Solar Battery Charger Circuit

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Declaration

This is to certify that the work presented in this thesis is the outcome of the analysis and

Experiments carried out by Najibullah, Farhad and Mahmoud Srhan under the supervision of Prof. Dr. Kazi Khairul Islam Department of Electrical and Electronics Engineering

(EEE), Islamic University of Technology (IUT), Dhaka, Bangladesh. It is also declared that

neither of this thesis nor any part of this thesis has been submitted anywhere else for any degree or diploma.

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Dedicated to our dear parents for the love and support they have given us throughout our studies

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Abstract

Solar concept is not new for us. As non-renewable energy sources are decreasing, usage of solar energy is increased. This solar energy is not only used on the Earth but also used in space stations where no electrical power is available. Solar energy begins with the sun. Solar panels, also known as photovoltaic, are used to convert light from the sun, which is composed of particles of energy called "photons", into electricity that can be used to power electrical loads. Light from the sun is a renewable energy resource that provides clean energy, produced by solar panels. Many people are familiar with so-called photovoltaic cells, or solar panels, found on things like spacecraft, rooftops, and handheld calculators. The cells are made of semiconductor materials like those found in computer chips. When sunlight hits the cells, it knocks electrons loose from their atoms. As the electrons flow through the cell, they generate electricity.

Here is the simple circuit to charge 12V, 1.3Ah rechargeable Lead-acid battery from the solar panel. This solar charger has current and voltage regulation and also has over voltage cut off facilities. This circuit may also be used to charge any battery at constant voltage because output voltage is adjustable.

Contents

Chapter 1

1.1 Introduction

Solar power is energy from the sun that is converted into thermal or electrical energy.

Solar energy is the cleanest and most abundant renewable energy source available, and the U.S. has some of the richest solar resources in the world. Modern technology can harness this energy for a variety of uses, including generating electricity, providing light or a comfortable interior environment, and heating water for domestic, commercial, or industrial use.

There are several ways to harness solar energy: photovoltaics (also called solar electric), solar heating & cooling, concentrating solar power (typically built at utility-scale), and passive solar.

The first three are active solar systems, which use mechanical or electrical devices that convert the sun's heat or light to another form of usable energy. Passive solar buildings are designed and oriented to collect, store, and distribute the heat energy from sunlight to maintain the comfort of the occupants without the use of moving parts or electronics.

Solar energy is a flexible energy technology, solar power plants can be built as distributed generation (located at or near the point of use) or as a central-station, utility-scale solar power plant (similar to traditional power plants). Some utility-scale solar plants can store the energy they produce for use after the sun sets.

Every hour the sun beams onto Earth more than enough energy to satisfy global energy needs for an entire year. Solar energy is the technology used to harness the sun's energy and make it useable. Today, the technology produces less than one tenth of one percent of global energy demand.

Solar energy used in space stations (satellite communication system) where no electrical power is available.

Solar energy doesn't work at night without a storage device such as a battery, and cloudy weather can make the technology unreliable during the day. Solar technologies are also very expensive and require a lot of land area to collect the sun's energy at rates useful to lots of people.

In this project the simple circuit is used to charge 12V, 1.3Ah rechargeable Lead-acid battery from the solar panel. This solar charger has current and voltage regulation and also has over voltage cut off facilities. This circuit may also be used to charge any battery at constant voltage because output voltage is adjustable.

The rest of the thesis book is organized as:

Chapter 2

Solar Energy, Importance of Solar Energy, Advantages and disadvantages of Solar Energy, Applications of Solar Energy, Solar Panel, Types of solar panel, working principle of solar panel, Solar Cell Overview, Basic theory of solar cell, Solar cell connection, Solar Cell Technologies, Solar Cell, Solar Module or Panel and Solar PV Array, PV Module, PV Array.

Chapter 3

LM 317 Adjustable Output, Positive Voltage Regulator, LM317 datasheet, Types of Batteries. And

Chapter 4

Related works

Chapter 2

2.1 Solar Energy

Solar energy is defined as energy obtained from the sun's radiation. The two main forms of solar energy include active solar energy and passive solar energy .

Active solar energy involves equipment or an action to convert solar energy into a useful form. One example of active solar energy is the use of solar cells to convert energy from the sun into electrical energy that can be used in the home.

Passive solar energy does not require any specific action or equipment. An example of passive solar energy is strategically placing windows in a home to allow sunlight to enter and provide heat. In this project we discuss about Active solar energy which involves solar panel.

2.1.1 Importance of Solar Energy:

As mentioned before solar energy is required and is important for survival of life on earth. Not only human beings, plants, animals everyone requires solar energy every day. Plants require solar energy to produce oxygen, prepare food i.e. photosynthesis. Solar energy is required to produce both pure and saltwater in oceans as it is the only source of melting the frozen ice formed on the mountain caps. Apart from that the electricity which we get to run various machines is all gained from the solar energy, thus its importance and existence is very important on a planet where there is life.

Solar energy is a clean and renewable energy. Also it's versatile and can help in producing power for watches and calculators that do not run on batteries. It's a clean energy because it is received directly from the sun. The fossil fuels and other gas and oil that are extracted from the mines are nonrenewable energy. Also they are costly and cause lot of pollution. But solar energy is something that is renewable and can be used for lots of activities. Also it is available free of cost. As fossil fuels and other oils are soon going to disappear solar energy which is available in abundant should be utilized well and hence is important.

2.1.2 Advantages and Uses of Solar Energy:

As we know solar energy is one such energy that is abundantly available and is free of cost, let’s have a look at some of its advantages.

