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Solar Power Charge Controller

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Abstract- The demand of renewable energy (alternative energy sources) is increasing day by day as our non renewable sources have started depleting. The other reason for increased demand is that it has a cleaner, easy setup and has a very low cost of maintenance during its operation. Due to which, solar powered equipments and appliances are making its way into various sectors of our day to day life. This research paper deals with the scenario that a storage or battery is needed in order to harness the solar energy when the sunlight is available and supply it in vice versa conditions. For this, a cost effective system is built which charges a battery with the help of solar panel and protection is given to the battery in case of overcharge, deep discharge and under voltage condition. The block diagram, circuit diagram, hardware design are discussed in the paper.

Keywords: *solar panel, battery, transistors, lm-324, op-amps, load.*

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Solar Power Charge Controller

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Abstract- The demand of renewable energy (alternative energy sources) is increasing day by day as our non renewable sources have started depleting. The other reason for increased demand is that it has a cleaner, easy setup and has a very low cost of maintenance during its operation. Due to which, solar powered equipments and appliances are making its way into various sectors of our day to day life. This research paper deals with the scenario that a storage or battery is needed in order to harness the solar energy when the sunlight is available and supply it in vice versa conditions. For this, a cost effective system is built which charges a battery with the help of solar panel and protection is given to the battery in case of overcharge, deep discharge and under voltage condition. The block diagram, circuit diagram, hardware design are discussed in the paper.

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I. Introduction

Solar Power Charge Controller can be used in various sectors. For instance, it can be used in solar home system, Hybrid systems, solar water pump system etc. In this, a solar panel converts sunlight energy into electrical energy through an electrochemical process also know as photovoltaic process. Energy is stored in the battery with the help of solar panel through a diode and a fuse. Energy stored in the battery can be used when there is no sunlight as during discharge, chemical energy is converted into electrical energy which in turn illuminates electrical appliances or helps in pumping water from the ground [1]. Hence, it is needed to protect battery form overcharge, deep discharging mode while dc loads are used or in under voltage as it is the main component in a solar power charge controller. [2]

In this project, indications are provided by a red LED for fully charged battery while a green LED indicates that battery is charging. White LED is provided in order to indicate overcharge, deep discharge or under voltage condition. Charge controller also uses MOSFET as power semiconductor switch to ensure cut off the load in low battery or overload condition. When the battery gets fully charged, a transistor is used in order to bypass the solar energy to a dummy load which protects the battery from getting over charged.

A solar charge controller or regulator is a small box placed between a solar panel and a battery consisting of solid state circuits PCB. They are used to regulate the amount of charge coming from the solar panel in order to protect the battery from getting overcharged. Adding to this, it can also be used to allow different dc loads and supply appropriate voltage. [2]

II. Block Diagram

In figure 1, the basic arrangement of the implemented project can be found.

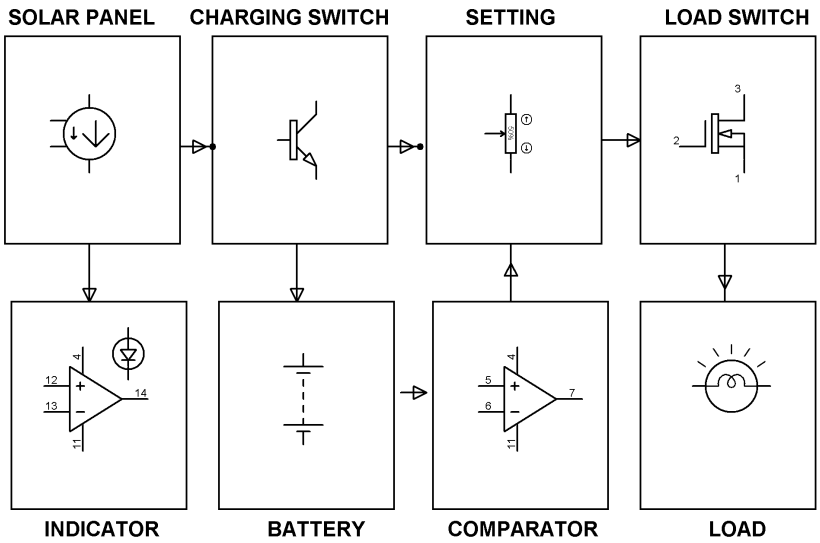

Figure 1: Block Diagram Arrangement of the Project

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a) Components Used

The main components used in order to establish the project are Photovoltaic Cells and Solar panel, battery, LM 324 and Transistors.

i. *Photovoltaic Cells and Solar panel*

Photovoltaic (PV) cells are the one which are made from special materials called semiconductors like Silicon. They are used for conversion of light into electricity using semiconductor materials that exhibit the photovoltaic effect. When the light strikes the cell, certain amount of light gets absorbed into the semiconductor material which triggers the flow of electrons that causes current to flow. We can place metal contacts on top and bottom of the cell, from which we can draw current externally.

