into the battery by using the solar charger. The capacity of the battery during charging and discharging process is shows by the solar battery indicator circuit which are use seven-segment display and the LED.

The developed of the solar charger circuit and the solar battery indicator have fulfilled the objective and scope of the project. The solar battery indicator are ready to use and can place it anywhere that need monitoring devices.

The battery used for this project is fit with the project system operation. On the other hand, the rechargeable battery had implement into several of the electrical appliances such for this project solar battery indicator. Besides that, the solar battery indicator use the DC voltage which suitable with many electrical appliances that needs monitoring devices

5.2 Future Recommendation

For further develop of this solar battery indicator in the future, here there are few recommendation which are:

1) Using the PIC controller for better precision of the voltage range monitoring and the displaying the percentage capacity of the battery.
2) Using the dot matrix devices to look more elegant and attractive features to display the percentages of the battery capacity.
3) Combine the solar charger circuit and solar battery indicator circuit in a circuit. This way will decrease the energy losses to the circuit design.

5.3 Costing and Commercialization

The total components and the prices for Solar Battery Indicator are summarized in the Table 5.1.

Components/devices	Specifications	Quantity	Price (RM)	Total (RM)
Hex Inverter	74LS04	1	4.50	4.50
Priority Encoder	74LS147	1	3.50	3.50
BCD to Seven-Segment Encoder	74LS247	1	2.50	2.50
Dot/Bar Display Driver	LM3914	2	3.50	7.00
Seven-Segment	LTS-542	1	3.50	3.50
LED	-	11	0.10	1.10
IC	TLC2272	1	3.00	3.00
Transistor	2N3904	1	1.50	1.50
Transistor	2N3906	1	1.50	1.50
Transistor	BC548B	1	1.50	1.50
Voltage regulator	LM7805	2	2.50	5.00
Variable Resistor	100k	3	1.50	4.50
Variable Resistor	10k	2	1.50	3.00
Resistor	2.2k	10	0.30	0.30
Resistor	10k	1	0.30	0.30
Resistor	100k	2	0.30	0.60
Resistor	750	1	0.30	0.30
Resistor	75k	1	0.30	0.30
Resistor	180k	1	0.30	0.30
Resistor	200k	1	0.30	0.30
Resistor	300k	1	0.30	0.30
Resistor	4.7M	1	0.30	0.30
Resistor	100	1	0.30	0.30
Resistor	1k	1	0.30	0.30
Resistor	22k	1	0.30	0.30
Resistor	3.3k	1	0.30	0.30

Resistor	4.7k	1	0.30	0.30
Resistor	5.1k	1	0.30	0.30
Resistor	680	1	0.30	0.30
Capacitor	470uF/16V	1	1.50	1.50
Capacitor	0.1uF	8	0.15	1.20
Capacitor	0.01uF	4	0.15	0.60
Capacitor	47uF	1	0.15	0.15
Zener diode	12V	1	2.00	2.00
Diode	1N4148	5	2.00	10.00
Schottky diode	90SQ045	1	4.00	4.00
Fuse	10A	1	1.00	1.00
Connecter	-	3	1.50	4.50
Heat sink	-	5	1.00	5.00
IC base	8 foot	3	0.50	1.50
IC base	16 foot	2	0.50	1.00
IC base	14 foot	2	0.50	1.00
Vera board	-	2	3.50	7.00
Wire jumper	-	0.5m	2.00	2.00
Total				96.65

Table 5.1: List of component

Total cost for the project is RM 96.65. Compared to the available solar battery indicator in the market, this value is very cheap. Some of the solar battery indicator can reach the price at RM 300. If the improvement implemented in the voltage range and the indicator of display, this project can be commercialize.

REFERENCES

[1] 17 March 2009, Citing Internet source URL
http://en.wikipedia.org/wiki/Photovoltaic_cell

[2] 17 March 2009, Citing Internet source URL
http://en.wikipedia.org/wiki/Solar_energy

[3] Andrew Stock, *Solar Panel*, http://www.freepatent.com

[4] Bruno Gailhard, *Voltage Regulator*, STMicroelectronics,
http://www.freepatent.com

[5] 17 March 2009, Citing Internet source URL
http://en.wikipedia.org/wiki/Voltage_regulator

[6] 18 March 2009, Citing Internet source URL
http://en.wikipedia.org/wiki/Solar_charger#Solar_chargers

[7] John W. Stevens and Garth P. Corey, *A Study of Lead-Acid Battery Efficiency Near Top-of-Charge and the Impact on PV System Design*,

[8] 20 March 2009, Citing Internet source URL
http://en.wikipedia.org/wiki/Seven-segment_display

[9] 04 November 2009, Citing Internet source URL
http://ezinearticles.com/?Various-Types-of-Battery-Chargers&id=939128

[10] Stand Alone Power Systems Calculator,
http://www.energymatters.com.au/climate-data/saps-calculate-solar.php

[11] http://www.brightgreenenergy.co.uk/solarpanel_sizing.asp

[12] www.solar4power.com

[13] http://www.cirkits.com

APPENDIX A

LM 3914 Datasheet

National Semiconductor

January 2000

LM3914 Dot/Bar Display Driver

LM3914
Dot/Bar Display Driver

General Description

The LM3914 is a monolithic integrated circuit that senses analog voltage levels and drives 10 LEDs, providing a linear analog display. A single pin changes the display from a moving dot to a bar graph. Current drive to the LEDs is regulated and programmable, eliminating the need for resistors. This feature is one that allows operation of the whole system from less than 3V.

The circuit contains its own adjustable reference and accurate 10-step voltage divider. The low-bias-current input buffer accepts signals down to ground, or V⁻, yet needs no protection against inputs of 35V above or below ground. The buffer drives 10 individual comparators referenced to the precision divider. Indication non-linearity can thus be held typically to ½%, even over a wide temperature range.

Versatility was designed into the LM3914 so that controller, visual alarm, and expanded scale functions are easily added on to the display system. The circuit can drive LEDs of many colors, or low-current incandescent lamps. Many LM3914s can be "chained" to form displays of 20 to over 100 segments. Both ends of the voltage divider are externally available so that 2 drivers can be made into a zero-center meter.

The LM3914 is very easy to apply as an analog meter circuit. A 1.2V full-scale meter requires only 1 resistor and a single 3V to 15V supply in addition to the 10 display LEDs. If the 1 resistor is a pot, it becomes the LED brightness control. The simplified block diagram illustrates this extremely simple external circuitry.

When in the dot mode, there is a small amount of overlap or "fade" (about 1 mV) between segments. This assures that at no time will all LEDs be "OFF", and thus any ambiguous display is avoided. Various novel displays are possible.

