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Cost Effective Multi-Purpose Solar Charger Unit for Rural Development

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***Abstract*—** The world is staring at a mounting energy crisis. Depletion of fossil fuels is no longer a threat, but is a harsh reality that can only be overcome by the accelerated adoption of renewable resources such as solar.Solar energy in particular presents a viable option, especially in homes. About 19706 villages in India are still un-electrified [1]. This work is about using solar energy for meeting the basic need like lighting and charging devices like mobile which is become a essential part of life. These multipurpose solar charger unit are simple, portable and ready to use devices which can be used by anyone especially in remote areas. 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. Here a 6 Volt 4.5 Am-hr battery is used as a power bank for charging the mobile and lighting a 4 W LED Solar Lantern. Protection for the circuit has been given through a Zener Diode.

***Keywords*-** SPV,LED,MPPT,Zener Diode.

I. INTRODUCTION

Lack of access to electricity is one of the biggest issues faced by over 1.6 billion people globally and left them in the dark [2]. Majority of these people live in rural areas of developing countries. Because of their poverty and unavailability of national grid due to remote location they have to rely on candles, kerosene lanterns, and firewood for their lighting purpose. This results in a daily expense that is expensive in the long run, along with this type of indoor lighting cause's indoor pollution and chronic lung problems. Solar energy is the most viable solution to this in all respect. A basic system consists of a small solar panel, a battery; a charge controller, LED lights, and a universal outlet for charging cell-phones or other small appliances will cost roughly Rs.800, and can be made affordable through microfinance options.

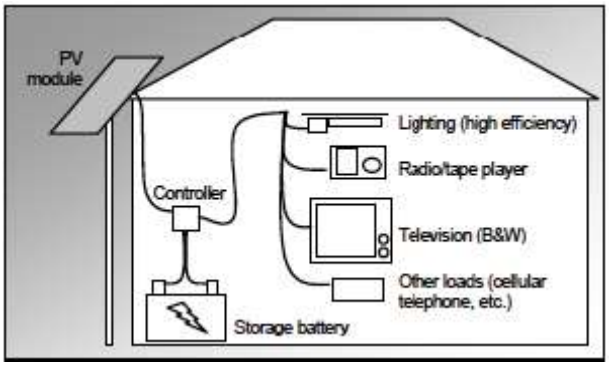

Fig.1.Components of a solar home lighting system

A. Principle of Operation of Solar Energy

Solar energy is available in abundance in most parts of the world. The amount of solar energy incident on the earth's surface is approximately1.5 x 1018 kWh/year, which is about 10,000 times the current annual energy consumption of the entire world. The density of power radiated from the sun (referred to as solar energy constant) is 1.373 kW/m2. Solar cell is a device which converts photons in Solar rays to direct-current (DC) and voltage. The associated technology is called Solar Photovoltaic (SPV).

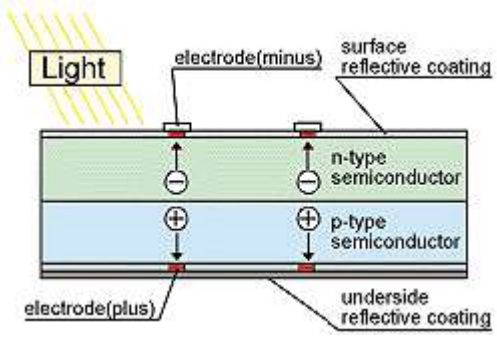

Fig. 2.Silicon Solar Cell and its working mechanism

A typical silicon PV cell is a thin wafer consisting of a very thin layer of phosphorous-doped (N-type) silicon on top of a thicker layer of boron-doped (P-type) silicon. An electrical field is created near the top surface of the cell where these two materials are in contact (the P-N junction). When the sunlight hits the semiconductor surface, an electron springs up and is attracted towards the N-type semiconductor material. This will cause more negatives in the n-type and more positives in the P-type semiconductors, generating a higher flow of electricity. This is known as Photovoltaic effect.

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.

Here we made a multi-purpose charging unit with dual charging mode (A.C 220 Volt and Solar Power). 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 instead of using a ready to use SOLAR CHARGER IC like LT3652. SOLAR CHARGER IC LT3652 is embedded with MPPT (Maximum Power Point Tracking) technology which simply means the IC gets the maximum possible power from the solar panel by sampling its output and applying the proper load resistance.

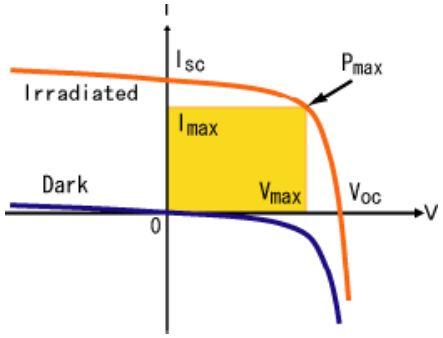

Fig. 3.Typical V-I Characteristics of Solar Module [3].