Solar panel is a panel designed to absorb sun's rays in order to generate electricity or heat. A PV module is a packaged consisting of solar cells. Solar panels constitute the solar array of a PV system that helps in generating and supplying electricity to commercial and residential sectors. Following are the advantages of solar panels-

– These are the equipments that can covert solar energy into electrical energy directly, easily and efficiently.
– They can easily last for 25 years and does not require much operational maintenance. [4]

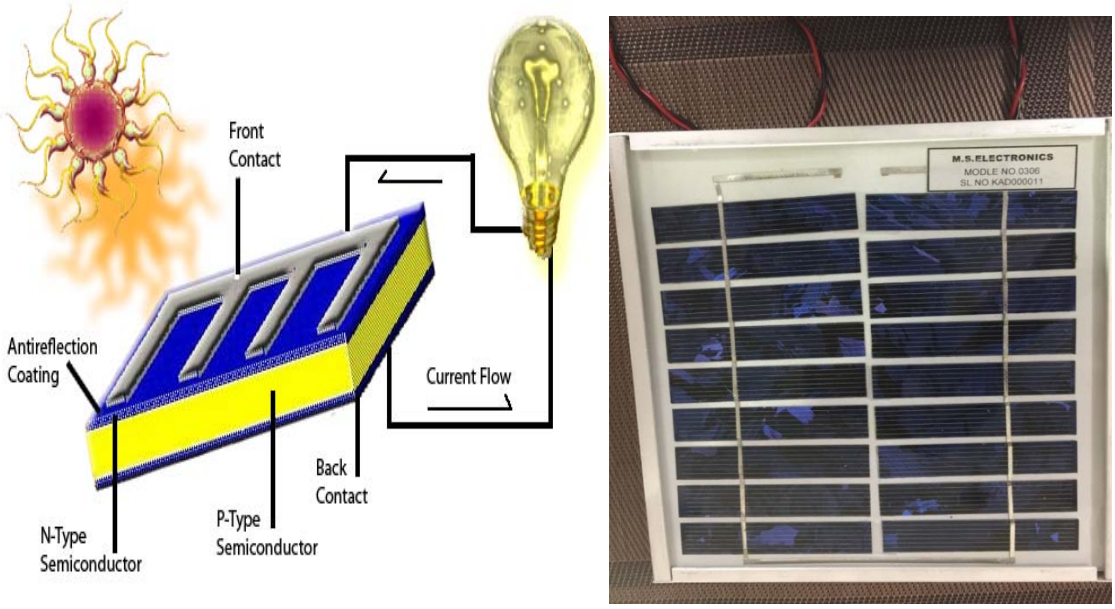

Figure 2: Solar Panel

ii. *Battery*

In this project a Sealed Rechargeable Battery (6V4.5AH/20HR) is used in order to store energy. An Electrical battery converts chemical energy directly into electrical energy comprising of one or more electro chemical cells. The battery comes in all shapes and sizes and can be used for household, robotics, industrial applications etc. For example, miniature (small) cells can be used to power devices such as hearing aids, wristwatches etc. whereas as large batteries can be used telephone exchanges, computer data centres, power substations etc. A 12V, lead-acid battery has 6 cells. The range is 0.1C rate, where C is the battery capacity in Ah in order to charge lead acid batteries safely. The major disadvantage of overcharging a battery is that it can cause reduction in its life span. [3][9]

Figure 3: Sealed Rechargeable Battery (6V4.5AH)

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iii. *LM 324*

It is a general purpose op-amp consisting of four independent, high-gain, internally compensated operational amplifiers designed to operate from a single power supply over wide range of voltages. It has a wide range of applications such as in transducer amplifiers, DC gain Blocks and Conventional op-amp circuits. Op-amps in LM 324 are used as comparators in this project. [6]

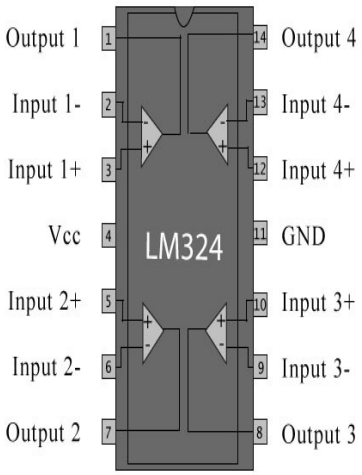

Figure 4: Pin Diagram

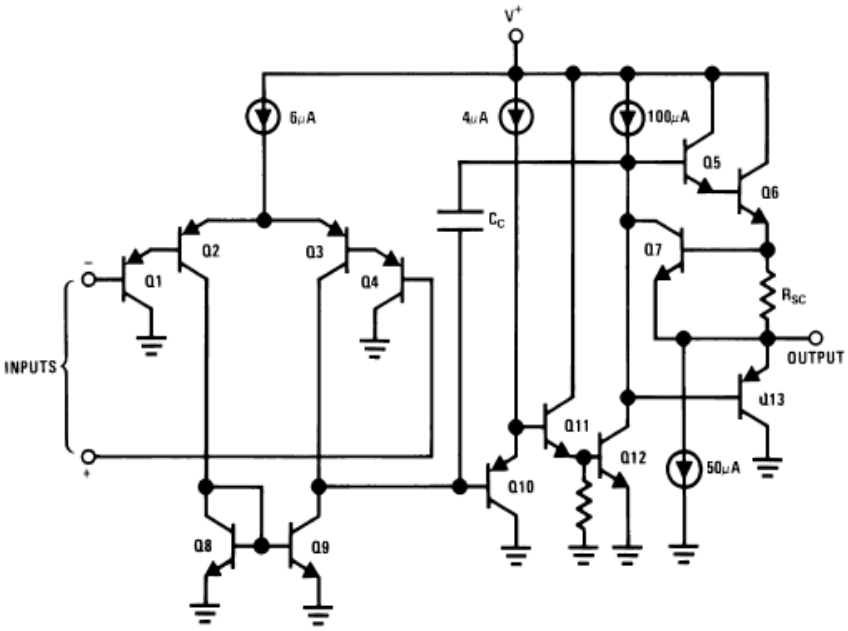

Figure 5: Schematic Diagram

iv. *Transistors*

There are three types of transistors used in this project.

