Design of Solar Power Charge Controller

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***Abstract*- Non-conventional power generation is one of the fastest growing sectors. Globally, all countries are busy developing and implementing non-conventional power to bridge the electricity demand and power supply. The sun is the ultimate source of limitless solar energy in the form of light and heat. Light of the sun is directly converted into electrical energy without any inter mediate step. Solar photovoltaic (PV) power is leading ahead of the other sources. In a solar power generation system, the PV cell plays a major role.**

LITERATURE SURVEY

Energy is the key influencing factor for development in all sectors i.e., Industrial, Commercial, Agriculture, Domestic etc. as per capita energy consumption is one of the indicators of national development status. per capita energy consumption is about 600 units in our country, where as it is 1400 units in China, 6898 units in Germany, 13,000 units in U.S.A. World average is about 2430units.

India is the sixth largest Country in the world in terms of generation and consumption levels. The total installed capacity of Power projects India is 1,47,402.81 Mega Watts , of this thermal mode of power generation including coal, gas and oil contributes 64.7%, Hydro contributes 24.65%, Nuclear 2.95% and Renewable energy 7.7 The present national peak deficit stands at 10.1%. Ministry of power had decided to add about 52,598 MW capacities for the XI plan (2008-2012). Continuous development of the Generation Sector is essential for meeting the GDP growth target of 8% set for the Economy. In Order to support the envisaged growth of GDP, the rate of growth of power supply needs to be over 9.5 percent annually. The demand-supply gap', which is denoted as 'energy shortage' is 8.8% of the total energy requirement in 2009 and the peak shortage, which is a measure of shortage during peak power consumption hours is approximately 14 percent of installed capacity. To meet the projected demand of 2016, generation capacity is required to be doubled in 10 years from 2006 to 2016. The Government of India has initiated several reform measures to create a favorable environment for addition of new generating capacity in the country. The Electricity Act 2003 has put in place a highly liberal framework for generation

INTRODUCTION

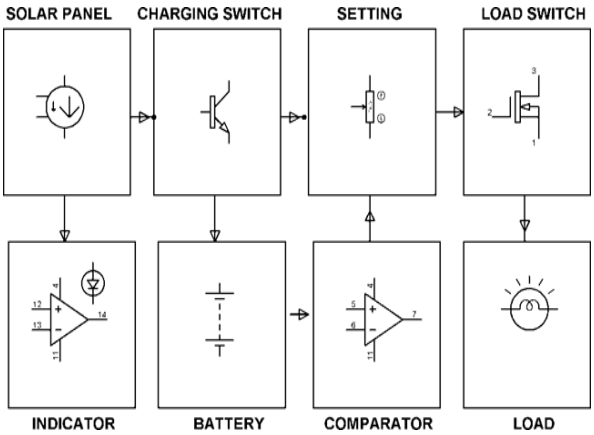
Solar Power Charge Controller can be used in various sectors. For instance, it can be used in solar home system, Hybrid systems, solar water pump system etc. In this, a solar panel converts sunlight energy into electrical energy through an electrochemical process also know as photovoltaic proce

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. 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. 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.

BASIC BLOCK DIAGRAM



Block Diagram

SOLAR PANEL

Photovoltaic (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibits the photovoltaic effect. Photovoltaic power generation employs solar panels comprised of a array of cells containing a photovoltaic material. The PV generator is formed by the combination of many PV cells connected in series and parallel to provide the desired value of the output voltage and current. PV Panel is connected to DC-DC converter.

CONTROLLER

Controller used in the project is PIC16F876A. Controller in this project is used for many purposes.

1. To generate the variable PWM for DC-DCCONVERTER.
2. To control the battery voltage.
3. Controlling the load variation.

BATTERY

Here Battery means the series of batteries that are connected in parallel. The battery will store the energy produced by Panel. This block is connected to the Inverter. Battery used in our system is standard 12 V battery from EXIDE Company.

INVERTER

It is used to convert the input DC voltage from the battery into output AC voltage. Inverter used here doesn't produce a pure sinusoidal output rather it generates square AC which is connected to almost all the appliances now-a-days except some high frequency appliances. We are using two MOSETs inverter instead of four MOSFETs inverter which will reduce the overall cost of project. After adding protection circuits/components for over voltage protection, over current protection, over load protection this project will be a complete solution to the energy crises problem.