- An energy that is totally free of cost and saves your money as the Sun is always going to be there.
- It is an environment friendly energy and hence does not create pollution.
- Provides electricity that is helps in producing electricity with the help of solar panels.
- A silent energy provider as the solar cells do not create sounds while extracting heat from the sun and producing electricity.
- Solar energy helps in reducing the electricity bill.
- The solar energy system can work independently without any connection and can be utilized and installed in remote areas too where there is no sign of electricity.
- Solar energy helps in decreasing the harmful gasses and does not contribute to acid rains, global warming, forest destruction and other natural disasters.
- No maintenance is required for solar energy and also it does not have any specific life span
- Solar energy is used for ventilating homes i.e. ceiling fans need electricity which is gained from solar energy
- Solar energy can be used to boil water instead of suing water heaters you can make use of the solar energy. Though you need to spend initially you will gain good benefits out of it in future.
- Solar energy can help in heating your homes and charging batteries.
- It can also be used for cooking purposes by using solar oven
- It can be used to heat swimming pools. Suppose you have a swimming pool outside you house you can make use of solar blanket to heat water during extreme cold seasons.
- You can use solar energy for indoor and outdoor lighting at night as it will help you see the entry door and walkway clearly.

Apart from these, solar energy can be used for commercial and industrial purposes too.

2.1.3 Disadvantages of Solar Energy:

- Solar energy can be used only during the daytime i.e. when the sun is shining bright
- The solar collectors, panels and cells that are used to absorb heat from the sun are very expensive
- In case of cloudy climate, there would be no signs of sun and solar energy which is difficult.
- The solar batteries that are charged or needs to be charged are very heavy and require large storage space. Replacing it is also difficult.
- Its low in efficiency and requires lots of land area
- There is no consistency because the devices that require energy of the sun will only work if the delivery of photons is consistent.
- Replacing the solar energy panels is also a very difficult job.
- Installation of solar energy requires large area so that the system can provide good amount of electricity. This is a great disadvantage in places where the area is small
- Pollution can be a hindrance to solar panels as pollution can degrade the efficiency of the photovoltaic cells. Clouds can also affect solar energy.
- The technology that is used to create solar energy is changing from time to time and we hope it makes lives better and more cost effective.

2.1.4 Applications of Solar Energy:

The applications of solar energy can be bifurcated into three types i.e. Power, Domestic and Agriculture. Few popular applications that can be listed under these are as follows:

- Solar Water heater
- Tank collector
- Portable solar still
- Solar Cooker
- Solar steam cooker
- Portable solar dryer
- Solar PV street light

These are some applications apart from these are many and are used on daily basis for different purposes. Let’s have a look in architecture applications. Under these applications we have the heating systems, cooling systems and the ventilation systems.

2.2 Solar Panel

Solar panel refers to a panel designed to absorb the sun's rays as a source of energy for generating electricity or heating. A photovoltaic (PV) module is a packaged, connect assembly of typically 6×10 solar cells. Solar Photovoltaic panels constitute the solar array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions, and typically ranges from 100 to 365 watts. Fig 2.1 show different size of solar panel.

Fig 2.1 Solar panel

2.2.1 Types of solar panel

There are three types of solar panels

I. Monocrystalline
II. Polycrystalline
III. Thin film

I. Monocrystalline:-

Solar cells made of monocrystalline silicon (mono-Si), also called single-crystalline silicon (single-crystal-Si), are quite easily recognizable by an external even coloring and uniform look, indicating high-purity silicon, as we can see on the picture below [Fig 2.2]

Fig 2.2 Monocrystalline silicon solar cells

Monocrystalline solar cells are made out of silicon ingots, which are cylindrical in shape. To optimize performance and lower costs of a single monocrystalline solar cell, four sides are cut out of the cylindrical ingots to make silicon wafers, which is what gives monocrystalline solar panels their characteristic look.

A good way to separate mono- and polycrystalline solar panels is that polycrystalline solar cells look perfectly rectangular with no rounded edges.

Advantages:-

- Monocrystalline solar panels have the highest efficiency rates since they are made out of the highest-grade silicon. The efficiency rates of monocrystalline solar panels are typically 15-20%. Sun Power produces the highest efficiency solar panels on the U.S. market today. Their E20 series provide panel conversion efficiencies of up to

20.1%.Update (April, 2013): Sun Power has now released the X-series at a record-breaking efficiency of 21.5%.

- Monocrystalline silicon solar panels are space-efficient. Since these solar panels yield the highest power outputs, they also require the least amount of space compared to any other types. Monocrystalline solar panels produce up to four times the amount of electricity as thin-film solar panels.
- Monocrystalline solar panels live the longest. Most solar panel manufacturers put a 25-year warranty on their monocrystalline solar panels.
- Tend to perform better than similarly rated polycrystalline solar panels at low-light conditions.
- Monocrystalline panels are generally constructed from high-quality silicon, giving them the highest performance rates in the industry, usually up to 21 percent. By comparison, monocrystalline panels outperform thin film by four to one. They also make wise use of space, so they offer a high power yield per square foot. Warranties often last for 25 years, and these panels perform better in low-light conditions than their poly-counterparts.

Disadvantages:-

- Monocrystalline solar panels are the most expensive. From a financial standpoint, a solar panel that is made of polycrystalline silicon (and in some cases thin-film) can be a better choice for some homeowners.
- If the solar panel is partially covered with shade, dirt or snow, the entire circuit can break down. Consider getting micro-inverters instead of central string inverters if you think coverage will be a problem. Micro-inverters will make sure that not the entire solar array is affected by shading issues with only one of the solar panels.
- The Czochralski process is used to produce monocrystalline silicon. It results in large cylindrical ingots. Four sides are cut out of the ingots to make silicon wafers. A significant amount of the original silicon ends up as waste.
- Monocrystalline solar panels tend to be more efficient in warm weather. Performance suffers as temperature goes up, but less so than polycrystalline solar panels. For most homeowners temperature is not a concern.
- The disadvantages of this panel type are significant.
  Because they are high-quality, these panels are also costly. Circuit break down is common when the panel is obstructed or shaded. The manufacturing process produces significant waste. The panels perform best in warm weather, with performance decreasing as temperatures increase.

