

Project Report on Solar Charger Circuit using IC LM317

Prepared by:

Neha Kondekar
Undergraduate 1st Year,
Indian Institute of Science,
Bangalore

Guided By:

Amit K Gupta, Prof. Navakant Bhat
Centre for Nano science and Engineering, IISc

Go Solar

Table of Contents

1. Abstracts
 2. Introduction
 3. Theory
 4. Experiments : Observations And Results
 5. Summary
 6. Conclusions
 7. Further Interests
-

Abstracts

With fuel hikes making news, solar energy is the most sought after energy source. Solar chargers are simple, portable and ready to use devices which can be used by anyone especially in remote areas. Going solar can solve more than one problems, right from cutting down on carbon emissions and dependence on fuels, to solving the energy crisis. This project aims to make a simple solar charger which can be used on the go. Solar panels don't supply regulated voltage while batteries need so for charging. Hence, an external adjustable voltage regulator is used to have the desired constant voltage. A zener diode switches on to ensure charging is cut off at the saturation point.

Introduction

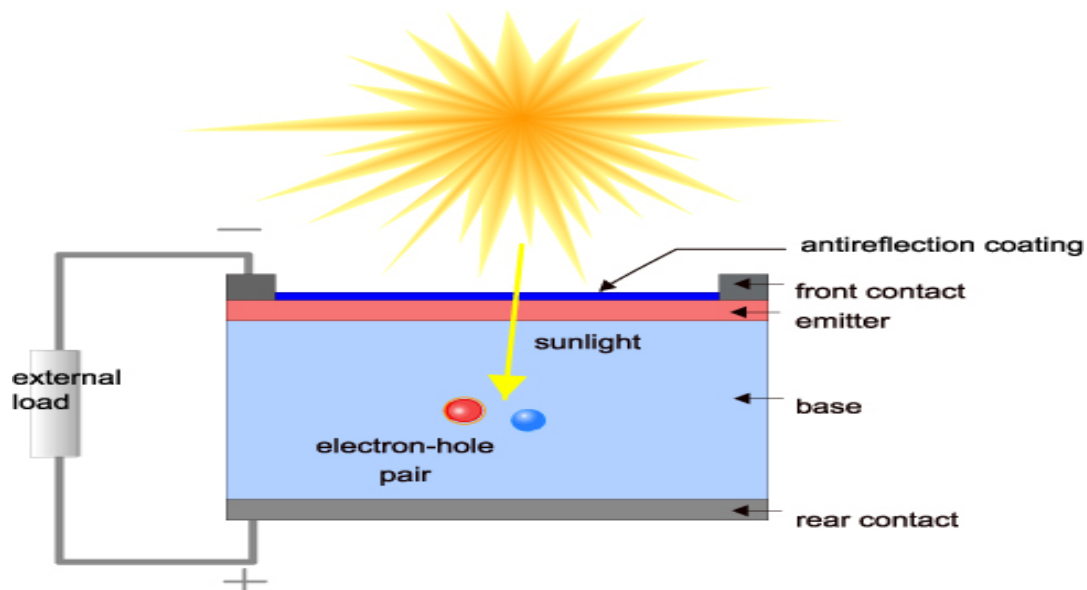
Gone are the days when you would look up at the Sun and curse yourself for being out on a hot sunny day. Take pride; very soon you will be a walking energy station with people asking you to help them charge their batteries with your clothes!

This isn't a scene out of a Sci-Fi movie. It is the simple application of solar cells. They are the only way we can convert sunlight into electricity directly and day by day they are getting better, smaller and cheaper.

Nothing can dare challenge the sun when it comes to radiating energy. Every hour the energy available from the sun is more than what human's require for an entire year. Petrol, diesel and all these fossil fuels are nothing but sun's energy concentrated over years and years. This makes them very efficient in terms of energy per unit of the fuel. So why not tap it directly?

Solar energy isn't something new. People have used sun to dry and preserve things. Vedic literatures in India even state the use of flying machines which were powered using the sun. Come 21st century, we have come a long way in developing solar cells which are the devices powering our future, converting sun's energy into electricity.