Much of the display flexibility derives from the fact that all outputs are individual, DC regulated currents. Various effects can be achieved by modulating these currents. The individual outputs can drive a transistor as well as a LED at the same time, so controller functions including "staging" control can be performed. The LM3914 can also act as a programmer, or sequencer.

The LM3914 is rated for operation from 0°C to +70°C. The LM3914N-1 is available in an 18-lead molded (N) package.

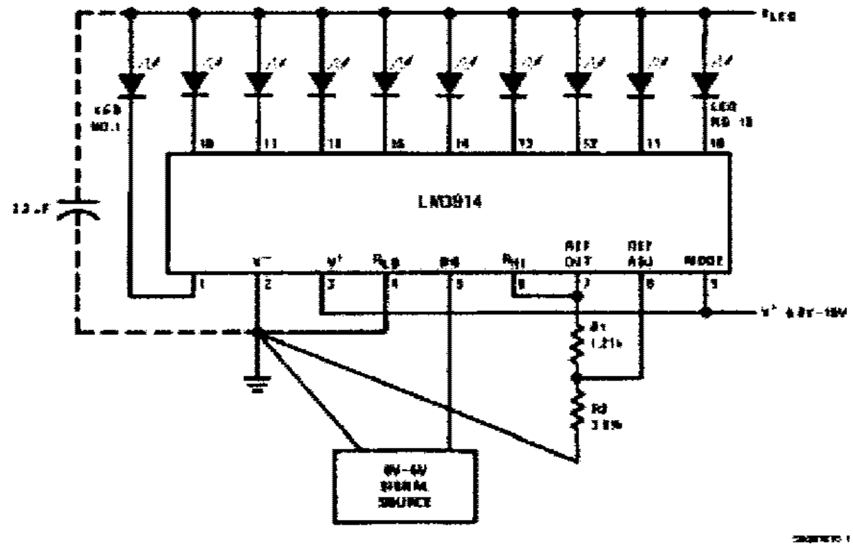
The following typical application illustrates adjusting of the reference to a desired value, and proper grounding for accurate operation, and avoiding oscillations.

Features

- Drives LEDs, LCDs or vacuum fluorescents
- Bar or dot display mode externally selectable by user
- Expandable to displays of 100 steps
- Internal voltage reference from 1.2V to 12V
- Operates with single supply of less than 3V
- Inputs operate down to ground
- Output current programmable from 2 mA to 30 mA
- No multiplex switching or interaction between outputs
- Input withstands ±35V without damage or false outputs
- LED driver outputs are current regulated, open-collectors
- Outputs can interface with TTL or CMOS logic
- The internal 10-step divider is floating and can be referenced to a wide range of voltages

Typical Applications

0V to 5V Bar Graph Meter



$$\text{Ref Out V} = 1.25\left(1 + \frac{R2}{R1}\right)$$

$$I_{LED} \approx \frac{12.5}{R1}$$

Note: Grounding method is typical of all uses. The 2.2 µF tantalum or 10 µF aluminum electrolytic capacitor is needed if leads to the LED supply are 6" or longer.

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Power Dissipation (Note 6)	
Molded DIP (N)	1365 mW
Supply Voltage	25V
Voltage on Output Drivers	25V
Input Signal Overvoltage (Note 4)	±35V
Divider Voltage	−100 mV to V+
Reference Load Current	10 mA
Storage Temperature Range	−55°C to +150°C
Soldering Information	
Dual-In-Line Package	
Soldering (10 seconds)	260°C
Plastic Chip Carrier Package	
Vapor Phase (60 seconds)	215°C
Infrared (15 seconds)	220°C

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.

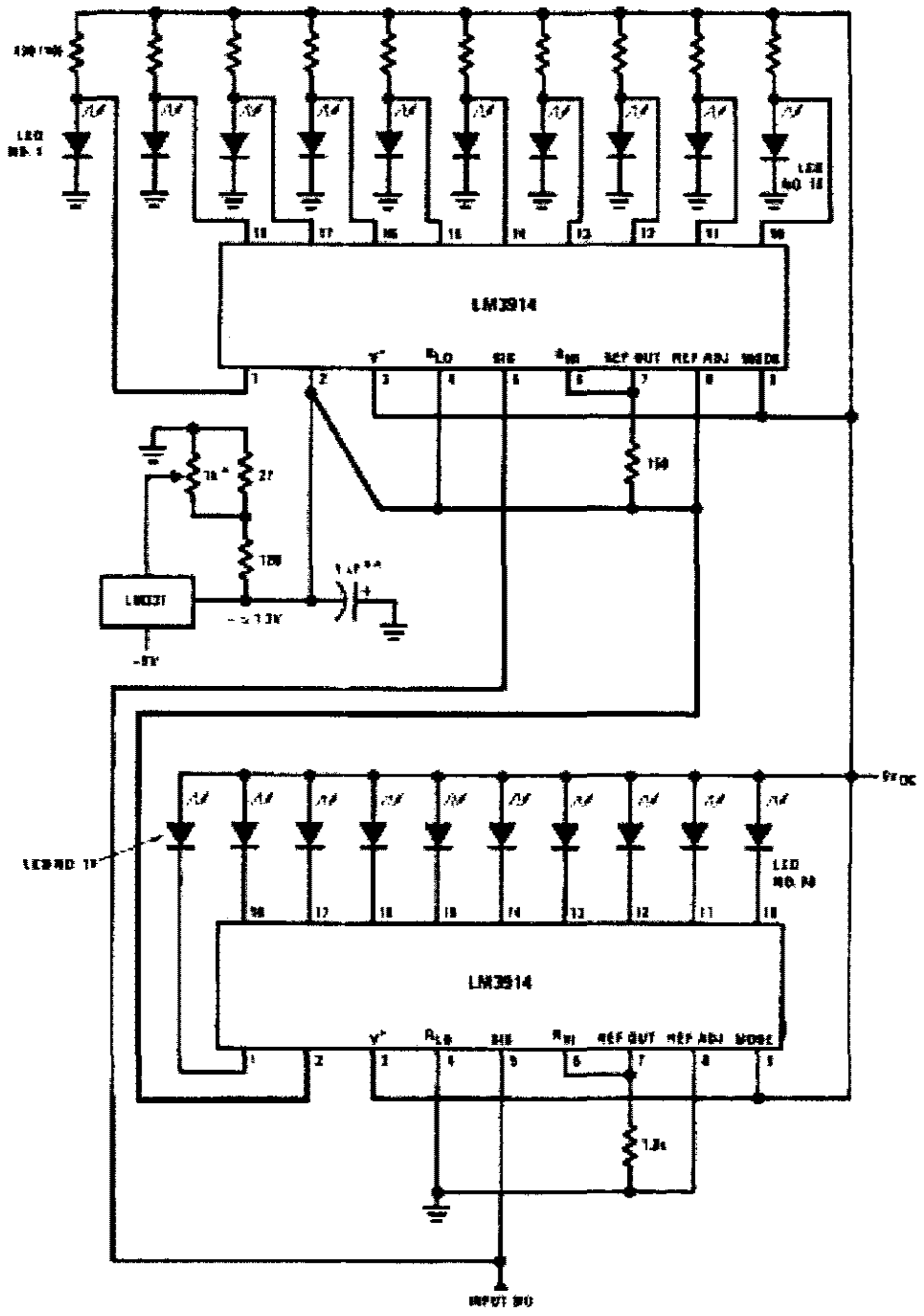
Electrical Characteristics (Notes 2, 4)