II. Polycrystalline:-

The first solar panels based on polycrystalline silicon, which also is known as polysilicon (p-Si) and multi-crystalline silicon (mc-Si), were introduced to the market in 1981. Unlike monocrystalline-based solar panels, polycrystalline solar panels do not require the

Czochralski process. Raw silicon is melted and poured into a square mold, which is cooled and cut into perfectly square wafers as we can see on the [Fig 2.3]

Fig 2.3 Polystalline silicon solar cells

Advantages:-

- The process used to make polycrystalline silicon is simpler and cost less. The amount of waste silicon is less compared to monocrystalline.
- Polycrystalline solar panels tend to have slightly lower heat tolerance than monocrystalline solar panels. This technically means that they perform slightly worse than monocrystalline solar panels in high temperatures. Heat can affect the performance of solar panels and shorten their lifespans. However, this effect is minor, and most homeowners do not need to take it into account.
- High temperature ratings are slightly lower than those for monocrystalline panels; however, the difference is minor, making these types of panels a good option for many homeowners. The manufacturing process produces little waste, and the technology allows for a cost-effective panel.

Disadvantages:-

- The efficiency of polycrystalline-based solar panels is typically 13-16%. Because of lower silicon purity, polycrystalline solar panels are not quite as efficient as monocrystalline solar panels.
- Lower space-efficiency. You generally need to cover a larger surface to output the same electrical power as you would with a solar panel made of monocrystalline

silicon. However, this does not mean every monocrystalline solar panel perform better than those based on polycrystalline silicon.

- Monocrystalline and thin-film solar panels tend to be more aesthetically pleasing since they have a more uniform look compared to the speckled blue color of polycrystalline silicon.
- Efficiency is lower, typically between 13 and 16 percent, which is not nearly as high as the ratings for monocrystalline panels. The panels require more space when installed to produce the same electrical output as a panel constructed from monocrystalline.

III. Thin film:-

Depositing one or several thin layers of photovoltaic material onto a substrate is the basic gist of how thin-film solar cells are manufactured. They are also known as thin-film photovoltaic cells (TFPV). The different types of thin-film solar cells can be categorized by which photovoltaic material is deposited onto the substrate:

- Amorphous silicon (a-Si)
- Cadmium telluride (CdTe)
- Copper indium gallium selenide (CIS/CIGS)
- Organic photovoltaic cells (OPC)

Depending on the technology, thin-film module prototypes have reached efficiencies between 7–13% and production modules operate at about 9%. Future module efficiencies are expected to climb close to the about 10–16%.

The market for thin-film PV grew at a 60% annual rate from 2002 to 2007. In 2011, close to 5% of U.S. photovoltaic module shipments to the residential sector were based on thin-film.

Fig [2.4] shows the picture of thin film solar cell.

Fig 2.4 Thin-film solar cells (TFSC)

Advantages:-

- Mass-production is simple. This makes them and potentially cheaper to manufacture than crystalline-based solar cells.
- Their homogenous appearance makes them look more appealing.
- Can be made flexible, which opens up many new potential applications.
- High temperatures and shading have less impact on solar panel performance.
- In situations where space is not an issue, thin-film solar panels can make sense.

Disadvantages:-

- Thin-film solar panels are in general not very useful for in most residential situations. They are cheap, but they also require a lot of space. Sun Power’s monocrystalline solar panels produce up to four times the amount of electricity as thin-film solar panels for the same amount of space.
- Low space-efficiency also means that the costs of PV-equipment (e.g. support structures and cables) will increase.
- Thin-film solar panels tend to degrade faster than mono- and polycrystalline solar panels, which is why they typically come with a shorter warranty.

Note: - The specifications of the solar panel used in this project will be discussed in the next chapter.

2.3 Working principle of solar panel:

2.3.1 How does a solar panel works?

The process starts when the sun shines on solar PV panels that have been installed on the roof. [Fig 2.5]

Solar panels are made up of smaller units called solar cells. The most common solar cells are made from Silicon. There are a number of silicon cells within each PV panels these reacts with photons, or units of light, from the sun to produce direct current (DC) or electricity. DC electricity then travels to an inverter which converts this energy to electricity known as Alternating current (AC) that can be used in our home or office.

AC electricity then travels to the distribution network in your home powering your domestic or office appliances.