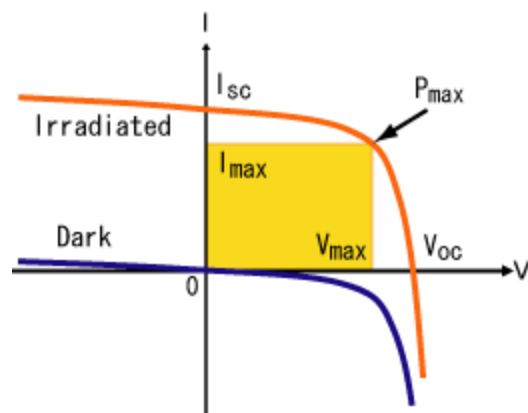
Solar panels are simply solar cells lined up together in series and parallel so as get sufficient voltage and are p-n junction semiconductor devices with pure silicon wafer doped with 'n' type phosphorous on the top and 'p' type boron on the base. If the PV cell is placed in the sun, **photons** of light strike the electrons in the p-n junction and energize them, knocking them free of their atoms. These electrons are attracted to the positive charge in the n-type silicon and repelled by the negative charge in the p-type silicon. Connecting wires across the junction will have a current in them.



Solar cells have come a long way from bulky 6% efficient chunks to thin films with as much as 30% efficiency. They are selling like hot cakes today given their necessity and utility. And the reason being they are faithful good chaps unlike oil which will soon be more precious to us than diamonds and the black monster: coal which has polluted the air, hand in cuff with the other fossil fuels.

We need to understand solar panels so as to understand their applications. Today, we have mono-crystalline, polycrystalline and amorphous thin film panels. Mono-crystalline are so far the most efficient, given that they have the maximum silicon in a unit area so more current for the same number of photons. They are made out of a single silicon crystal as a continuous lattice. While for the polycrystalline panels, molten silicon is poured into molds and separate boundaries can be seen due to this. Lesser quantity of silicon in a unit area means lesser efficiency of production of electricity. Amorphous thin film panels are layers of silicon on a glass surface and are the least expensive. Hence, they are used in applications where you can do away with efficiency for lowering the costs.

Solar panels are really useful in broad daylight but we need energy when the Sun isn't shining above our rooftops. That's why we need solar chargers which will store energy in rechargeable batteries. This project aims to make a solar charger using a voltage regulator IC so as to charge a Lead Acid Battery with the constant output voltage obtained through this IC LM317(Details explained later). Today there are many more options like a SOLAR CHARGER IC LT3652. This is an IC with embedded MPPT (Maximum Power Point Tracking) algorithm. MPPT simply means the IC gets the maximum possible power from the solar panel by sampling its output and applying the proper load resistance. This small chip simplifies life given its ease of use and maximum efficiency is always ensured.



Even 15% efficient solar panels installed across the world's wastelands can produce enough clean energy to sustain mankind for a year.

Yet new technology is continuously being developed though solar energy generation is still in its infancy. The concept of SOLAR FARMING is new and catching up fast in investors. India is a tropical country and can soon become the Saudi Arabia of solar energy. With Concentrated Photo Voltaics (CPV : which increase efficiency by concentrating large amount of sunlight on the solar cells using mirrors) coming up in India, we are definitely headed towards a cleaner future.

Reducing dependence on fossil fuels and cutting down on our carbon emissions is one of the most important aspects of solar energy. Another crucial point is it can make any country, especially tropical ones like India, self-sufficient in energy. With ambitious project like the National Solar missions aiming at producing 20GW (India's energy consumption 2012: 100GW out of which 1GW was Solar energy) by 2020 is a big step toward progress. Rural areas are now lit up with solar lamps. Solar parks are also an emerging trend with Charanka Solar Park, Gujarat producing 20MW of energy. Government is also taking initiatives to encourage people to make use of the sun by subsidizing electricity bills for consumers using the solar panels. So if you make more energy than you use, you will end up in a profit without even burning a calorie!

Going Solar is exciting but some challenges also need to be addressed. Space constraints, weather constraints and expensive technology involved do hinder the process. But with increase in production and development of technology, prices will fall, demands increase and we will be living in a cleaner, safer environment, making the energy we need. Renewable sources of energy alone can ensure sustainable development. Economic growth can also be ensured by energy reaching to each and every household in turn increasing the productivity of industries and standard of living of people. It is a bright future we have ahead of us; the only thing is we need to focus the glare rather than evading it.