Parameter	Conditions (Note 2)		Min	Typ	Max	Units
COMPARATOR						
Offset Voltage, Buffer and First Comparator	$0V \le V_{RLO} = V_{RHI} \le 12V$, $I_{LED} = 1$ mA			3	10	mV
Offset Voltage, Buffer and Any Other Comparator	$0V \le V_{RLO} = V_{RHI} \le 12V$, $I_{LED} = 1$ mA			3	15	mV
Gain ($\Delta I_{LED}/\Delta V_{IN}$)	$I_{L(REF)} = 2$ mA, $I_{LED} = 10$ mA		3	8		mA/mV
Input Bias Current (at Pin 5)	$0V \le V_{IN} \le V^+ - 1.5V$			25	100	nA
Input Signal Overvoltage	No Change in Display		−35		35	V
VOLTAGE-DIVIDER						
Divider Resistance	Total, Pin 6 to 4		8	12	17	kΩ
Accuracy	(Note 3)			0.5	2	%
VOLTAGE REFERENCE						
Output Voltage	$0.1\ mA \le I_{L(REF)} \le 4$ mA, $V^+ = V_{LED} = 5V$		1.2	1.28	1.34	V
Line Regulation	$3V \le V^+ \le 18V$			0.01	0.03	%/V
Load Regulation	$0.1\ mA \le I_{L(REF)} \le 4$ mA, $V^+ = V_{LED} = 5V$			0.4	2	%
Output Voltage Change with Temperature	$0°C \le T_A \le +70°C$, $I_{L(REF)} = 1$ mA, $V^+ = 5V$			1		%
Adjust Pin Current				75	120	µA
OUTPUT DRIVERS						
LED Current	$V^+ = V_{LED} = 5V$, $I_{L(REF)} = 1$ mA		7	10	13	mA
LED Current Difference (Between Largest and Smallest LED Currents)	$V_{LED} = 5V$	$I_{LED} = 2$ mA		0.12	0.4	mA
		$I_{LED} = 20$ mA		1.2	3	
LED Current Regulation	$2V \le V_{LED} \le 17V$	$I_{LED} = 2$ mA		0.1	0.25	mA
		$I_{LED} = 20$ mA		1	3	
Dropout Voltage	$I_{LED(ON)} = 20$ mA, $V_{LED} = 5V$, $\Delta I_{LED} = 2$ mA				1.5	V
Saturation Voltage	$I_{LED} = 2.0$ mA, $I_{L(REF)} = 0.4$ mA			0.15	0.4	V
Output Leakage, Each Collector	(Bar Mode) (Note 5)			0.1	10	µA
Output Leakage	(Dot Mode) (Note 5)	Pins 10–18		0.1	10	µA
		Pin 1	60	150	450	µA
SUPPLY CURRENT						
Standby Supply Current (All Outputs Off)	$V^+ = 5V$, $I_{L(REF)} = 0.2$ mA			2.4	4.2	mA
	$V^+ = 20V$, $I_{L(REF)} = 1.0$ mA			6.1	9.2	mA

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. Electrical Characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

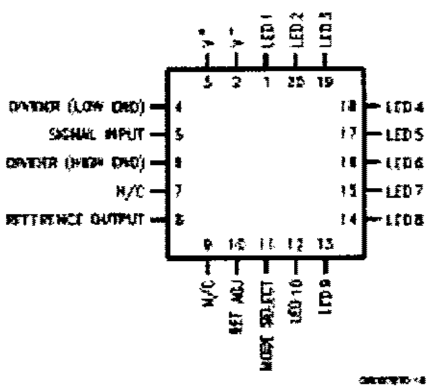
Typical Applications

Zero-Center Meter, 20-Segment



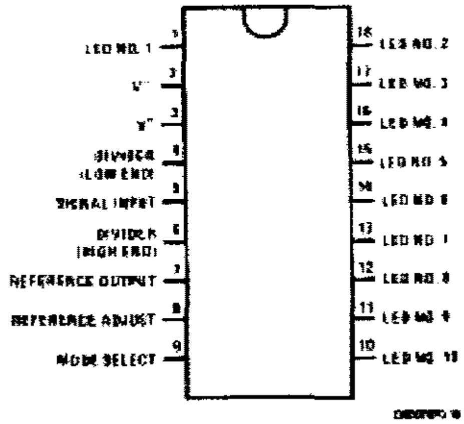
Connection Diagrams

Plastic Chip Carrier Package



Top View
Order Number LM3914V
See NS Package Number V20A

Dual-In-Line Package



Top View
Order Number LM3914N-1
See NS Package Number NA18A
Order Number LM3914N *
See NS Package Number N18A
*** Discontinued, Life Time Buy date 12/20/99**

APPENDIX B

7805 Datasheet

FAIRCHILD SEMICONDUCTOR® www.fairchildsemi.com

KA78XX/KA78XXA

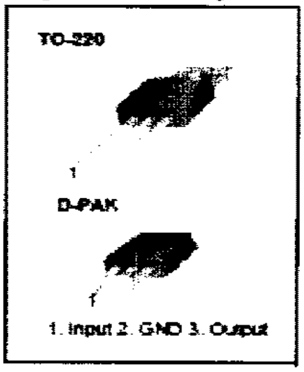
3-Terminal 1A Positive Voltage Regulator

Features

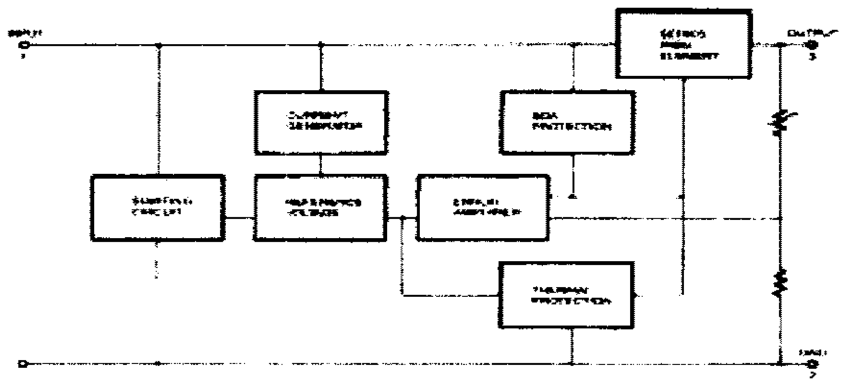
- Output Current up to 1A
- Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24V
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor Safe Operating Area Protection

Description

The KA78XX/KA78XXA series of three-terminal positive regulator are available in the TO-220/D-PAK package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.