Cut-off circuit consisting of Zener diode is used to cut-off the circuit when battery is full charged. The battery is used as a power bank. The battery can charge the smart phone through data cable or we can glow LED light or it can charge the phone and can glow the LED simultaneously.

B. Theory

Fig.4.Schematic Diagram of the unit

It can charge the battery through 220V AC supply or Solar panel. In case of AC source voltage will be stepped down from 220 volts A.C to 6 volts A.C by using a step down transformer. Then by using the Bridge Rectifier consisting of 4 diodes 6 volts A.C will be converted to 6 Volt D.C. After this IC 7806 is used to get constant 6-volt output. Two Capacitor are used to eliminate the distortion of the output. For solar charging we use a 12 volt 10-watt solar panel. The positive terminal of the panel is connected to a diode. Then a voltage regulator IC LM 317 is used. The variable resistance is adjusted at a certain point which can provide the maximum output current. A transistor BC548 and Zener diode 1N4735 is used to cut off the circuit when battery voltage exceeds 6.2 volt. By using the switch, the mode of charging may be changed. Here LED is used as the indicator of charging. One IC7806 is connected through a switch. USB port is connected across the IC7806 output pin and ground pin. A mobile phone may be charged through a data cable. A 6V, 4 Watt led light is connected through another switch. By controlling this two switches charging of mobile or lightning up the LED or both at the same time may be done.

II. CIRCUIT DIAGRAM

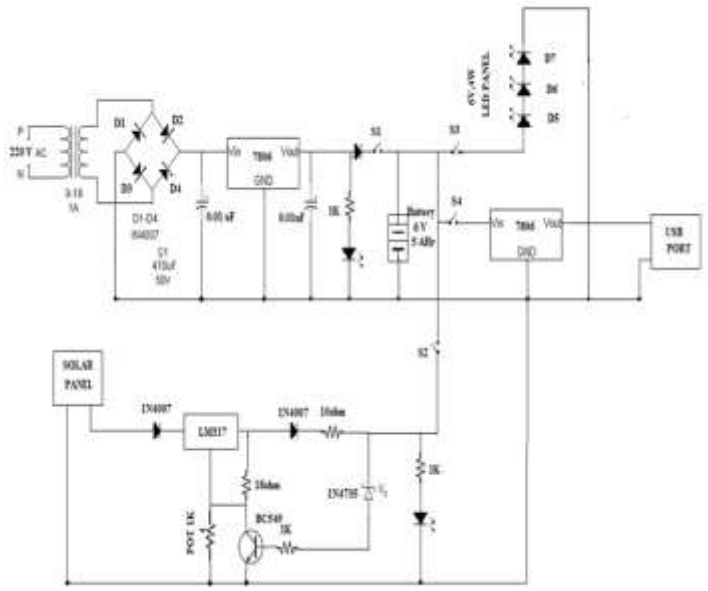

Fig.5. Circuit Diagram

III. COMPONENTS USED

Sl. No.	Name of the components	Specifications	No. of component
1	Solar Panel	12V,10 Watt	1
2	Diode	1N4007	7
3	IC	LM317	1
4	Variable Resistance	1K	1
5	Resistance	180ohm,10ohm,1K	1

6	Transistor	BC548	1
7	Zener Diode	1N4735	1
8	LED	Red and green led	2
9	Battery	6V,5Ahr	1
10	Switch	-	4
11	IC	7806	2
12	LED Light	6V,4Watt	1
13	USB Port	-	1
14	Data Cable	-	1
15	Transformer	220/6V	1
16	Capacitor	4700µF	2

IV.EXPERIMENTS

A. *Solar panel output with different intensities of light*

Conditions	**Open circuit voltage across the panel**
Covered with cardboard	1.9
Facing the desk	2.80
Covered with Paper	7.6
At the windows(11am)	19.21
In the Lab	13.50
Using a bulb at distance 15cm	17.08
At the terrace(2pm)	19.00

Observation: The 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 1.9V to 19V.

B.V-I Characteristics of Solar Cell

Load Resistance (in Ohm)	Voltage (volt)	Current (mAmp)	Temperature & Humidity
1.8	0.27	169.7	35 Degree C. Humidity 40%
6	0.8	173.4	
13	1.31	170.3	
42	4.05	165.5	
78	8.01	159.2	
100	8.32	125.2	
200	10.45	72	
300	13.5	43.4	

Observation: The following V-I characteristics has been observed with our solar module [4].