– SL 100

It is a general purpose, medium power NPN transistor and is commonly used as a switch in common emitter configuration. The transistor terminal requires a fixed DC voltage in order to operate in a desired region of its characteristic curves. It is known as biasing and is used for switching applications. Biasing is done in such a way that it will remain fully on if there is a signal at its base otherwise not. The emitter can be recognized as it will be projecting out. The base is nearest to emitter while collector is far away in the casing. [5]

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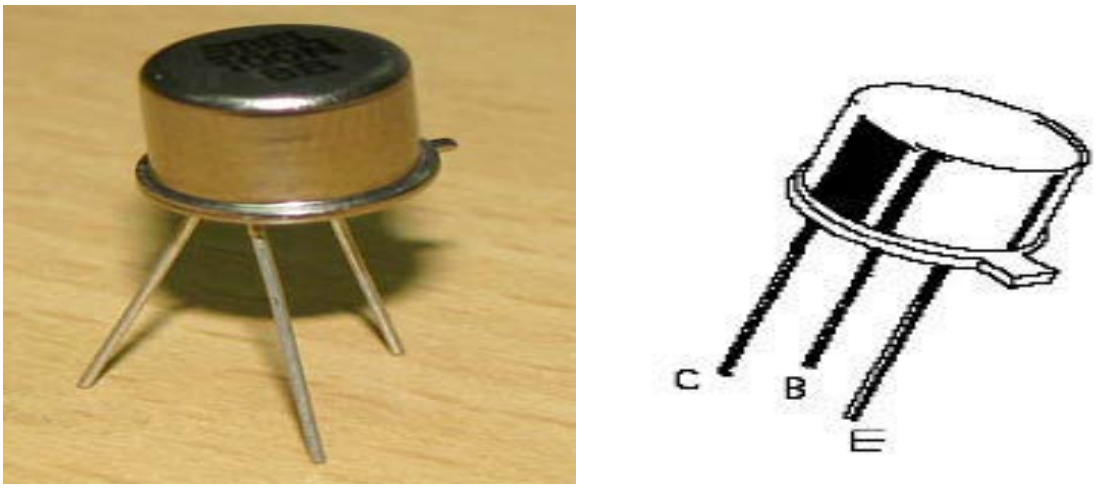


(a) (b)

Figure 6: SL 100

In Figure 6 (b): C, B and E indicates collector, base and emitter.

– BC 547

It is an NPN bi-polar junction transistor. A transistor means transfer of resistance which is used to amplify current. In BC547, its base having small current controls larger current at emitter and collector terminals. [7]

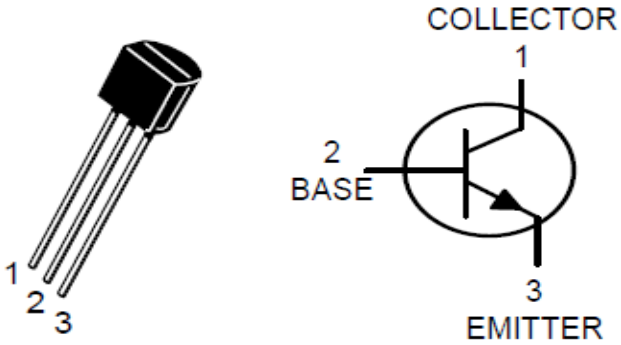
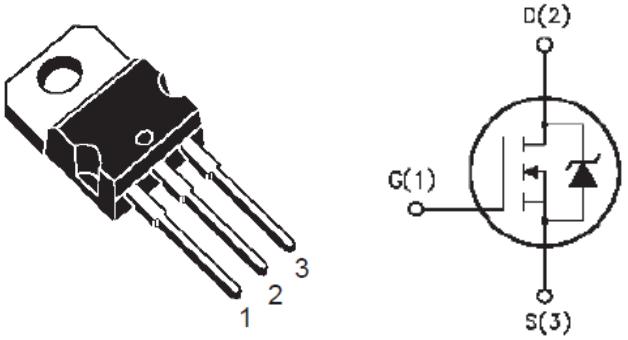


Figure 7: BC 547

– IRF 630

It is an N-type power MOSFET. It can be used in high current switching, uninterruptible power supply (UPS), DC-DC converters for telecom, industrial and lighting equipment etc. [8]



(a) (b)

Figure 8: IRF 630

In Figure 8 (b): D, G and S represents Drain, Gate and Source.