Internal Block Digram



Rev. 1.0.0

Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Input Voltage (for V_O = 5V to 18V) (for V_O = 24V)	V_I V_I	35 40	V V
Thermal Resistance Junction-Cases (TO-220)	$R_{\theta JC}$	5	°C/W
Thermal Resistance Junction-Air (TO-220)	$R_{\theta JA}$	65	°C/W
Operating Temperature Range (KA78XX/A/R)	T_{OPR}	0 ~ +125	°C
Storage Temperature Range	T_{STG}	-65 ~ +150	°C

Electrical Characteristics (KA7805/KA7805R)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I =10V, C_I= 0.33μF, C_O=0.1μF, unless otherwise specified)

Parameter	Symbol	Conditions		KA7805 Min.	KA7805 Typ.	KA7805 Max.	Unit
Output Voltage	V_O	T_J =+25 °C		4.8	5.0	5.2	V
		5.0mA ≤ I_O ≤ 1.0A, P_O ≤ 15W V_I = 7V to 20V		4.75	5.0	5.25	
Line Regulation (Note1)	Regline	T_J=+25 °C	V_O = 7V to 25V	-	4.0	100	mV
			V_I = 8V to 12V	-	1.6	50	
Load Regulation (Note1)	Regload	T_J=+25 °C	I_O = 5.0mA to1.5A	-	9	100	mV
			I_O =250mA to 750mA	-	4	50	
Quiescent Current	I_Q	T_J =+25 °C		-	5.0	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	0.03	0.5	mA
		V_I= 7V to 25V		-	0.3	1.3	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O= 5mA		-	-0.8	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A=+25 °C		-	42	-	μV/V_O
Ripple Rejection	RR	f = 120Hz V_O = 8V to 18V		62	73	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	15	-	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A =+25 °C		-	230	-	mA
Peak Current	I_{PK}	T_J =+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (KA7805A)

(Refer to the test circuits. 0°C < T_J < +125°C, I_O =1A, V_I = 10V, C_I=0.33μF, C_O=0.1μF, unless otherwise specified)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C	4.9	5	5.1	V
		I_O = 5mA to 1A, P_O ≤ 15W V_I = 7.5V to 20V	4.8	5	5.2	
Line Regulation (Note1)	Regline	V_I = 7.5V to 25V I_O = 500mA	-	5	50	mV
		V_I = 8V to 12V	-	3	50	
		T_J =+25 °C, V_I= 7.3V to 20V	-	5	50	
		T_J =+25 °C, V_I= 8V to 12V	-	1.5	25	
Load Regulation (Note1)	Regload	T_J =+25 °C I_O = 5mA to 1.5A	-	9	100	mV
		I_O = 5mA to 1A	-	9	100	
		I_O = 250mA to 750mA	-	4	50	
Quiescent Current	I_Q	T_J =+25 °C	-	5.0	6.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A	-	-	0.5	mA
		V_I = 8 V to 25V, I_O = 500mA	-	-	0.8	
		V_I = 7.5V to 20V, T_J =+25 °C	-	-	0.8	
Output Voltage Drift	ΔV/ΔT	Io = 5mA	-	-0.8	-	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz T_A =+25 °C	-	10	-	μV/Vo
Ripple Rejection	RR	f = 120Hz, I_O = 500mA V_I = 8V to 18V	-	68	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25 °C	-	2	-	V
Output Resistance	r_O	f = 1KHz	-	17	-	mΩ
Short Circuit Current	I_{SC}	V_I= 35V, T_A =+25 °C	-	250	-	mA
Peak Current	I_{PK}	T_J= +25 °C	-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Change in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

APPENDIX C

74LS147 Datasheet

SN54147, SN54148, SN54LS147, SN54LS148
SN74147, SN74148 (TIM9907), SN74LS147, SN74LS148
10-LINE TO 4-LINE AND 8-LINE TO 3-LINE PRIORITY ENCODERS

SDLS053B – OCTOBER 1976 – REVISED MAY 2004

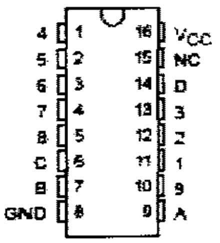
'147, 'LS147

- Encode 10-Line Decimal to 4-Line BCD
- Applications Include:
  - Keyboard Encoding
  - Range Selection

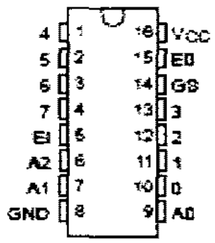
'148, 'LS148

- Encode 8 Data Lines to 3-Line Binary (Octal)
- Applications Include:
  - n-Bit Encoding
  - Code Converters and Generators

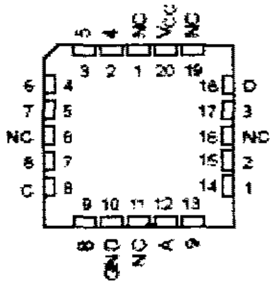
SN54147, SN54LS147 . . . J OR W PACKAGE
SN74147, SN74LS147 . . . D OR N PACKAGE
(TOP VIEW)



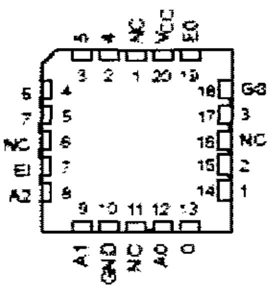
SN54148, SN54LS148 . . . J OR W PACKAGE
SN74148, SN74LS148 . . . D, N, OR NS PACKAGE
(TOP VIEW)



SN54LS147 . . . FK PACKAGE
(TOP VIEW)



SN54LS148 . . . FK PACKAGE
(TOP VIEW)



NC – No internal connection

TYPE	TYPICAL DATA DELAY	TYPICAL POWER DISSIPATION
'147	10 ns	225 mW
'148	10 ns	190 mW
'LS147	15 ns	60 mW
'LS148	15 ns	60 mW

NOTE: The SN54147, SN54LS147, SN54148, SN74147, SN74LS147, and SN74148 are obsolete and are no longer supplied.

description/ordering information

These TTL encoders feature priority decoding of the inputs to ensure that only the highest-order data line is encoded. The '147 and 'LS147 devices encode nine data lines to four-line (8-4-2-1) BCD. The implied decimal zero condition requires no input condition, as zero is encoded when all nine data lines are at a high logic level. The '148 and 'LS148 devices encode eight data lines to three-line (4-2-1) binary (octal). Cascading circuitry (enable input EI and enable output EO) has been provided to allow octal expansion without the need for external circuitry. For all types, data inputs and outputs are active at the low logic level. All inputs are buffered to represent one normalized Series 54/74 or 54/74LS load, respectively.