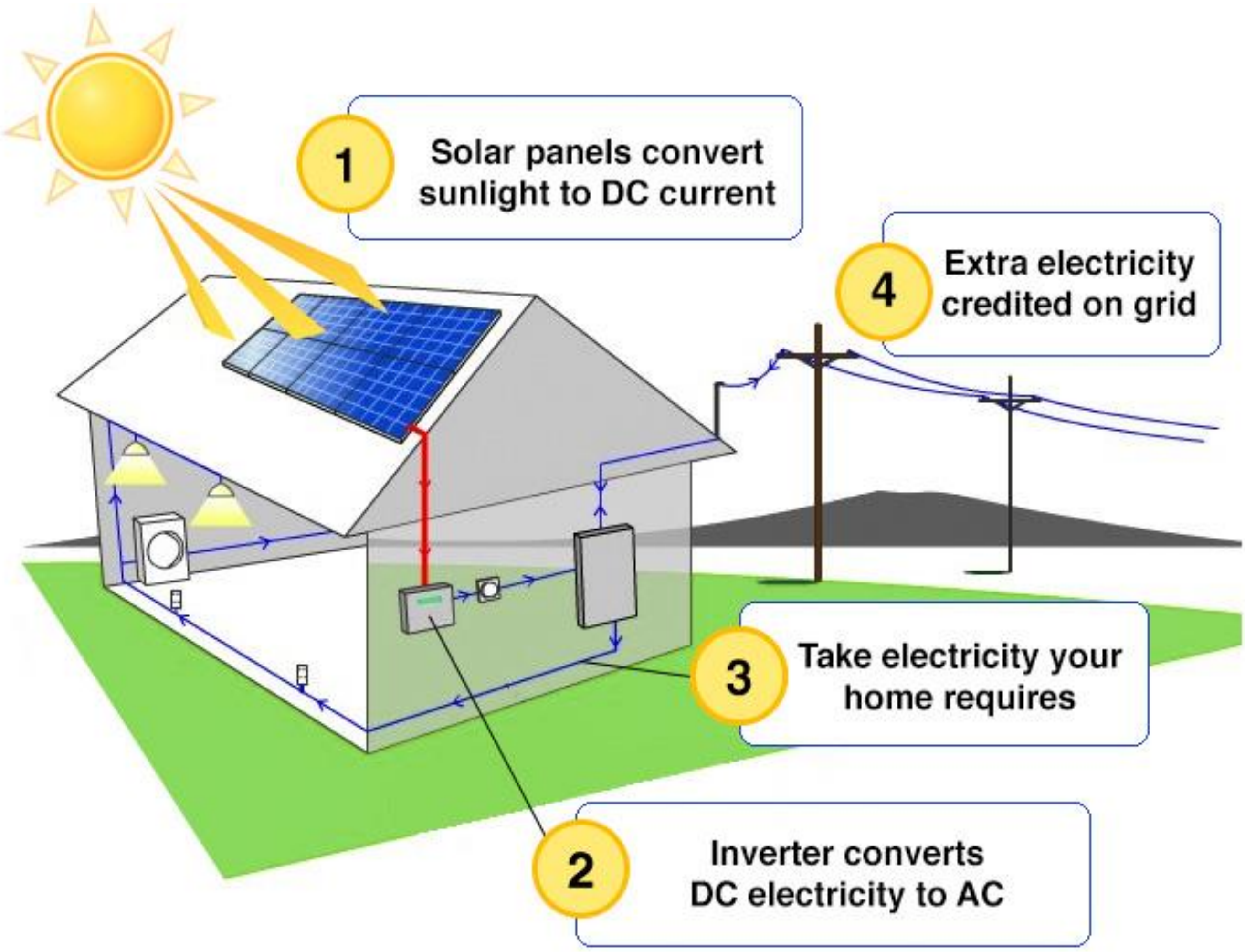

Fig 2.5 Solar panels converting sunlight to DC current.

2.4 Solar Cell Overview

A solar cell is an electronic device that converts the light energy directly into electric energy without any form of moving parts by using photovoltaic effect.

Fig 2.6 Solar cell

- A Solar cell is also known as Photovoltaic (PV) cell.
- It is a static device, no moving part.
- “Photo” means Light and “voltaic” means producing electricity.
- It is a solid state electronic device made of semiconductor materials like silicon.
- Solar cell converts energy of light directly into Direct current (DC).
- Solar cell does not use heat of light to produce electrical energy.
- In 1839 the photovoltaic effect was discovered, in 1883 first thin film solar cells fabricated and the first practical photovoltaic cell was developed in 1954.
- Efficiency of solar cell depends on many factors like shading on cells, irradiance, temperature etc.
- In 2014 the highest 44.7% efficiency has achieved by using the multiple junction cells.

2.5 Basic theory of solar cell

Solar cells are made by two types of semiconductor materials one is n-type semiconductor and other is P-type semiconductor material for generation of electricity.

- When light strikes on semiconductor, it generates electrons (-) and holes (+) pairs.
- when electron and hole pair reaches between two different type of semiconductor's joint surface then electron and hole are separated, electron is attached by N-type semiconductor and hole is attached by P-type semiconductor after that they are not rejoin due to joint surface do not allow both way traffic.

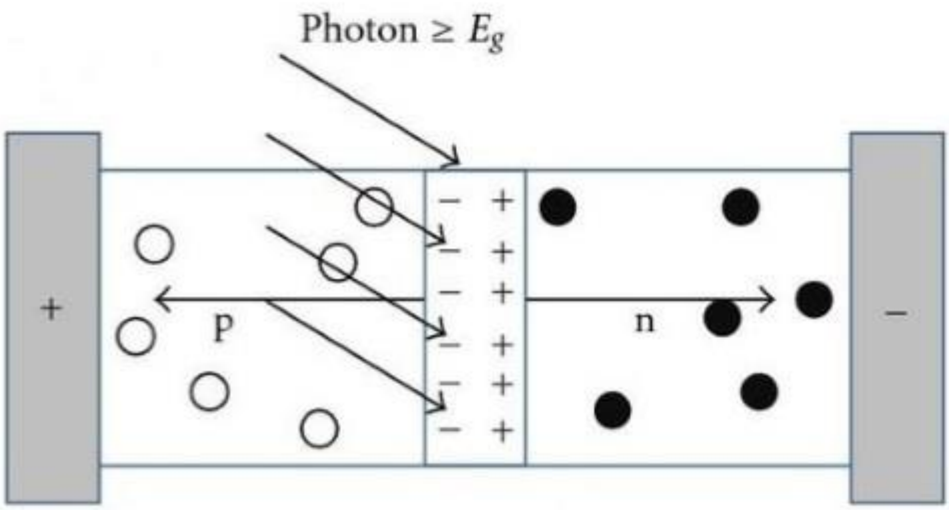

Fig 2.7 P-N junction illustration of PV cell

➢ Now electrons are contained by N-type semiconductor and holes are contained by P-type semiconductor, an electro motive force (emf) is generated in electrodes.
➢ When these electrodes are connected together by a conductor electrons run toward O-type semiconductor and holes run toward N-type semiconductor.