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b) *Quantities of components used*

Table 1

Major Components Used	Quantity
Solar Panel	1
Battery (6V4.5AH/20HR)	1
LM 324	1
Transistors	3
LEDs	3
Slide Switch	2
PCB Connector 2-PIN	2
Diodes- IN 4007	3
Diodes- IN 4148	6
DC Fan (12V)	1

c) *Voltage at IC Pins*

Table 2

Integrated Chip (IC)	Pin (No.)	Voltages at Pin Without IC (Voltage)	Voltages at Pin With IC (Voltage)
LM 324 (Operational Amplifier)	1	0	3.2
	2	2	1.9
	5	2	1.9
	8	0	3.2
	14	0	5

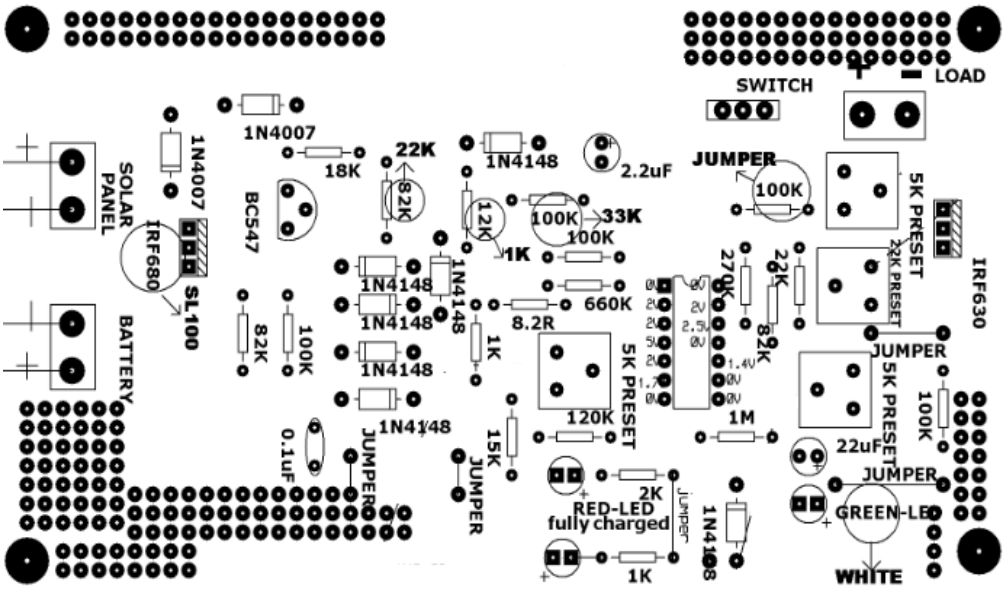

Figure 9: Voltages at IC Pins without IC (PCB)

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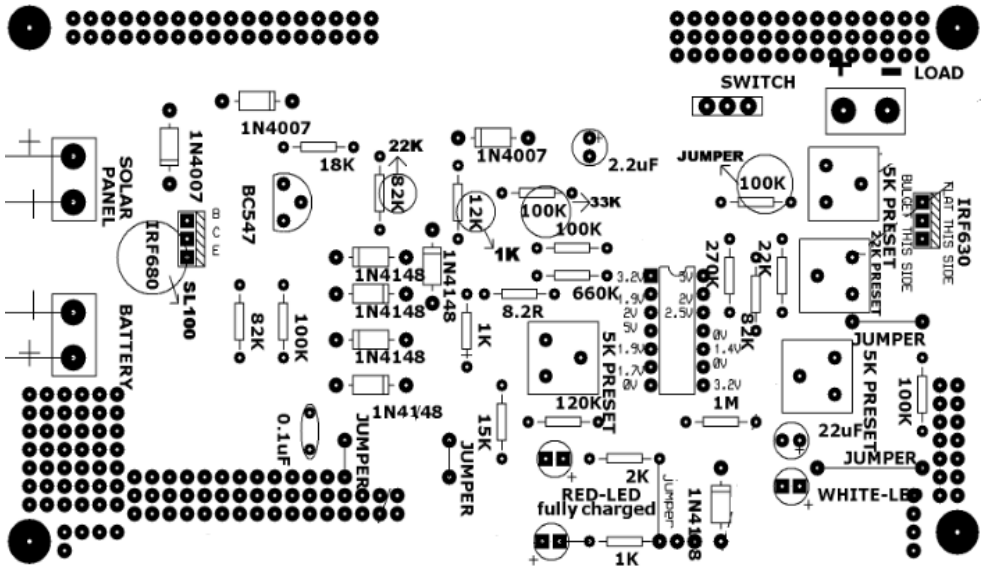

Figure 10: Voltages at IC Pin with IC (PCB)