Theory

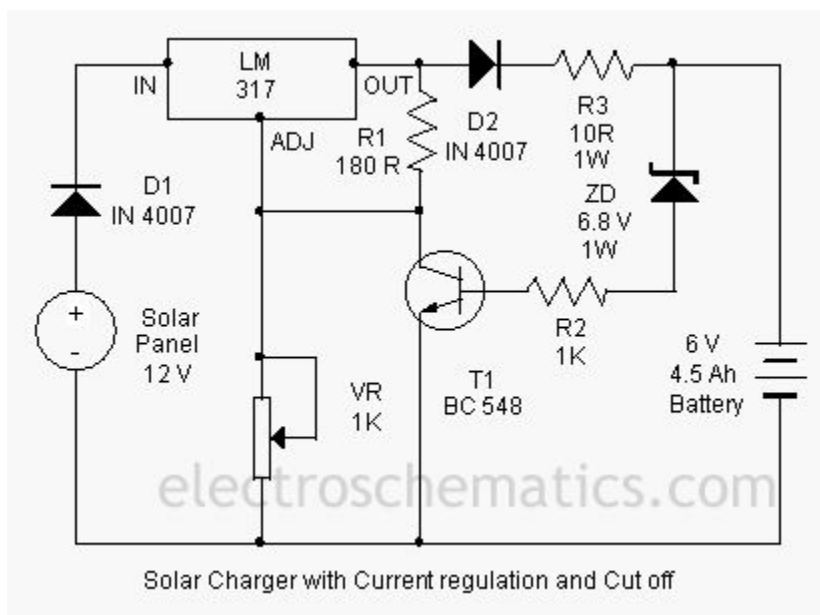
SOLAR PANEL, 5W, 17.5V,
362X163X8MM
Power Rating: 5W
Power Voltage Max: 17.2V
Current at P Max: 290mA
Open Circuit Voltage: 21.4V
Short Circuit Current: 320mA
Solar Battery charger IC(LT3652)
Battery: Li-ion(3.7V,1400mAh)

IC LM 317 :
Adjustable Voltage
Regulator so as to
have constant
voltage charging for
the battery

Lead Acid Battery ;
6V, 5Ah

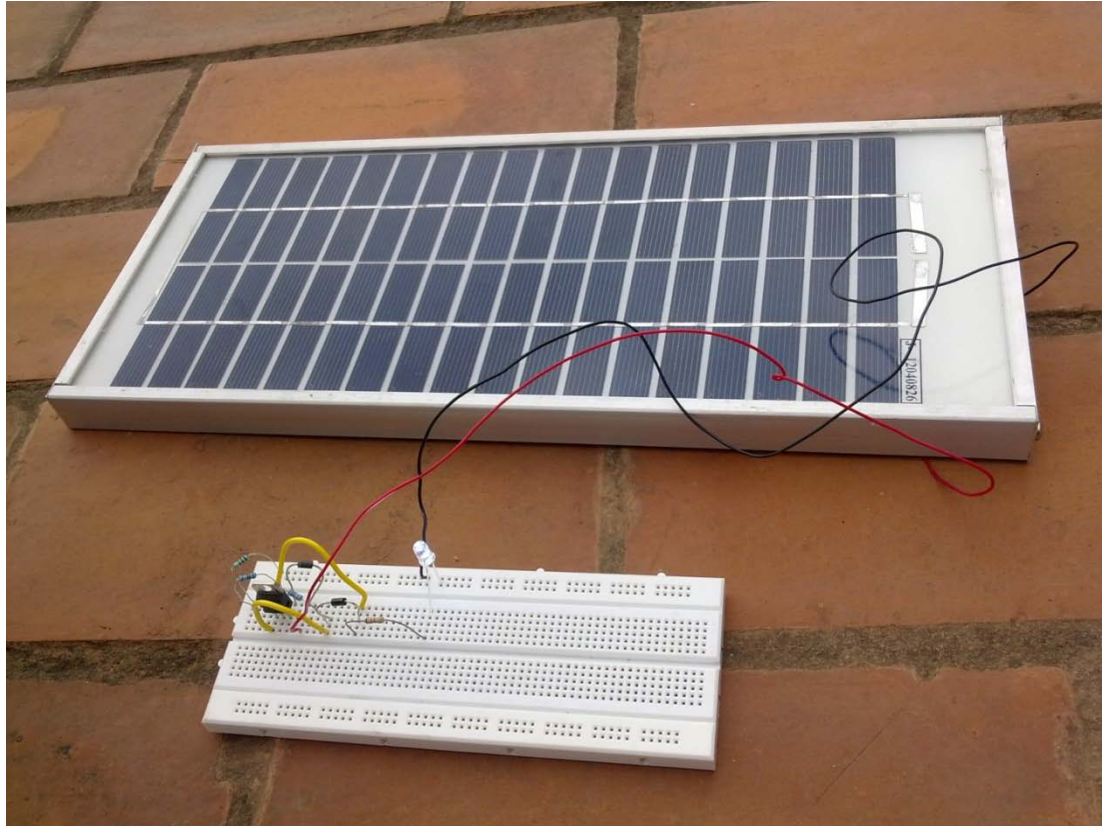
Zener diode : To
cut off charging
after battery
reaches
saturation