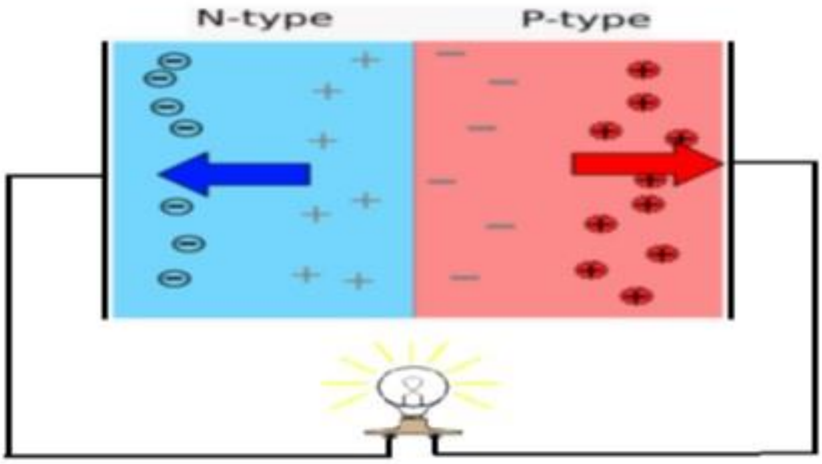

Fig 2.8 Flow of current

2.6 Solar cell connections

Solar cell connection is just like battery connection. When positive terminal of one solar cell is connected to negative terminal of another solar cell then they form series connection. In series connection current is same for all cells and voltage is added by each cell shown in figure 5.

And when all positive terminals of solar cells connected to one terminal and all negative positive terminals of solar cells connected to another one terminal then forms parallel connection. As shown in figure 6 here current is added and voltage is same for all cells.

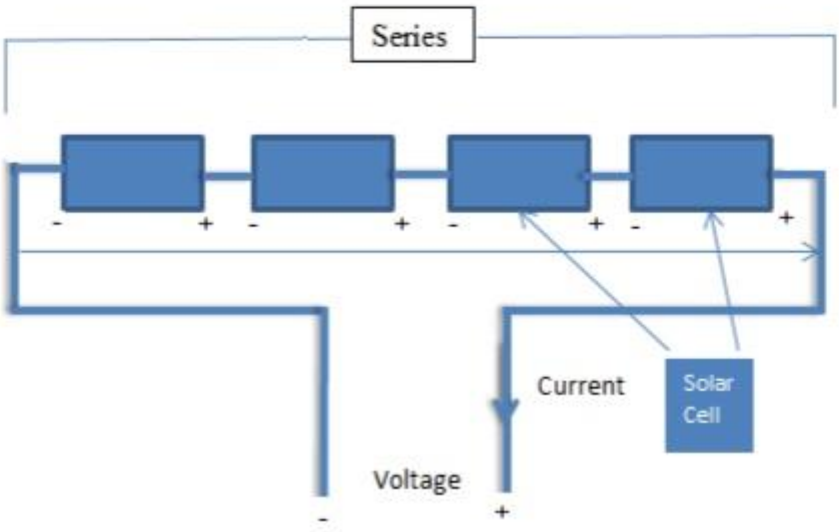

Fig 2.9 Series connection of solar cell

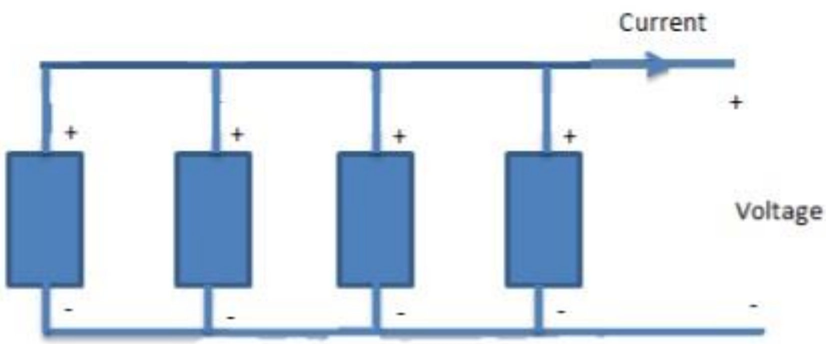

Fig 2.10 Parallel connection of solar cell

2.7 Solar Cell Technologies

Solar cell is manufacturing by different materials. The two major technologies are wafer-based silicon and thin-film [3].

Crystalline silicon solar cell is more efficient than thin-film solar cell but that is more expensive to produce. They are most commonly uses in large to medium electric applications like grid connected PV power generation.

Mono-crystalline solar cell is manufactured by pure semi-conducting materials so it has higher efficiency (above 17% in industrial production and 24% in research laboratories [4]. Poly-crystalline solar cell is slightly less efficient than Mono-crystalline but less in cost.

In thin-film solar cell very thin layers of semiconducting materials are uses so they can be produces in large quantity at lower cost but it efficiency is less. This technology is uses in calculators, watches and toys etc.

There are too many other PV technologies available like Organic cells, Hybrid PV cells combination of both mono crystalline and thin film silicon etc.

2.8 Solar Cell, Solar Module or Panel and Solar PV Array

In solar power generation system number of solar cells is required to produce high power so they are connected in form of Solar Module or Solar panel and for higher capability form Array as shown in figure 2.6

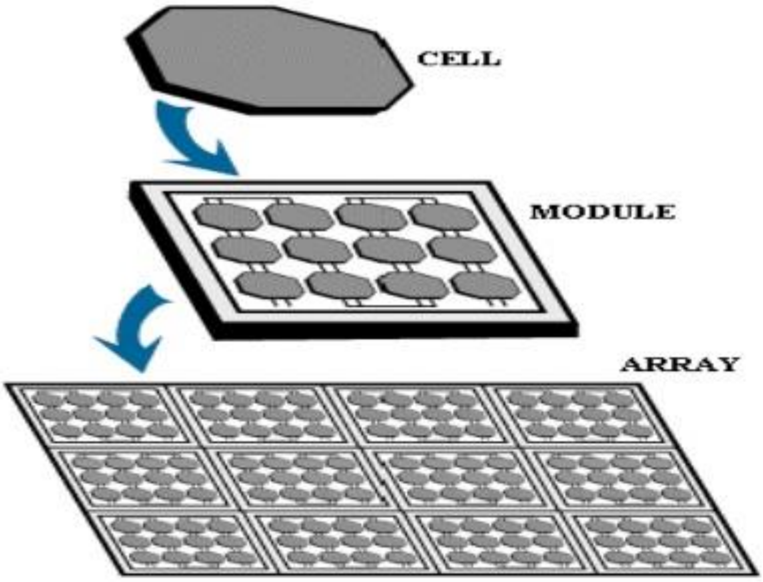

Fig 2.11 Formation of solar Module and solar PV Array

2.8.1 PV Module

A solar panel or module is a group of connected solar photovoltaic cells electrically and mounted on a sustaining structure. A photovoltaic module is a systematical arranged series connection of solar cells.