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III. Schematic Diagram

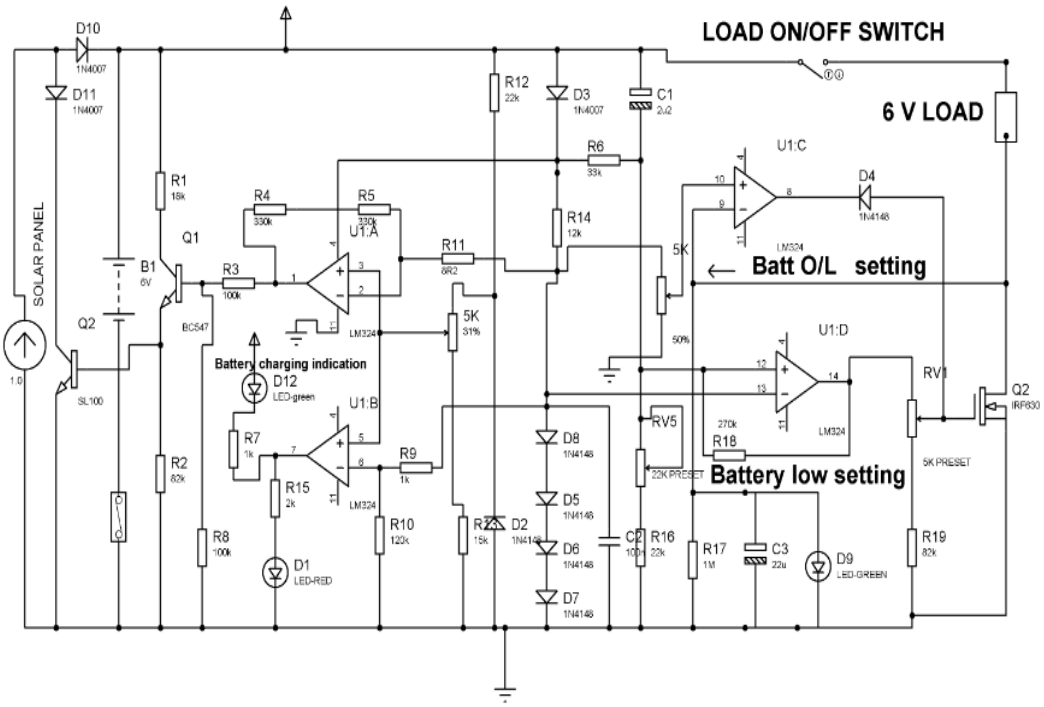

Figure 9: Circuit diagram

a) Connections

A solar panel is used in a solar charging circuit. In this project, the base of SL 100 (power transistor) is connected to the emitter of the transistor (BC 547), collector is connected to the +VE terminal and emitter is connected to GND. Transistor (SL 100), battery (6V) and a transistor (BC 547) are connected parallel to each other. The collector of BC 547 is connected to +VE terminal through R1 of resistance 18K and the emitter is connected to GND through R2 of resistance 82K. The base of BC 547 is connected to the Pin no. 1 of LM 324 through R3 of resistance 100K. Pin no. 4 is connected to +VE terminal and 11th is connected to GND for all four op-amps U1: A and U1: B. 2nd Pin of U1: A is connected to Pin 1 of op-amp through two resistors R4 of 330K and R5 of 330k. Pin 3 of U1: A and Pin 5 of U1: B are shorted and connected to POT of 5K. 6th Pin of U1: B is

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connected to GND through resistor R10 of 120K. 7th Pin of U1: B is an O/P pin connected to Led Green and Red through R7 of 1K and R15 of 2K respectively. . VI: C is also an op-amp whose 10th Pin is connected to POT of 5K of which one of the terminal is connected to 2nd Pin of U1:A whereas 9th Pin is connected to GND. 8th Pin of U1: C is an O/P Pin which is connected to Gate of MOSFET Q2 through Diode IN4148. Along with this, 9th Pin of U1: C is also connected to drain of MOSFET whose gate is also connected to POT of RV1 which will also get O/P of U1: D known as Pin 14. 12th Pin and 13th Pin of U1: D is connected to RV5 (22K PRESET) and to 4 diodes in series known as D5, D6, D7, D8 respectively. The Source of U1: D is connected to GND.

b) Working

Solar panel section

In this, battery B1 is charged via d10 and fuse. After battery getting fully charged, Q1 conducts from output of the comparator ie Pin 1, resulting in Q2 to conduct and divert the solar power through D11 and Q2. In this way battery is not over charged.

The project uses one IC LM 324 having four op-amps used as comparators that is U1: A, B, C, D. U1: A is used for sensing over charging of the battery to be indicated by action of U1: B output fed D1 (Red) and D12 (Green) for indicating battery status. Diodes D5 to D8 all are connected in series and forward biased through R14 and D3. This provides a fixed reference voltage of 0.65*4= 2.6v at anode (+) point of D8 which is fed to pin 2 (-) of U1: A through R11, pin 13 of U1: D, pin 6 of U1:B via R9 and pin 10 of U1:C via 5K variable resistor. Solar panel being a current source is used to charge the battery B1 via D10. While the battery is fully charged, the voltage at cathode point of D10 goes up resulting in the set point voltage at pin 3 of U1: A to go up above the reference voltage because of the potential divider formed by R12 of 22K, 5K variable resistor, R13 of 15K goes up.

This results in pin no 1 of U1: A to go high to switch 'ON' the transistor Q1 that places drive voltage to the transistor SL 100 such that the current from solar panel is bypassed via D11 and the transistor's collector and emitter. Simultaneously pin 7 of U1: B also goes high to drive a led D1 indicating battery is being fully charged. While the load is used by the switch operation Q2 usually provides a path to the (-ve) while the (+ve) is connected to the DC (+ve) via the switch in the event of over charge, the reference voltage at Pin 10 results in pin 8 of U1: C going low to remove the drive to the gate through the D4 of the MOSFET Q2 which in turn disconnects the load. In the event of over charge, Q2 voltage across drain and source goes up which results in Pin no 9 going above pin no 10 via R22. In the event of battery voltage falling below minimum voltage is duly sensed by the combination of D3, R6, RV5 and R16 in Pin 12 resulting in Pin 14 going zero to remove the drive to Q2 gate via R20 and RV1. The correct operation of the load in normal condition is indicated by D9 when the MOSFET Q2 conducts.