ORDERING INFORMATION

T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	PDIP – N	Tube	SN74LS148N	SN74LS148N
	SOIC – D	Tube	SN74LS148D	LS148
		Tape and reel	SN74LS148DR	
	SOP – NS	Tape and reel	SN74LS148NSR	74LS148
–55°C to 125°C	CDIP – J	Tube	SNJ54LS148J	SNJ54LS148J
	CFP – W	Tube	SNJ54LS148W	SNJ54LS148W
	LCCC – FK	Tube	SNJ54LS148FK	SNJ54LS148FK

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

FUNCTION TABLE – '147, 'LS147

INPUTS									OUTPUTS			
1	2	3	4	5	6	7	8	9	D	C	B	A
H	H	H	H	H	H	H	H	H	H	H	H	H
X	X	X	X	X	X	X	X	L	L	H	H	L
X	X	X	X	X	X	X	L	H	L	H	H	H
X	X	X	X	X	X	L	H	H	H	L	L	L
X	X	X	X	X	L	H	H	H	H	L	L	H
X	X	X	X	L	H	H	H	H	H	L	H	L
X	X	X	L	H	H	H	H	H	H	L	H	H
X	X	L	H	H	H	H	H	H	H	H	L	L
X	L	H	H	H	H	H	H	H	H	H	L	H
L	H	H	H	H	H	H	H	H	H	H	H	L

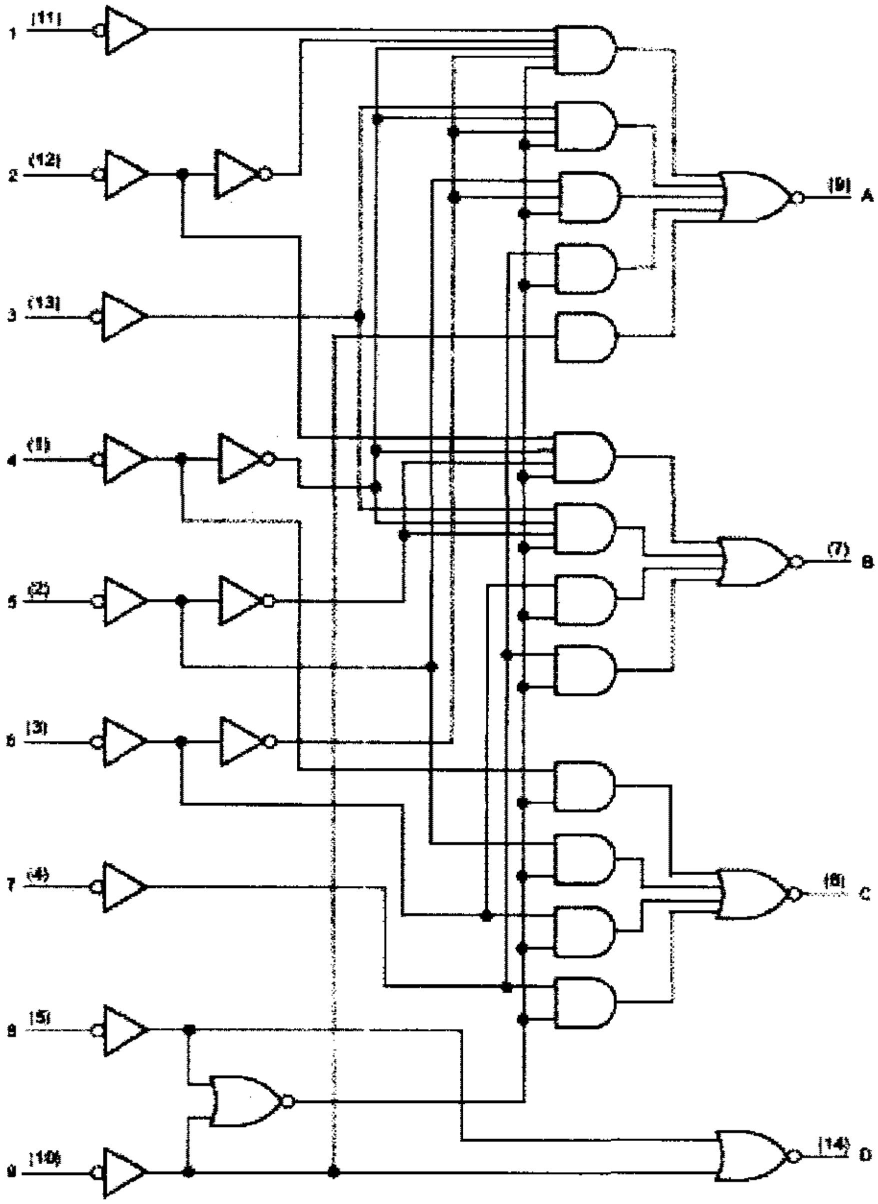
H = high logic level, L = low logic level, X = irrelevant

FUNCTION TABLE – '148, 'LS148

INPUTS									OUTPUTS				
EI	0	1	2	3	4	5	6	7	A2	A1	A0	GS	EO
H	X	X	X	X	X	X	X	X	H	H	H	H	H
L	H	H	H	H	H	H	H	H	H	H	H	H	L
L	X	X	X	X	X	X	X	L	L	L	L	L	H
L	X	X	X	X	X	X	L	H	L	L	H	L	H
L	X	X	X	X	X	L	H	H	L	H	L	L	H
L	X	X	X	X	L	H	H	H	L	H	H	L	H
L	X	X	X	L	H	H	H	H	H	L	L	L	H
L	X	X	L	H	H	H	H	H	H	L	H	L	H
L	X	L	H	H	H	H	H	H	H	H	L	L	H
L	L	H	H	H	H	H	H	H	H	H	H	L	H

H = high logic level, L = low logic level, X = irrelevant

'147, 'LS147 logic diagram (positive logic)



Pin numbers shown are for D, J, N, and W packages.