2.8.2 PV Array

A solar array is a group of solar photovoltaic panels or modules connected electrically together and mounted on a sustainable structure to produce higher amount of power. For this project the main task is to design a stand-alone power generation system for a small load like a house situated on hilly area or for any small load that is not connected to grid network.

For this kind of loads design such a system that uses the power generated from PV Array and convert it into AC for AC loads or stores it in storage element with efficiently and paralleling supplies the load. In this project Vikram solar panel is used so not need to bother about solar PV Array implementation.

Chapter 3

3.1 LM 317 Adjustable Output, Positive Voltage Regulator

The LM317 is an adjustable 3−terminal positive voltage regulator capable of supplying in excess of 1.5A over an output voltage range of 1.25 V to 37 V. This voltage regulator is exceptionally easy to use and requires only two external resistors to set the output voltage. Further, it employs internal current limiting, thermal shutdown and safe area compensation, making it essentially blow−out proof. The LM317 serves a wide variety of applications including local, on card regulation.

This device can also be used to make a programmable output regulator, or by connecting a fixed resistor between the adjustment and output, the LM317 can be used as a precision current regulator.

Features

- Output Current in Excess of 1.5 A
- Output Adjustable between 1.2 V and 37 V
- Internal Thermal Overload Protection
- Internal Short Circuit Current Limiting Constant with Temperature
- Output Transistor Safe−Area Compensation
- Floating Operation for High Voltage Applications
- Eliminates Stocking many Fixed Voltage
- Available in Surface Mount D2PAK−3, and Standard 3−Lead Transistor Package
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable
- These are Pb−Free Devices

3.2 LM317 datasheet

The LM317 is versatile in its applications, including uses in programmable output regulation and local on-card regulation. Or, by connecting a fixed resistor between the ADJUST and OUTPUT terminals, the LM317 can function as a precision current regulator. An optional output capacitor can be added to improve transient response. The ADJUST terminal can be bypassed to achieve very high ripple-rejection ratios, which are difficult to achieve with standard three-terminal regulators.