IV. Hardware Implementation

Step 1

First, the circuit is implemented on the Printed Circuit board (PCB).

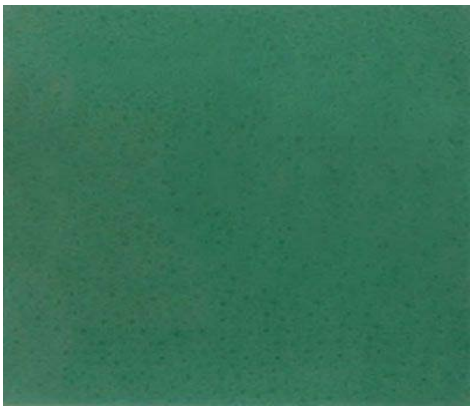

Figure 10: PCB.

Then, all the connections should be done on PCB as discussed above.

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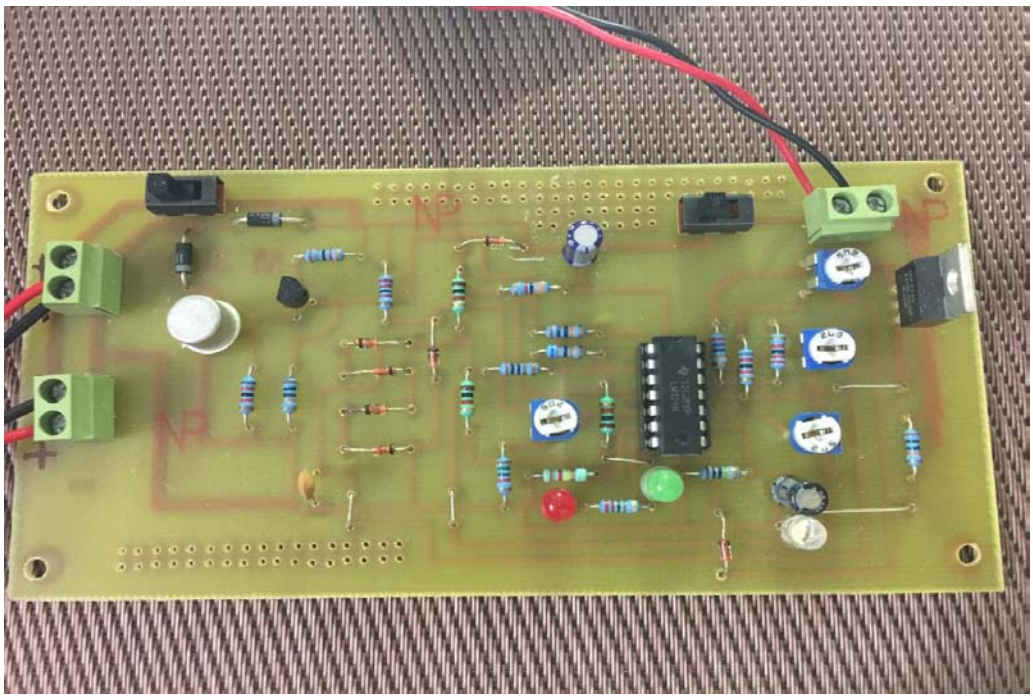

Figure 11: Components fitted on the PCB

After this, a solar panel, battery and the load i.e. a fan (12V DC/0.15A) is attached to the PCB.

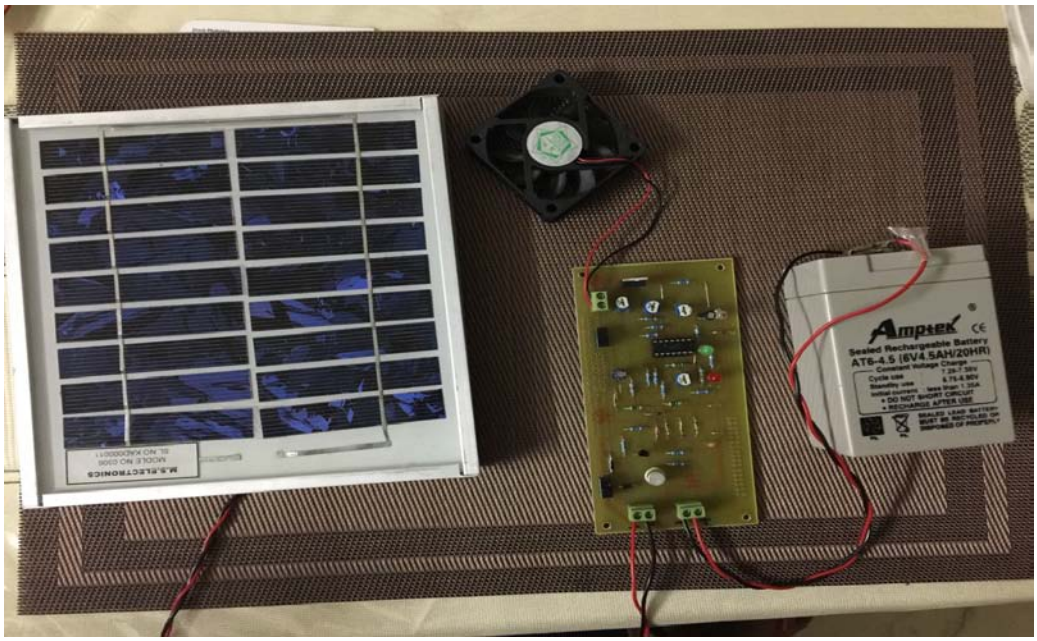

Figure 12: Solar Power charge Controller Hardware Module

Step 2 Powering the Circuit

The "slide switch on the side of solar panel and battery" is switched "On" due to which, Red LED glows indicating that battery is fully charged.