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER			TEST CONDITIONS†		'147 MIN	'147 TYP‡	'147 MAX	'148 MIN	'148 TYP‡	'148 MAX	UNIT
V_{IH}	High-level input voltage				2			2			V
V_{IL}	Low-level input voltage						0.8			0.8	V
V_{IK}	Input clamp voltage		V_{CC} = MIN,	$I_I = -12$ mA			−1.5			−1.5	V
V_{OH}	High-level output voltage		V_{CC} = MIN, V_{IL} = 0.8 V	V_{IH} = 2 V, $I_{OH} = -800$ µA	2.4	3.3		2.4	3.3		V
V_{OL}	Low-level output voltage		V_{CC} = MIN, V_{IL} = 0.8 V,	V_{IH} = 2 V, I_{OL} = 16 mA		0.2	0.4		0.2	0.4	V
I_I	Input current at maximum input voltage		V_{CC} = MAX,	V_I = 5.5 V			1			1	mA
I_{IH}	High-level input current	0 input	V_{CC} = MAX,	V_I = 2.4 V						40	µA
		Any input except 0					40			80	
I_{IL}	Low-level input current	0 input	V_{CC} = MAX,	V_I = 0.4 V						−1.6	mA
		Any input except 0					−1.6			−3.2	
I_{OS}	Short-circuit output current§		V_{CC} = MAX		−35		−85	−35		−85	mA
I_{CC}	Supply current		V_{CC} = MAX (See Note 5)	Condition 1		50	70		40	60	mA
				Condition 2		42	62		35	55	

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.
‡ All typical values are at V_{CC} = 5 V, T_A = 25°C
§ Not more than one output should be shorted at a time.
NOTE 5: For '147, I_{CC} (Condition 1) is measured with input 7 grounded, other inputs and outputs open; I_{CC} (Condition 2) is measured with all inputs and outputs open. For '148, I_{CC} (Condition 1) is measured with inputs 7 and EI grounded, other inputs and outputs open; I_{CC} (Condition 2) is measured with all inputs and outputs open.

SN54147, SN74147 switching characteristics, V_{CC} = 5 V, T_A = 25°C (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	WAVEFORM	TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{PLH}	Any	Any	In-phase output	C_L = 15 pF, R_L = 400 Ω		9	14	ns
t_{PHL}						7	11	
t_{PLH}	Any	Any	Out-of-phase output			13	19	ns
t_{PHL}						12	19	

SN54LS147, SN74LS147 switching characteristics, V_{CC} = 5 V, T_A = 25°C (see Figure 2)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	WAVEFORM	TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{PLH}	Any	Any	In-phase output	C_L = 15 pF, R_L = 2 kΩ		12	18	ns
t_{PHL}						12	18	
t_{PLH}	Any	Any	Out-of-phase output			21	33	ns
t_{PHL}						15	23	

SN54LS148, SN74LS148 switching characteristics, V_{CC} = 5 V, T_A = 25°C (see Figure 2)

PARAMETER†	FROM (INPUT)	TO (OUTPUT)	WAVEFORM	TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{PLH}	1–7	A0, A1, or A2	In-phase output	C_L = 15 pF, R_L = 2 kΩ		14	18	ns
t_{PHL}						15	25	
t_{PLH}	1–7	A0, A1, or A2	Out-of-phase output			20	36	ns
t_{PHL}						16	29	
t_{PLH}	0–7	EO	Out-of-phase output			7	18	ns
t_{PHL}						25	40	
t_{PLH}	0–7	GS	In-phase output			35	55	ns
t_{PHL}						9	21	
t_{PLH}	EI	A0, A1, or A2	In-phase output			16	25	ns
t_{PHL}						12	25	
t_{PLH}	EI	GS	In-phase output			12	17	ns
t_{PHL}						14	36	
t_{PLH}	EI	EO	In-phase output			12	21	ns
t_{PHL}						23	35	

† t_{PLH} = propagation delay time, low-to-high-level output
t_{PHL} = propagation delay time, high-to-low-level output

APPENDIX D

74LS247 Datasheet

SN74LS247

BCD-to-Seven-Segment Decoders/Drivers

The SN74LS247 is a BCD-to-Seven-Segment Decoder/Drivers.

The LS247 composes the 6 and 9 with the tails. The LS247 has active low outputs for direct drive of indicators.

The LS247 features a lamp test input and have full ripple-blanking input/output controls. An automatic leading and/or trailing-edge zero-blanking control (RBI and RBO) is incorporated and an overriding blanking input (BI) is contained which may be used to control the lamp intensity by pulsing or to inhibit the output's lamp test may be performed at any time when the BI/RBO node is at high level. Segment identification and resultant displays are shown below. Display pattern for BCD input counts above 9 are unique symbols to authenticate input conditions.

- Open Collector Outputs Drive Indicators Directly
- Lamp Test Provision
- Leading/Trailing Zero Suppression

GUARANTEED OPERATING RANGES

Symbol	Parameter	Min	Typ	Max	Unit
V_{CC}	Supply Voltage	4.75	5.0	5.25	V
T_A	Operating Ambient Temperature Range	0	25	70	°C
I_{OH}	Output Current – High BI/RBO			–50	µA
I_{OL}	Output Current – Low BI/RBO			3.2	mA
$V_{O(off)}$	Off–State Output Voltage a – g			15	V
$I_{O(on)}$	On–State Output Current a – g			24	mA

ON Semiconductor

Formerly a Division of Motorola

http://onsemi.com

LOW POWER SCHOTTKY

PLASTIC
N SUFFIX
CASE 648

SOIC
D SUFFIX
CASE 751B

ORDERING INFORMATION

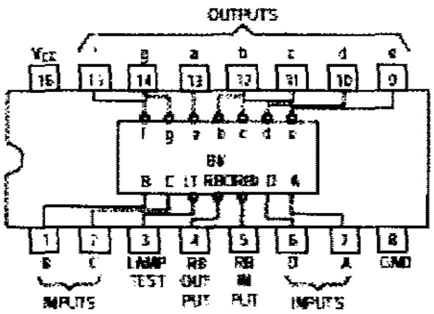
Device	Package	Shipping
SN74LS247N	16 Pin DIP	2000 Units/Box
SN74LS247D	16 Pin	2500/Tape & Reel

SN74LS247

NUMERICAL DESIGNATIONS AND RESULTANT DISPLAYS

SEGMENT IDENTIFICATION

SN74LS247
(TOP VIEW)



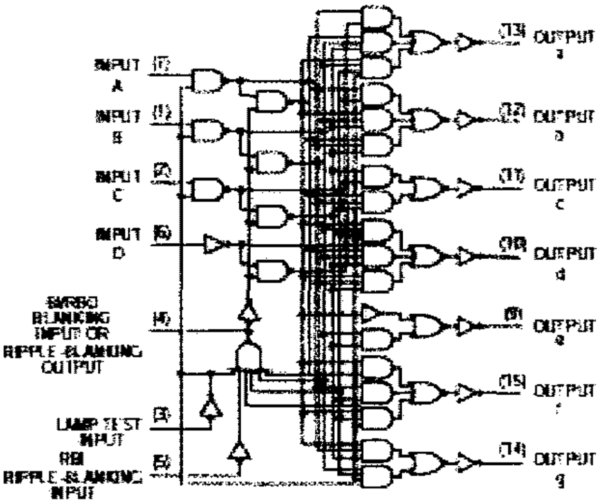
CIRCUIT FEATURES LAMP INTENSITY MODULATION CAPABILITY

TYPE	DRIVER OUTPUTS				TYPICAL POWER DISSIPATION
	ACTIVE LEVEL	OUTPUT CONFIGURATION	SINK CURRENT	MAX VOLTAGE	
SN74LS247	low	open-collector	24 mA	15 V	35 mW