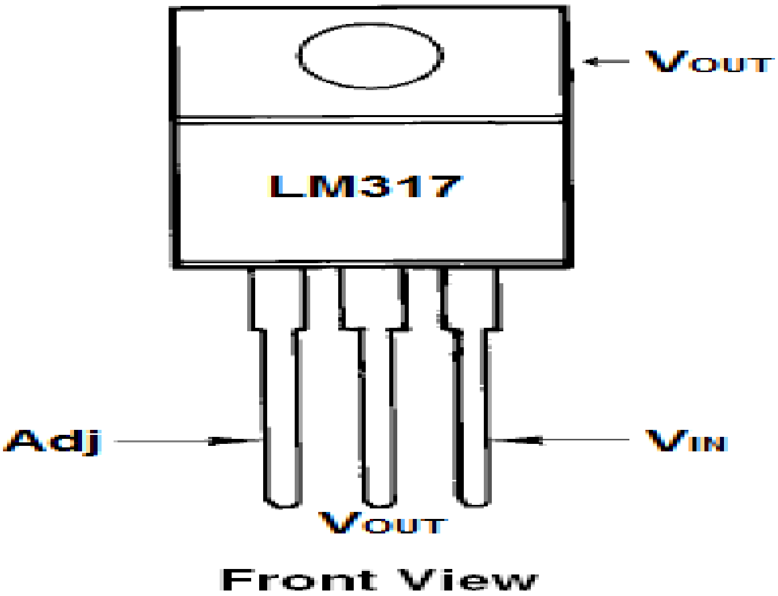

Fig 3.1 LM 317 front view

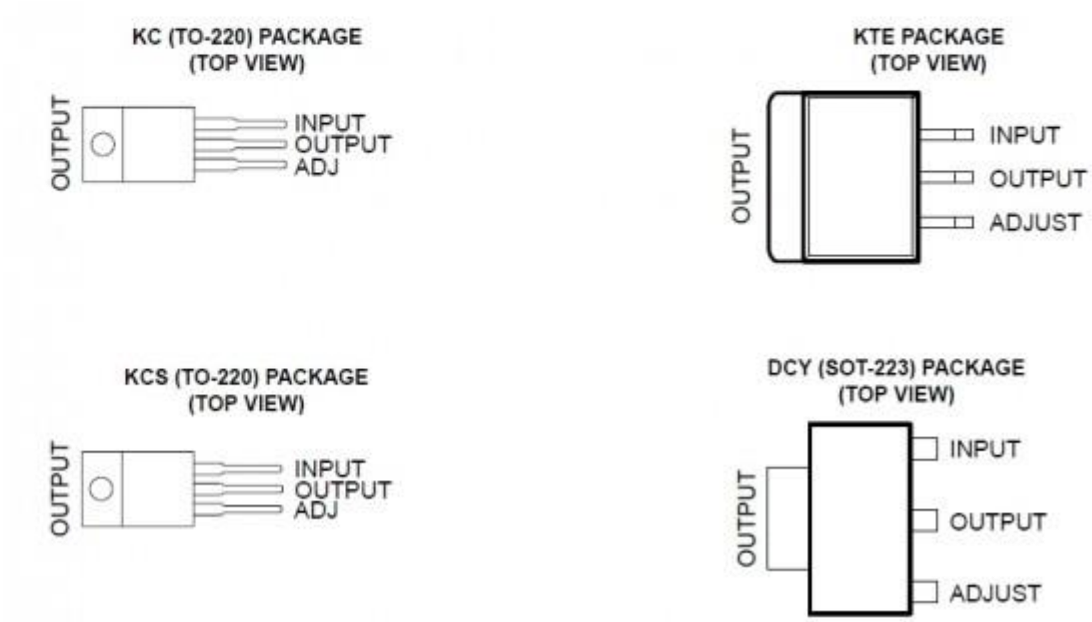

Fig 3.2 LM 317 top view

3.2 Types of Batteries

Rechargeable batteries play an important role in our lives and many daily chores would be unthinkable without the ability to recharge. The most common rechargeable batteries are lead acid, NiCd, NiMH and Li-ion. Here is a brief summary of their characteristics.

- Lead Acid – This is the oldest rechargeable battery system. Lead acid is rugged, forgiving if abused and is economically priced, but it has a low specific energy and limited cycle count. Lead acid is used for wheelchairs, golf cars, personnel carriers, emergency lighting and uninterruptible power supply (UPS). Lead is toxic and cannot be disposed in landfills.

- Nickel-cadmium – Mature and well understood, NiCd is used where long service life, high discharge current and extreme temperatures are required. NiCd is one of the most rugged and enduring batteries; it is the only chemistry that allows ultra-fast charging with minimal stress. Main applications are power tools, medical devices, aviation and UPS. Due to environmental concerns, NiCd is being replaced with other chemistries, but it retains its status in aircraft due to its good safety record.

- Nickel-metal-hydride – Serves as a replacement for NiCd as it has only mild toxic metals and provides higher specific energy. NiMH is used for medical instruments, hybrid cars and industrial applications. NiMH is also available in AA and AAA cells for consumer use.

- Lithium-ion – Li-ion is replacing many applications that were previously served by lead and nickel-based batteries. Due to safety concerns, Li-ion needs a protection circuit. It is more expensive than most other batteries, but high cycle count and low maintenance reduce the cost per cycle over many other chemistries.

Here in this project we used a 12v, 1.3A rechargeable battery as shown in picture below [Fig 3.3]

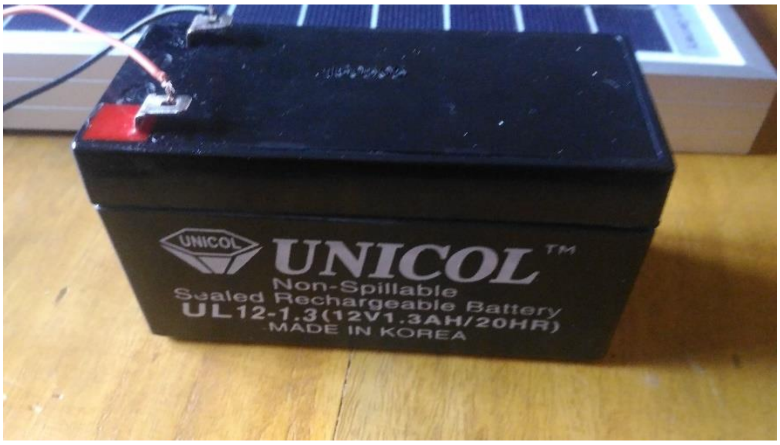

Fig 3.3 A 12V-1.3Ah rechargeable battery

Chapter 4

4.1 Related works

4.1.1 Specifications of the Charging Circuit

- Solar panel rating – 5W /17V
- Output Voltage –Variable (5V – 14V)
- Maximum output current – 0.29 Amps
- Drop out voltage- 2- 2.75V
- Voltage regulation: +/- 100mV

4.1.2 Solar Battery Charger Circuit Principle:

Solar battery charger operated on the principle that the charge control circuit will produce the constant voltage. The charging current passes to LM317 voltage regulator through the diode D1. The output voltage and current are regulated by adjusting the adjust pin of LM317 voltage regulator. Battery is charged using the same current.