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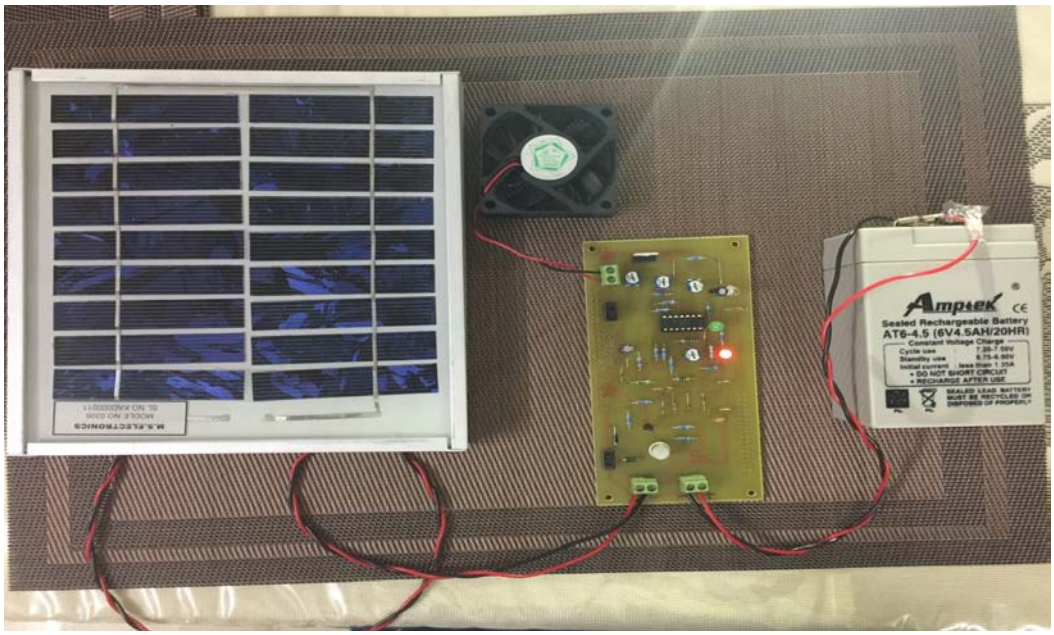

Figure 13: Powering the circuit

Now, switch "ON" the "second slide switch nearer to the load". After switching both, load will also switch on and the fan will start rotating.

The "Preset 1 nearer to red and green led" is adjusted in this project in order to set the battery charge. A battery while charging is indicated by a glowing "Green" LED.

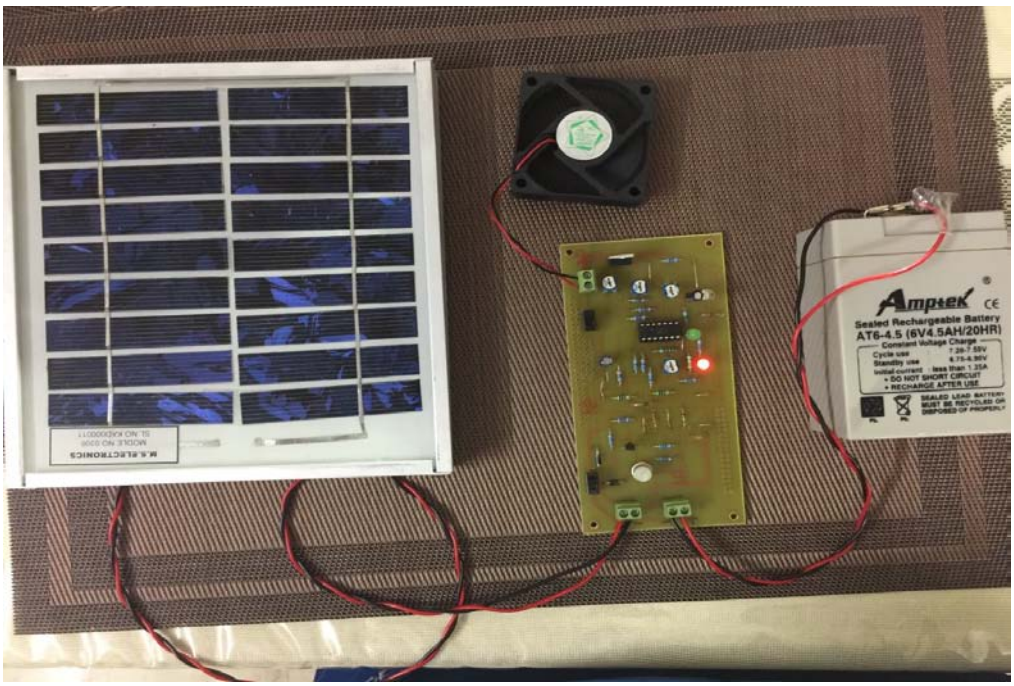

Figure 14: After switching "On" both switches

– First Test of Protection given to the battery

In order to test overcharge protection, rotate Preset 2 one which is close to white LED and is subjected to deep discharge/overcharge. So, when the preset is rotated, the white LED starts glowing and the fan will stop rotating.