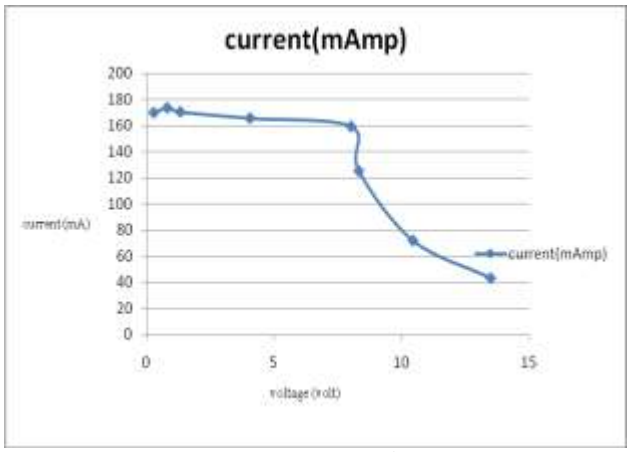

Fig.6. V-I Characteristics of Solar Cell

C. To study the discharging of batteries with led light

Time (in Minutes)	Battery Voltage (in Volts)	Discharging Currents(in Amp)
0	6.15	0.36
100	6.09	0.356
200	6.01	0.35
300	5.92	0.23
400	5.76	0.07

Fig.7. Discharging of batteries with led light

Observation: The voltage vs. Time and Discharging current vs. Time profile has been shown in Fig.8 and Fig.9 respectively.

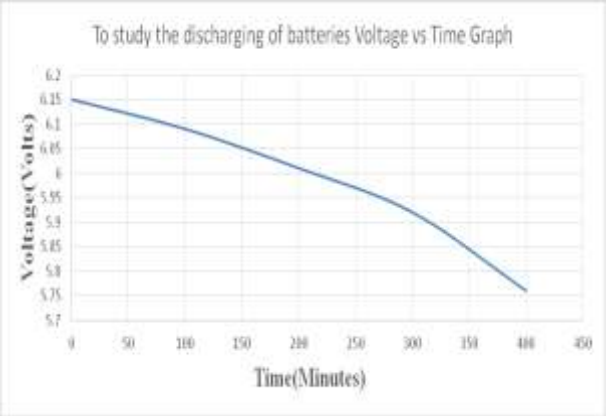

Fig.8. voltage vs. time profile for battery discharge

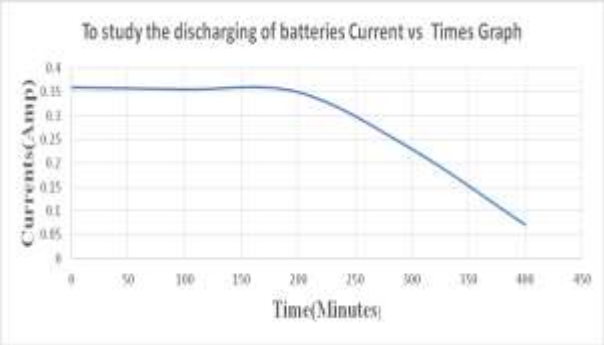

Fig.9. Discharging current vs time profile for battery discharge

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

Time (Minutes)	Output Voltage (Volt)	Charging Current (mA)	Battery Voltage (Volt)
10 A.M.	6.08	4.3	6.04
10.15	6.11	4.3	6.09
10.30	6.13	4.2	6.12
11	6.45	4.28	6.14
11.30	6.24	4.4	6.15
12	6.17	4.3	6.16
12.30	6.20	3.5	6.17
1	6.18	3.6	6.18
1.30	6.15	0	6.18
2P.M.	6.16	0	6.18

Fig.10. *charging of batteries using the solar panel*

Observation: It is observed from the below table that the charging current is low.

E. Charging the Mobile Phone

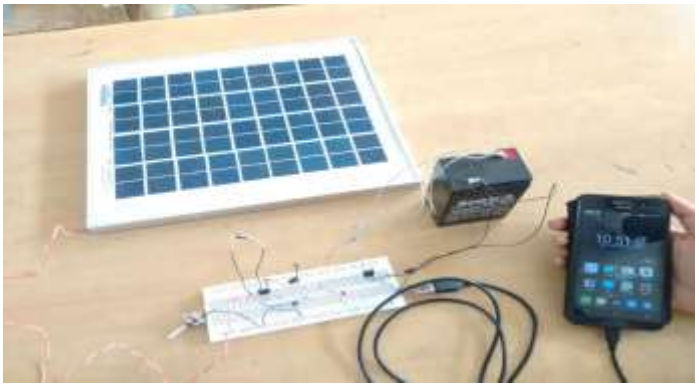

Fig.11. *Charging the Mobile Phone*

Observation: It will take longer time to charge the mobile as charging current in the range of 8mA.

Output Voltage	Current
5.9 Volt	8mA

F. To light up a LED Light

Rating of LED light	Run Hours	Approximate Lumen value (using Lux meter)	Lumens=0.09290304 × Ev(Lx) × 4.π.r(ft)2
6 Volt 4 Watt	10 Hours	30000 Lx	243.09 (We are using a 4 Watt LED light. So, 243.09/4=60.77 lumens/watt)

Observation: The lumen value is quite high as 60.77 lumen/watt.

CONCLUSIONS

It is a very low cost and multi-purpose charging device. Both the conventional and non-conventional mode of charging is available. It is a very easy circuit to construct. This circuit can be used for charging the device as well as for glow the LED light. The only problem with this circuit is the charging current rate is very low that leads to increase the required charging time of the battery.

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