4.2 Solar Battery Charger Circuit Diagram:

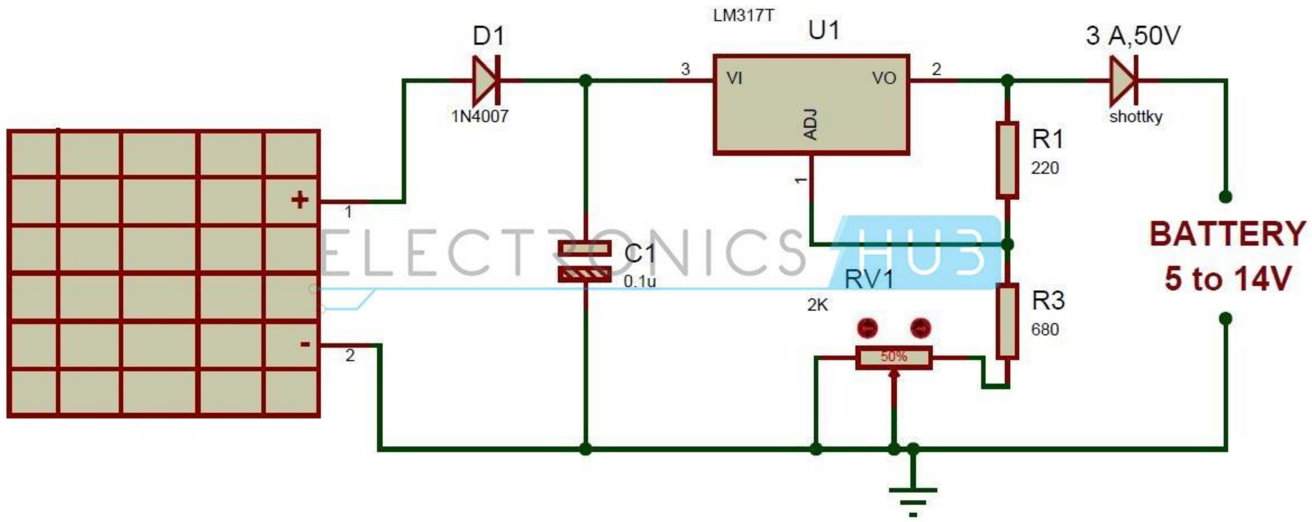

Fig 4.1 Solar Battery Charger Circuit diagram

4.3 Circuit Components

- Solar panel – 17V
- LM317 voltage regulator
- DC battery
- Diode – 1n4007
- Capacitor – 0.1uF
- Schottky diode – 3A, 50V
- Resistors – 220, 680 ohms
- Pot – 2K
- Connecting wires

4.4 Solar Battery Charger Circuit Design

Circuit must have adjustable voltage regulator, so Variable voltage regulator LM317 is selected. Here LM317 can produce a voltage from 1.25 to 37 volts maximum and maximum current of 1.5 Amps.

Adjustable Voltage regulator has typical voltage drop of 2 V-2.5V .So Solar panel is selected such that it has more voltage than the load. Here I am selecting 17v/5w solar panel.

Lead acid battery which is used here has specification of 12v/1.3Ah. In order to charge this battery following are required.

Schottky diode is used to protect the LM317 and panel from reverse voltage generated by the battery when it is not charging. Any 3 A diode can be used here.

4.4.1 for Charging 12V Battery

Output voltage

- Set the output voltage to 14.5 volts (This voltage is specified on the battery as cycle use.)

Charging current

- Charging current = Solar panel wattage/Solar Panel Voltage = 5 / 17 = 0.29A.
- Here LM317 can provide current upto 1.5A .So it is recommended to use high wattage panels if more current is required for your application.(But here my battery requires initial current less than 0.39Amps. This initial current is also mentioned on the battery).
- If the battery requires initial current more than 1.5A,it is not recommended to use LM317.

Time taken for charging

Time taken for charging = 1.3Ah/0.29A = 4.44hours.

Power dissipation

Here solar panel has 5Watts

- Power going into battery = 14.5*0.29 =4 watts
- Thus 1 watt of power going into regulator.
- All the above mentioned parameters have to be taken into account before charging a battery.

4.4.2 For 6V Application

Output voltage

- Set the output voltage to 7.5-8 volts (This voltage is specified on the battery as cycle use.)

Charging current

- Charging current = Solar panel wattage/Solar Panel Voltage = 5 / 17 = 0.29A.
- Here LM317 can provide current upto 1.5A .So it is recommended to use high wattage panels if more current is required for your application.(But here my battery requires initial current less than 0.39Amps. This initial current is also mentioned on the battery).
- If the battery requires initial current more than 1.5A, it is not recommended to use LM317.

Time taken for charging

- Time taken for charging = 1.3Ah/0.29A = 4.44hours.

Power dissipation for 6V battery

Here solar panel has 5Watts

- Power going into battery = 7.5*0.29 =2.175watts
- Thus 2.825 watt of power going into regulator.
- All the above mentioned parameters have to be taken into account before charging a battery.

4.4.3 Power Dissipation

In this project, power is limited because of the thermal resistance of LM317 voltage regulator and the heat sink. To keep the temperature below 125 degree Celsius, the power must be limited to 10W. LM317 voltage regulator internally has temperature limiting circuit so that if it gets too hot, it shuts down automatically.

When battery is charging, heat sink becomes warm. When completing the charging at maximum voltage, heat sink runs hot. This heat is because of excess power that not needed in the process of charging a battery.

4.4.4 Current Limiting

As the solar panel provides constant current, it acts as a current limiter. Therefore the circuit does not need any current limiting.

4.4.5 Solar Charger Protection

In this circuit, capacitor C1 protects from the static discharge. Diode D1 protects from the reverse polarity. And voltage regulator IC provides voltage and current regulation.

4.4.6 Solar Charger Specifications

- Solar panel rating: 20W (12V) or 10W (6V)
- Vout range: 5 to 14V
- Maximum power dissipation: 10W (includes power dissipation of schottky diode)
- Typical drop out value: 2 to 2.75V (depends on load current)
- Max current: 1.5A (internally it limited to 2.2A)
- Voltage regulation: +/- 100mV

4.4.7 How to Operate this Solar Battery Charger Circuit?

1. Give the connections according to the circuit diagram.
2. Place the solar panel in sunlight.
3. Now set the output voltage by adjusting pot RV1
4. Check the battery voltage using digital multi meter.

4.4.8 Solar Battery Charger Circuit Advantages

- Adjustable output voltage
- Circuit is simple and inexpensive.
- Circuit uses commonly available components.
- Zero battery discharge when no sunlight on the solar panel.

4.4.9 Solar Battery Charger Circuit Applications

This circuit is used to charge Lead-Acid or Ni-Cd batteries using solar energy.

4.4.10 Limitations of this Circuit:

1. In this project current is limited to 1.5A.
2. The circuit requires high drop-out voltage

Chapter 5

Conclusions

5.1 Summary

In this paper we present a solar battery charger circuit to charge 12V, 1.3Ah rechargeable Lead-acid battery from the solar panel. This solar charger has current and voltage regulation and also has over voltage cut off facilities. This circuit may also be used to charge any battery at constant voltage because output voltage is adjustable.

We bought the components and done the project practically.

5.2 Limitations

1. In this project current is limited to 1.5A.
2. The circuit requires high drop-out voltage.

5.3 Future Work

The current circuit is to charge 12V, 1.3Ah rechargeable Lead-acid battery from the solar panel. We chose the circuit in such way so that can be used to charge any battery at constant voltage because output voltage is adjustable.