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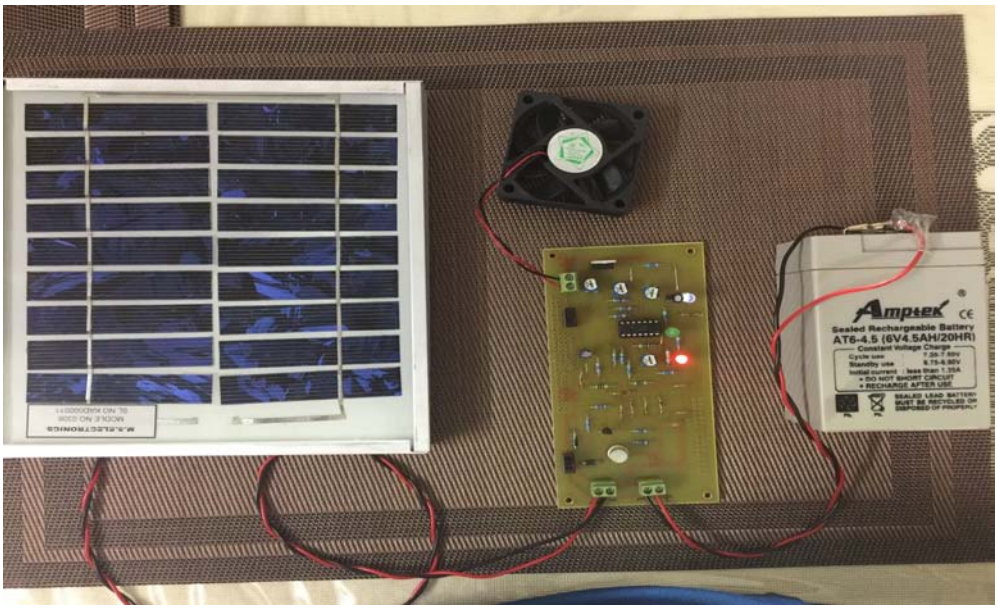

Figure 15: Overcharge/Deep Discharge Protection Test

– Second Protection

Secondly, in order to test under voltage protection, rotate Preset 3 which is second to white LED. After preset is rotated, the white LED will glow and the fan will stop rotating. This will conclude our under voltage test.

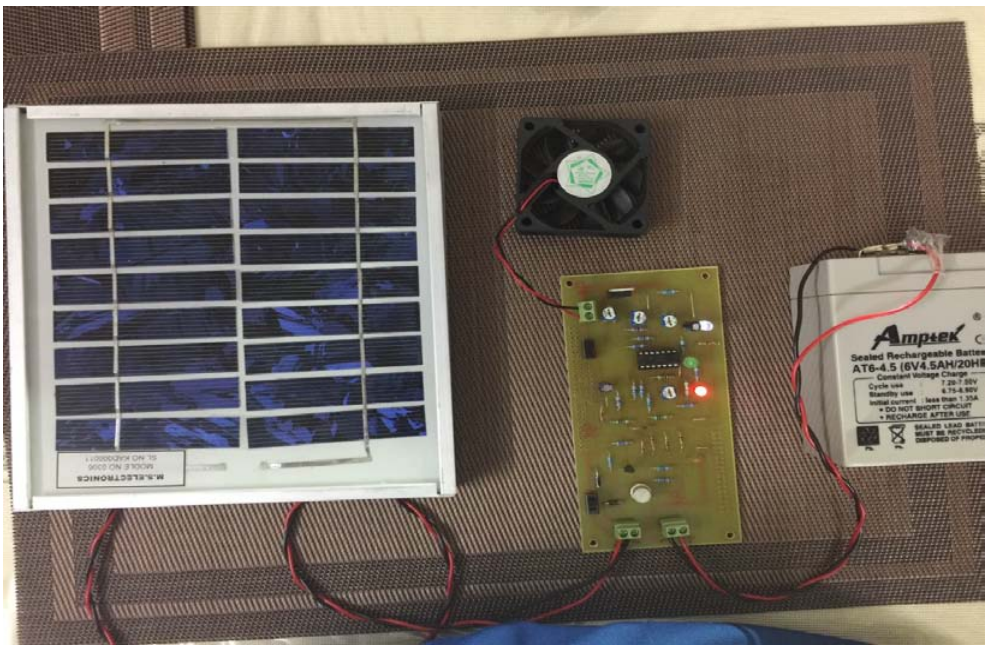

Figure 16: Under voltage Protection Test

Finally rotate a Preset 4 closer to the load's PCB Connector 2 PIN. After rotating the preset we will see that the rotating speed of the fan will increase and vice versa will happen when done in opposite direction.

V. Conclusion

In this paper, a solar power charge controller has been discussed effectively i.e. how rechargeable battery is used to store energy with the help of solar energy through a solar panel and how it can be used in order to supply power when there is no sun. It also includes protection methods for the battery in order to curb problems like overcharging, deep discharge or under voltage which harm the life of a battery. The proposed system used solar PV module as an input and DC load (fan) as an output. Further the project can be

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enhanced by using microcontroller and GSM modem to communicate the status of the system to a control room via SMS. This system can also be upgraded to control normal UPS, when connected with the solar charger will convert to SOLAR INVERTER/UPS with solar charge as priority. [2]

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