This project aims to make a solar charger circuit using IC LM 317 which is an adjustable voltage regulator.



This solar charger then charges a Lead acid battery which in turn will power our solar lamp.

Note: Several options are available in solar charger circuits but I chose to have IC LM317 given the limitations in availability of the ICs as well as the learning involved in having an entire analog circuit as compared to just having a ready to use Solar charger IC.



Components Involved:

- Solar Panel: The heart of the circuit. It has the following specifications:
 - i) $V_{oc} = 17.4V$
 - ii) $I_{sc} = 0.33A$
 - iii) $V_{mp} = 17.4V$
 - iv) Max Power= 5W

This is our power supply. It is responsible for charging the battery.



LM 317:

- It is an adjustable voltage regulator IC which means it provides Line Regulation (irrespective of the changes in the input voltage, the output voltage remains constant) and Load Regulation (irrespective of the changes in load the output voltage is fixed).

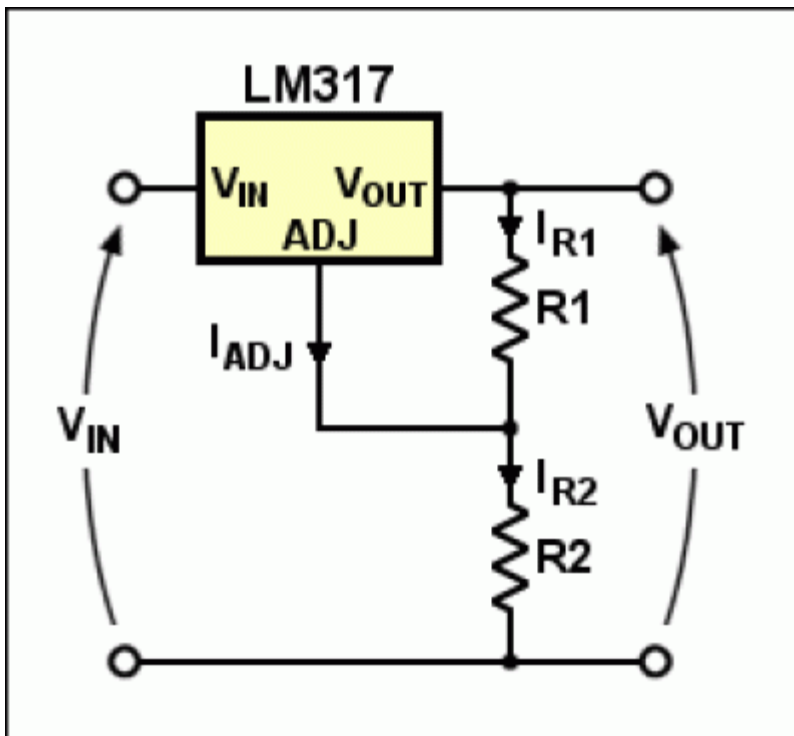
We can adjust the output voltage by varying the resistance across the adjust pin.

This is needed to have a fixed voltage across the battery (to limit the current and charge it at constant voltage). Directly connecting the solar panel to the battery may even explode it due to the varying output from it.

The voltage across R1 is maintained to be 1.25 V using an internal circuit. The Vout is also then obtained to be constant and given by:

$$V_{out} = V_{R1} * (1 + R2/R1) + I_{adj} * R2.$$

This I_{adj} is of the order of microA so can be neglected to have a regulated output voltage.



- Battery: (SEALED LEAD ACID BATTERY): This circuit is designed for a 6V, 5Ah battery. This means a 5A current will charge the battery in 1hour. Lead acid batteries are not the best available options in rechargeable batteries (unlike portable and easy to use Li-ion batteries). But for small

applications like our solar lamp, they are good enough. Care must be taken while handling acid



batteries.