SN74LS247

LOGIC DIAGRAM

LS247



LS247
FUNCTION TABLE

DECIMAL OR FUNCTION	INPUTS						BI/RBO†	OUTPUTS							NOTE
	LT	RBI	D	C	B	A		a	b	c	d	e	f	g	
0	H	H	L	L	L	L	H	ON	ON	ON	ON	ON	ON	OFF	1
1	H	X	L	L	L	H	H	OFF	ON	ON	OFF	OFF	OFF	OFF	
2	H	X	L	L	H	L	H	ON	ON	OFF	ON	ON	OFF	ON	
3	H	X	L	L	H	H	H	ON	ON	ON	ON	OFF	OFF	ON	
4	H	X	L	H	L	L	H	OFF	ON	ON	OFF	OFF	ON	ON	
5	H	X	L	H	L	H	H	ON	OFF	ON	ON	OFF	ON	ON	
6	H	X	L	H	H	L	H	ON	OFF	ON	ON	ON	ON	ON	
7	H	X	L	H	H	H	H	ON	ON	ON	OFF	OFF	OFF	OFF	
8	H	X	H	L	L	L	H	ON	ON	ON	ON	ON	ON	ON	
9	H	X	H	L	L	H	H	ON	ON	ON	ON	OFF	ON	ON	
10	H	X	H	L	H	L	H	OFF	OFF	OFF	ON	ON	OFF	ON	
11	H	X	H	L	H	H	H	OFF	OFF	ON	ON	OFF	OFF	ON	
12	H	X	H	H	L	L	H	OFF	ON	OFF	OFF	OFF	ON	ON	
13	H	X	H	H	L	H	H	ON	OFF	OFF	ON	OFF	ON	ON	
14	H	X	H	H	H	L	H	OFF	OFF	OFF	ON	ON	ON	ON	
15	H	X	H	H	H	H	H	OFF	OFF	OFF	OFF	OFF	OFF	OFF	
BI	X	X	X	X	X	X	L	OFF	OFF	OFF	OFF	OFF	OFF	OFF	2
RBI	H	L	L	L	L	L	L	OFF	OFF	OFF	OFF	OFF	OFF	OFF	3
LT	L	X	X	X	X	X	H	ON	ON	ON	ON	ON	ON	ON	4

H = HIGH Level, L = LOW Level, X = Irrelevant

NOTES:
1. The blanking input (BI) must be open or held at a high logic level when output functions 0 through 15 are desired. The ripple-blanking input (RBI) must be open or high if blanking of a decimal zero is not desired.
2. When a low logic level is applied directly to the blanking input (BI), all segment outputs are off regardless of the level of any other input.
3. When ripple-blanking input (RBI) and inputs A, B, C, and D are at a low level with the lamp test input high, all segment outputs go off and the ripple-blanking output (RBO) goes to a low level (response condition).
4. When the blanking input/ripple blanking output (BI/RBO) is open or held high and a low is applied to the lamp-test input, all segment outputs are on.

† BI/RBO is wire-AND logic serving as blanking input (BI) and/or ripple-blanking output (RBO).

SN74LS247

DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (unless otherwise specified)

Symbol	Parameter	Limits Min	Limits Typ	Limits Max	Unit	Test Conditions	
V_{IH}	Input HIGH Voltage	2.0			V	Guaranteed Input HIGH Voltage for All Inputs	
V_{IL}	Input LOW Voltage			0.8	V	Guaranteed Input LOW Voltage for All Inputs	
V_{IK}	Input Clamp Diode Voltage		−0.65	−1.5	V	V_{CC} = MIN, I_{IN} = −18 mA	
V_{OH}	Output HIGH Voltage BI/RBO	2.4	4.2		V	V_{CC} = MIN, I_{OH} = MAX, V_{IN} = V_{IH} or V_{IL} per Truth Table	
V_{OL}	Output LOW Voltage BI/RBO		0.25	0.4	V	I_{OL} = 1.6 mA	V_{CC} = V_{CC} MIN, V_{IN} = V_{IL} or V_{IH} per Truth Table
			0.35	0.5	V	I_{OL} = 3.2 mA	
$I_{O(off)}$	Off-State Output Current a–g			250	µA	V_{CC} = MAX, V_{IH} = 2.0 V, $V_{O(off)}$ = 15 V, V_{IL} = MAX	
$V_{O(on)}$	On-State Output Voltage a–g		0.25	0.4	V	$I_{O(on)}$ = 12 mA	V_{CC} = MIN, V_{IH} = 2.0 V, V_{IL} per Truth Table
			0.35	0.5	V	$I_{O(on)}$ = 24 mA	
I_{IH}	Input HIGH Current			20	µA	V_{CC} = MAX, V_{IN} = 2.7 V	
				0.1	mA	V_{CC} = MAX, V_{IN} = 7.0 V	
I_{IL}	Input LOW Current Any Input, except BI/RBO			−0.4	mA	V_{CC} = MAX, V_{IN} = 0.4 V	
	BI/RBO			−1.2			
I_{OS}	Short Circuit Current BI/RBO (Note 1)	−0.3		−2.0	mA	V_{CC} = MAX	
I_{CC}	Power Supply Current		7.0	13	mA	V_{CC} = MAX	

Note 1: Not more than one output should be shorted at a time, nor for more than 1 second.

AC CHARACTERISTICS (V_{CC} = 5.0 V, T_A = 25°C)

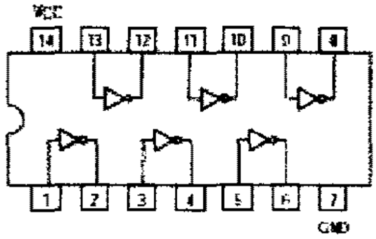
Symbol	Parameter	Limits Min	Limits Typ	Limits Max	Unit	Test Conditions
t_{PLH} t_{PHL}	Turn-Off Time from A Input Turn-On Time from A Input			100 100	ns	C_L = 15 pF R_L = 665 Ω
t_{PHL} t_{PLH}	Turn-Off Time from RBI Input Turn-On Time from RBI Input			100 100	ns	

APPENDIX E

74LS04 Datasheet

SN74LS04

Hex Inverter



ON Semiconductor

Formerly a Division of Motorola

http://onsemi.com

LOW POWER SCHOTTKY

GUARANTEED OPERATING RANGES

Symbol	Parameter	Min	Typ	Max	Unit
V_{CC}	Supply Voltage	4.75	5.0	5.25	V
T_A	Operating Ambient Temperature Range	0	25	70	°C
I_{OH}	Output Current – High			–0.4	mA
I_{OL}	Output Current – Low			8.0	mA

PLASTIC
N SUFFIX
CASE 646

SOIC
D SUFFIX
CASE 751A

ORDERING INFORMATION

Device	Package	Shipping
SN74LS04N	14 Pin DIP	2000 Units/Box
SN74LS04D	14 Pin	2500/Tape & Reel

December, 1999 – Rev. 6

Publication Order Number:
SN74LS04/D

SN74LS04

DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (unless otherwise specified)

Symbol	Parameter	Limits Min	Limits Typ	Limits Max	Unit	Test Conditions	
V_{IH}	Input HIGH Voltage	2.0			V	Guaranteed Input HIGH Voltage for All Inputs	
V_{IL}	Input LOW Voltage			0.8	V	Guaranteed Input LOW Voltage for All Inputs	
V_{IK}	Input Clamp Diode Voltage		−0.65	−1.5	V	V_{CC} = MIN, I_{IN} = −18 mA	
V_{OH}	Output HIGH Voltage	2.7	3.5		V	V_{CC} = MIN, I_{OH} = MAX, V_{IN} = V_{IH} or V_{IL} per Truth Table	
V_{OL}	Output LOW Voltage		0.25	0.4	V	I_{OL} = 4.0 mA	V_{CC} = V_{CC} MIN, V_{IN} = V_{IL} or V_{IH} per Truth Table
			0.35	0.5	V	I_{OL} = 8.0 mA	
I_{IH}	Input HIGH Current			20	µA	V_{CC} = MAX, V_{IN} = 2.7 V	
				0.1	mA	V_{CC} = MAX, V_{IN} = 7.0 V	
I_{IL}	Input LOW Current			−0.4	mA	V_{CC} = MAX, V_{IN} = 0.4 V	
I_{OS}	Short Circuit Current (Note 1)	−20		−100	mA	V_{CC} = MAX	
I_{CC}	Power Supply Current Total, Output HIGH			2.4	mA	V_{CC} = MAX	
	Total, Output LOW			6.6			

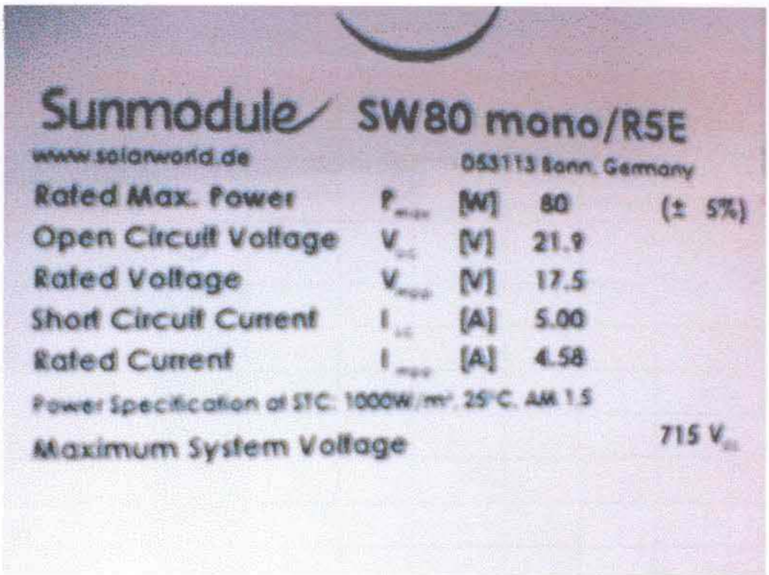
Note 1: Not more than one output should be shorted at a time, nor for more than 1 second.

AC CHARACTERISTICS (T_A = 25°C)

Symbol	Parameter	Limits Min	Limits Typ	Limits Max	Unit	Test Conditions
t_{PLH}	Turn–Off Delay, Input to Output		9.0	15	ns	V_{CC} = 5.0 V C_L = 15 pF
t_{PHL}	Turn–On Delay, Input to Output		10	15	ns	

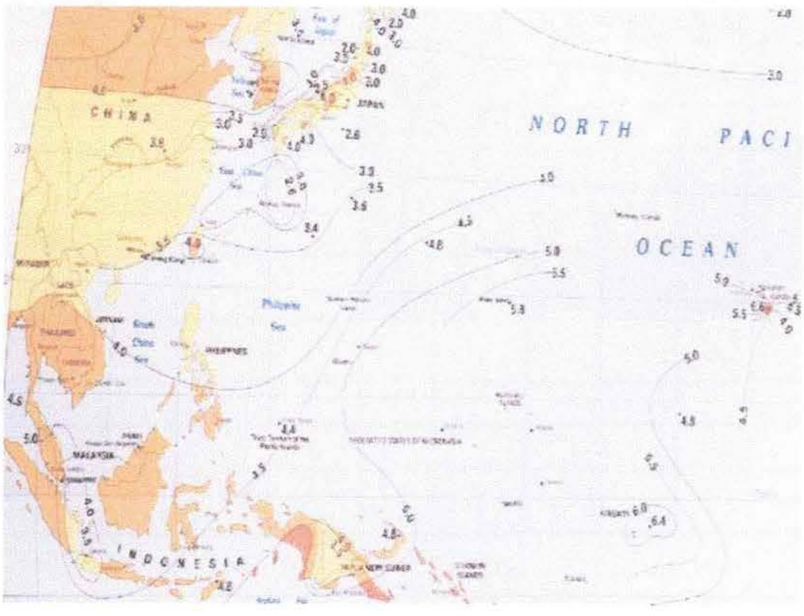
APPENDIX F

Data of Solar Panel



APPENDIX G

Solar Irradiation in Asia



APPENDIX H

Gantt Chart of Project

		PSM 1				PSM 2					
MONTH	Jan-09	Feb-09	Mac-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09
ACTIVITIES											
Title selection and registration											
Title and supervisor registration											
Project research											
Preparing proposal											
Preparing Presentation											
Slide for seminar 1.											
Submit Proposal											
Project Presentation											
(PSM 1 Seminar)											
Submit Report & Log Book											
Study about each hardware											
Study about hardware interface											
Analysis about the hardware											
interface											
Design the hardware circuit											
Determine the component and											
availability											
Construction of hardware											
Testing the hardware											
Troubleshoot the hardware											
Presentation and DEMO											
(PSM 2 Seminar)											
Preparing report											
Submit final report and log book											