- Diodes(1N5812): These are simply blocking diodes which ensure that the current flows only in one way so that the battery doesn't discharge when the output from solar panel is low.
 - Zener Diode(1N4736) and the Transistor(BC548): This part of circuit ensures that once the charging cut off voltage is reached by the battery, the charging stops. The Zener is rated at 6.8V as breakdown. This allows all the voltage to drop across the Zener and the transistor switches on due to biasing of the Base-Emitter junction. The transistor acts like a switch and once the battery is charged, it draws all the current thus protecting the battery.
-

Experiments

Note: We conduct experiments step by step to understand how each component works and then assemble the circuit together.

1. TO study how solar panels behave to different intensities of light

Conditions	Open circuit voltage across the panel
Covered with cardboard	0.263V
Facing the desk	0.468V
Covered with Paper	2.5V
At the window(11am)	14.72V
In the lab	7.62V
At the desk	5.2V
Using a torchlight at distance 15cm	11.22V
At the terrace(2pm)	21.2V(maximum Voc=21.4V)

Observations: Solar panels are heavily dependent on the intensity and the nature of light falling on them to produce any kind of voltage. The output varies right from 0.2V to 21.2V.

Conclusions: Sunlight matters a lot. So to make the best out of a fixed solar panel, we need to have some kind of power tracking which will always allow the panel to produce a maximum power by impedance matching (external resistor across the cell).

2. To study the working of IC LM317(using power supply)

Conditions: R1=180Ohm, R2=500ohm

Vin	Vref	Vout	Vin-Vout	Iref(mA)	Iadj(uA)
6.85V	1.225	4.64V	2.12V	6.81	19
8.30V	1.225	4.657V	3.67V	6.815	53
10.59V	1.224	4.65V	4.65V	6.815	46.6
12.16v	1.225	4.667V	4.667v	6.81	73
15.68V	1.225	4.68V	11.00V	6.81	99
23.67V	1.225	4.651V	18.19V	6.817	41

Using Solar panel

Conditions: R1=180Ohm, R2=500ohm

Vin	Vref(V)	Vout	Iref(mA)	Iadj(uA)
4.85V	1.225	4.64V	6.81	19
6.30V	1.225	4.657V	6.815	53

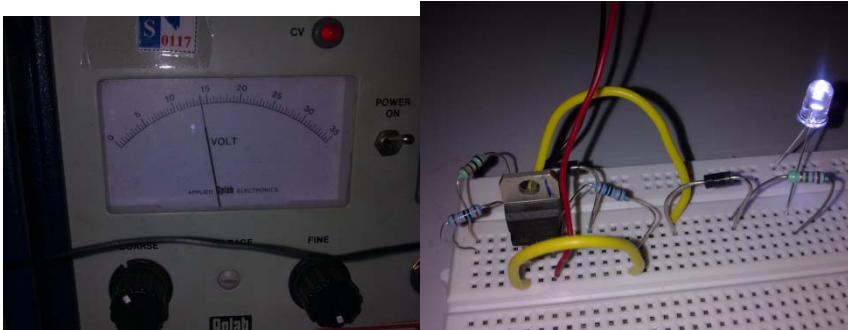
7.59V	1.224	4.65V	6.815	46.6
8.16v	1.225	4.667V	6.81	73
10.68V	1.225	4.68V	6.81	99
11.67V	1.225	4.651V	6.817	41

Observations: The output voltage from the IC is observed to be nearly constant with the input-output differential voltage ranging from 2.1V to 20V (Power supply limit).

Results: IC LM 317 gives a regulated output for a particular range of input voltage.

3. To understand the working of LEDS

Conditions: R1=120ohm, R2= 500ohm



Observations: LED starts glowing with voltage across it > 2.67V.

Maximum Intensity at $V_{led} = 3.2V$ (Supply 25V). At that point, current through the LED = 49.7mA. After that the LED blows out. So the LED is rated at 2.6V, 49mA practically.

4. To study working of Zener Diodes

Setup: The Zener is tested for its rating using a power supply, LED and a resistor. The Zener conducts only after the voltage across it is > 6.78V (i.e. reverse breakdown voltage). This is easily seen when the LED lights up.

Observations: (Series resistor: 1k)

Vin	Vzener	Led status
1V	0.3V	OFF
3.2V	2.1V	OFF
6.4V	4.5V	OFF
10.5V	6.77V	ON
12V	6.77V	ON



5. **To study the discharging of batteries**

Setup: the sealed lead acid battery available is fully charged with voltage across it as 6.39V. We need to discharge it to atleast 5.8V so as to charge it using our solar charger circuit. For this an emergency lamp was used to discharge the 5Ah battery as fast as possible.

Observations:

Time(mins)	Voltage(V)
0	6.17
15	6.146
30	6.120
45	6.099
60	6.082
120	5.981
150	5.89

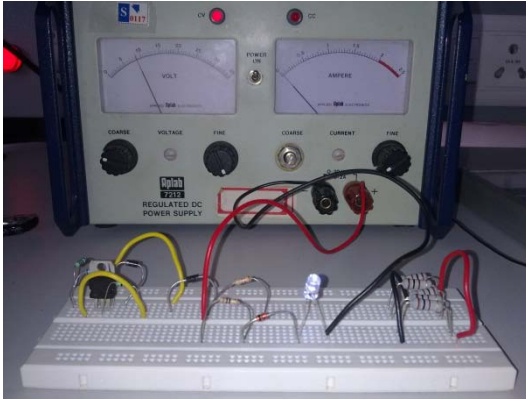
*Battery discharging depends on the capacity of the battery and the current drawn through it. Here, the current drawn was 140mA and hence to totally discharge a 5Ah battery, 30hours are required. This is a slow process. Hence, we allow it only to discharge up to 5.8V.

6. **To light up a LED**

Setup: LEDs need to be tested for specifications because experimental and theoretical ratings do differ. This is done using the power supply firstly, then the solar panel is connected to ensure the output match its ratings.

Observations:

With power supply



Vin(at the IC)	Vout	Vled+Vresistor
10.62V	7.40V	7.12V

With solar panel

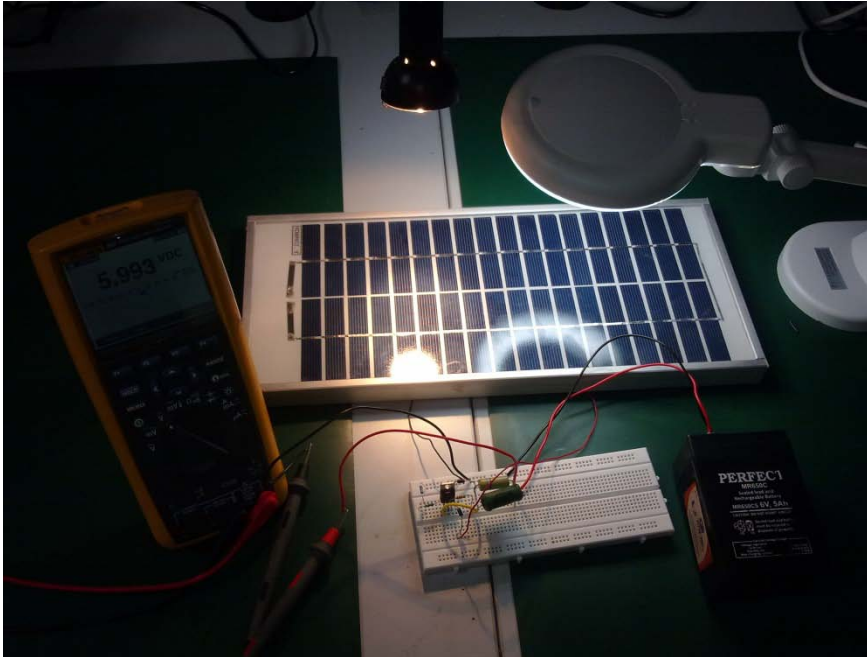


6.51V	5.022V	5.144V
-------	--------	--------

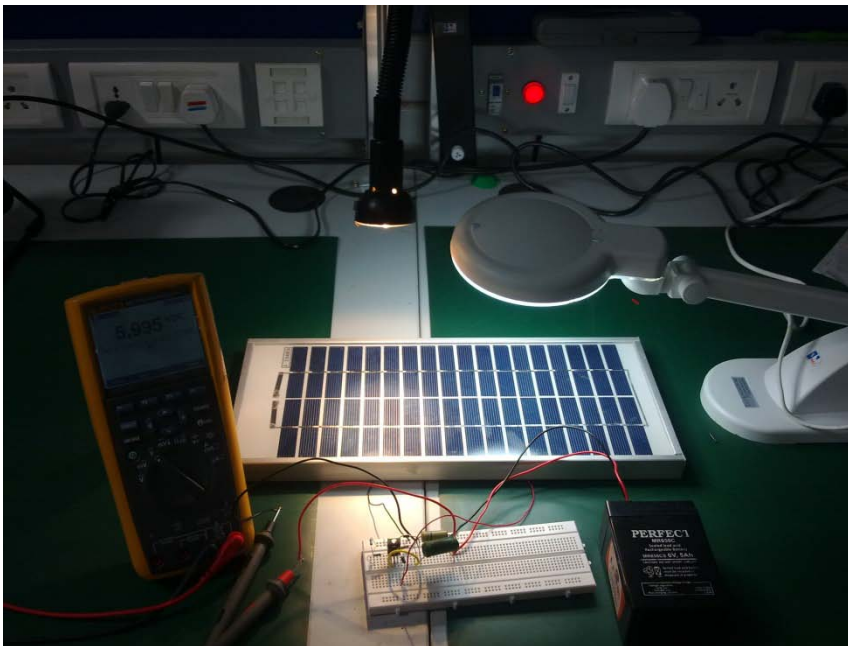
7. To study the charging of batteries using the solar panel

Setup: Battery is firstly discharged upto 5.99V and then charged using the solar panel.

Readings are constantly measured after equal intervals of time. Two bulbs White And Yellow used to simulate sunlight.



After 15mins,



Observations:

Voc	Vpanel	Ipanel	Vin(IC)	Vop(IC)	Vbattery(initially)	After 10min	After 15min	Icharging
16.7V	7.961V	10mA	7.717V	6.228V	5.996V	5.997V	5.998V	1.733mA

Results: The sun simulator gives an input of 7.961V to the circuit. But this limits the output voltage only to 6.228V hence the charging voltage is reduced too. This causes a charging current of 1.733mA which charges the 5Ah battery very slowly.

Conclusions

- Solar panels are as good as power supplies of an average of 12V in bright sunlight. The only problem is unregulated voltage due to variation in intensity of light.
- IC LM 317 solves the problem by regulating the output voltage but it again dissipated 2V across it which makes the system less efficient
- Solar charger circuits need voltage regulators so as to charge the batteries at constant voltage.
- The battery charging process should be stopped once it is fully charged and this is ensured using a zener which will start conducting at the cut off voltage.
- The charger circuit is a simple, ready to use lead acid battery charger and is a good way to tap sun's energy on the go.

Summary

- Solar energy is a clean energy source and it is high time we understand its importance and embrace it in our daily lives.
- Solar cells are the heart of any circuit. In the circuit for this project, Solar panels were used as a power supply and fed into a voltage regulator so as to have a constant voltage charging for the battery.
- Batteries are the easiest way to store energy. Hence solar charger circuits aim at charging batteries rather than driving components.
- Rechargeable batteries like Lead Acid, Li-ion and NiMH are used depending on the user's requirements. Here we have used sealed Lead Acid ones.
- It is also very necessary to cut off charging once the battery is fully charged. This is managed using a zener diode which switches on at the cut-off voltage and diverts the current through the transistor.
- The battery is thus charged at constant voltage and at desired rate depending on the amount of current supplied.
- Solar energy is the most abundant but least used source of energy. But it's the solution to most of our problems
- The major challenges we face in going solar is expensive technology, limited space and energy. We need to address them by having more efficient materials and most importantly awareness among people so that they use it to their benefits.

References

- www.main.org/polycosmos/glxywest/vimanas.htm - Indian Flying Machines
- <http://www.triplepundit.com/2011/08/solar-farming-potential-india/> - Solar Farming
- http://en.wikipedia.org/wiki/Solar_cell
- http://www.planetarypower.com.au/solar_panels.htm
- <http://www.earthtimes.org/energy/solar-cells-future/1403/>
- Element14 – to look up devices, ICs
- Physics of Solar Cells- A Text for Undergraduates, J Nelson

Further Interests

I am interested in learning how to make easy, portable and ready to use devices which run on solar power. The scope of imagination is large as solar power can run anything on DC voltage. Specifically, I want to explore solar chargers in greater detail and understand how to increase efficiency of power generation (IC LM317 drops the precious 3V across it thus wasting energy). Another area of interest is exploring different technologies available in making solar cells(Mono-crystalline, Polycrystalline, Thin Films) and be able to explain why their efficiency changes so much by understanding their crystal structures.