This is our attempt to utilizing solar power for meeting the growing energy needs and also to contribute for reduction of greenhouse gasses emissions.

TYPES OF CHARGE CONTROLLERS:

There are three different types of solar charge controllers, they are:

1. Simple 1 or 2 stage controls
2. PWM (pulse width modulated)
3. Maximum power point tracking (MPPT)

Simple 1 or 2 Controls: It has shunt transistors to control the voltage in one or two steps. This controller basically just shorts the solar panel when a certain voltage is arrived at. Their main genuine fuel for keeping such a notorious reputation is their unwavering quality – they have so not many segments, there is very little to break.

PWM (Pulse Width Modulated): This is the traditional type charge controller, for instance anthrax, Blue Sky and so on. These are essentially the industry standard now.

Maximum power point tracking (MPPT): The MPPT solar charge controller is the sparkling star of today's solar systems. These controllers truly identify the best working voltage and amperage of the solar panel exhibit and match that with the electric cell bank. The outcome is extra 10-30% more power out of your sun oriented cluster versus a PWM controller. It is usually worth the speculation for any solar electric systems over 200 watts.

COMPONENTS USED

PV 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.

PV Panel

BATTERY:

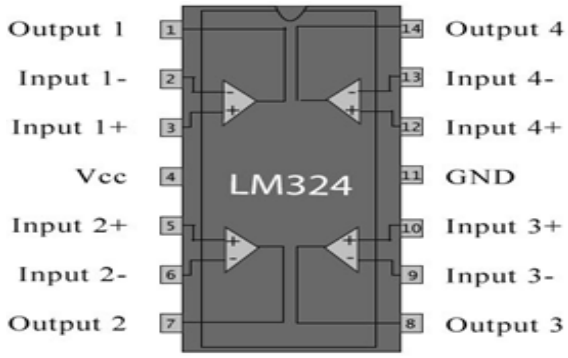
A battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices such as flashlights, smartphones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode. The terminal marked negative is the source of electrons that will flow through an external electric circuit to the positive terminal. When a battery is connected to an external electric load, a redox reaction converts high-energy reactants to lower-energy products, and the free-energy difference is delivered to the external circuit as electrical energy. Historically the term "battery" specifically referred to a device composed of multiple cells, however the usage has evolved to include devices composed of a single cell.

Sealed Rechargeable Battery (6V4.5AH)

OP-AMP (LM324):

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 LM324 are used as comparators in this project.



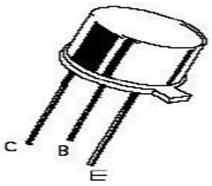
Pin Diagram LM 324

TRANSISTORS:

SL100:

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 away that it will remain fully on if there is a signal at its base otherwise not.

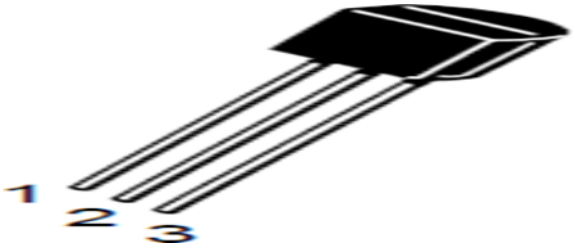
The emitter can be recognized as it will be projecting out. The base is nearest to emitter while collector is far away in the casing.



SL 100

BC547:

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.



BC 547

MOSFET IRF 630:

A power MOSFET is a specific type of metal oxide semiconductor field-effect transistor (MOSFET) designed to handle significant power levels.

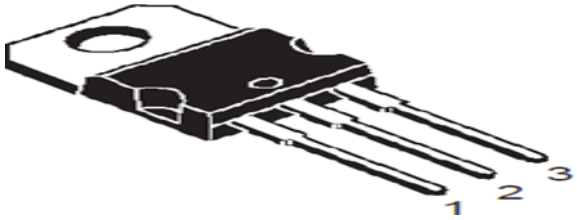


Fig: MOSFET

IRF 630

RESITORS:

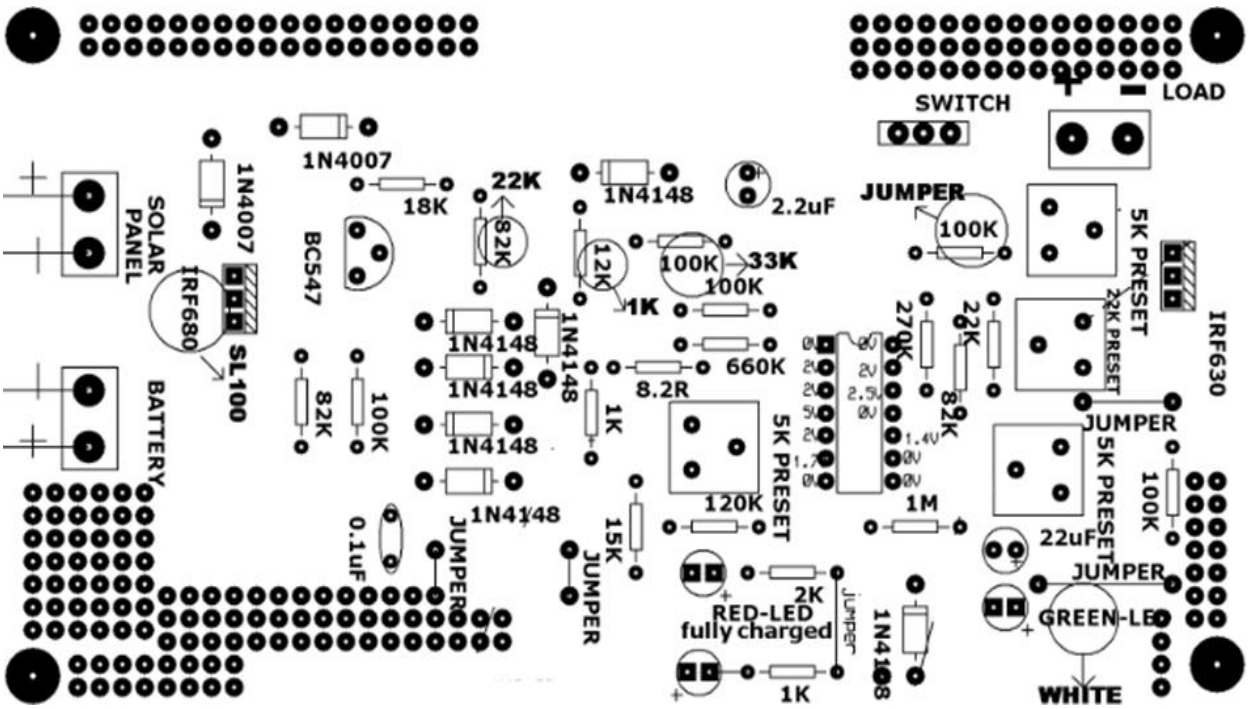
A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. High-power resistors that can dissipate many watts of electrical power as heat, may be used as part of motor controls, in power distribution

Resistors

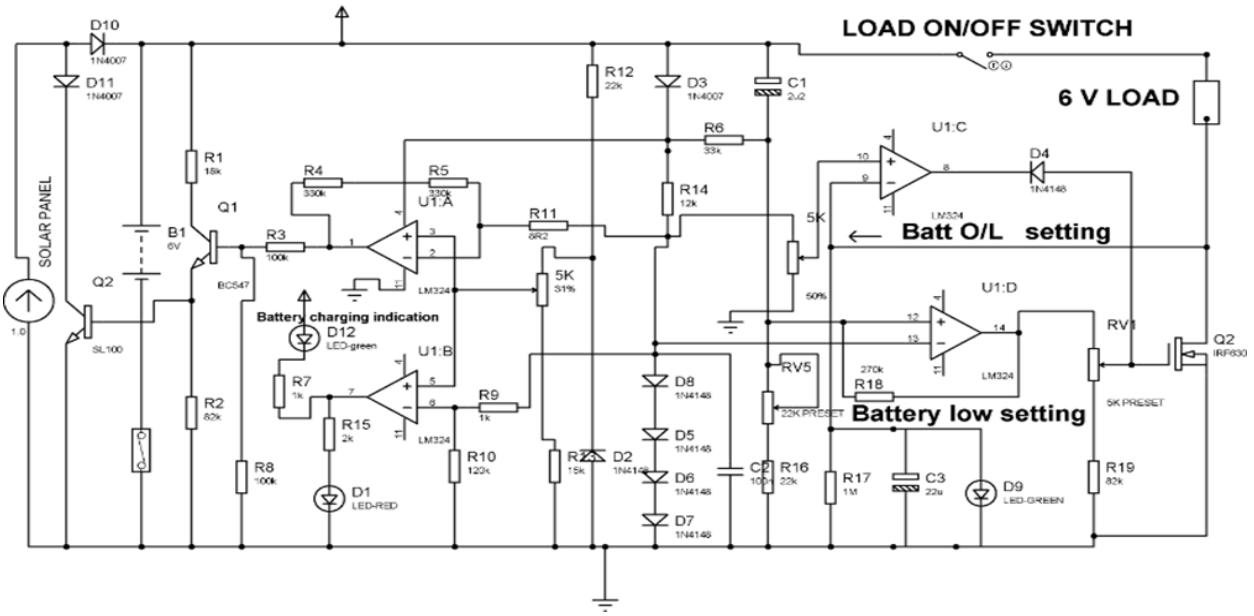
Quantities of components used:

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

6.2 PIN DIAGRAM:



SCHEMATIC DIAGRAM:



Circuit diagram

6.4 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 (SL100), battery (6V)and a transistor (BC 547) are connected parallel to each other. The collector of BC 547 is connected to +VE terminal throughR1 of resistance 18K and the emitteris 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 toPin1of op-amp through two resistors R4 of 330K and R5 of 330k. Pin3 of U1:A and Pin5 of U1: Bare shorted and connected to POT of 5K. 6th Pin of U1: B is connected to GND through resistor R10 of 120K. 7thPin 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 9thPin 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 Pin14.12th Pin and13th 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.

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 i.e. 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 LM324 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 voltageof0.65*4=2.6v at anode (+) point of D8 which is fed to pin2 (-) of U1:A through R11, pin13 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 B1via D10.While the battery is fully charged, the voltage at cathode point of D10 goes up resulting in the set point voltage at pin3 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 pin8 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 Pin12 resulting in Pin14 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.

Step 1:

First, the circuit is implemented on the Printed Circuit board (PCB). Then, all the connections should be done on PCB as discussed above.

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 .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.

First Test of Protection given to the battery:

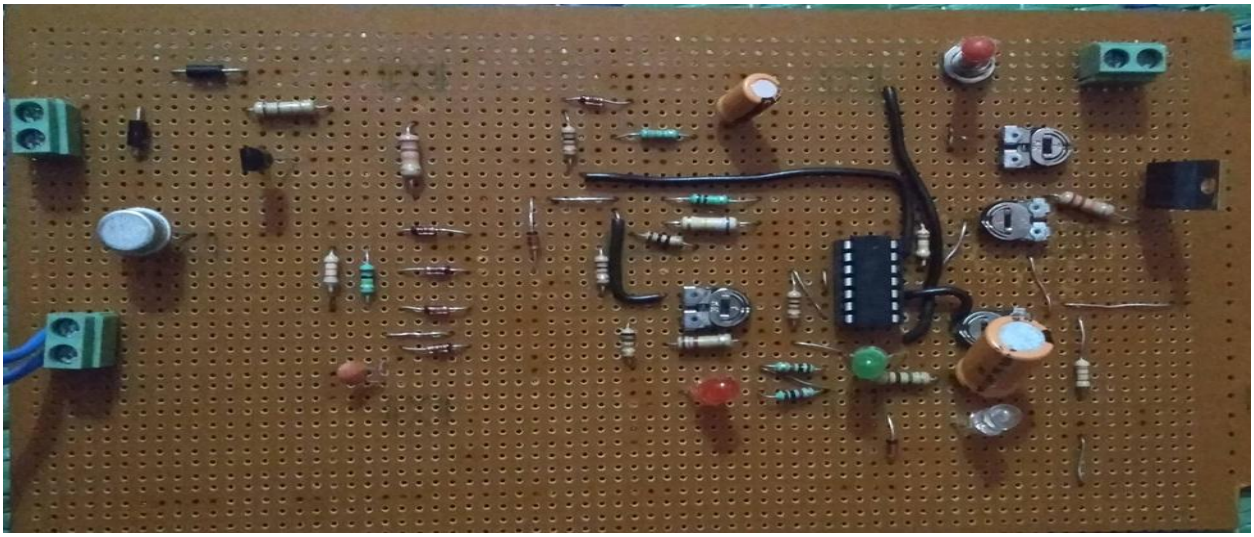
In order to test overcharge protection, rotate Preset 2 one which is close to white LED and is subjected to deep discharge/overcharge. So, when the preset is rotated, the white LED starts glowing and the fan will stop rotating.

CONCLUSION

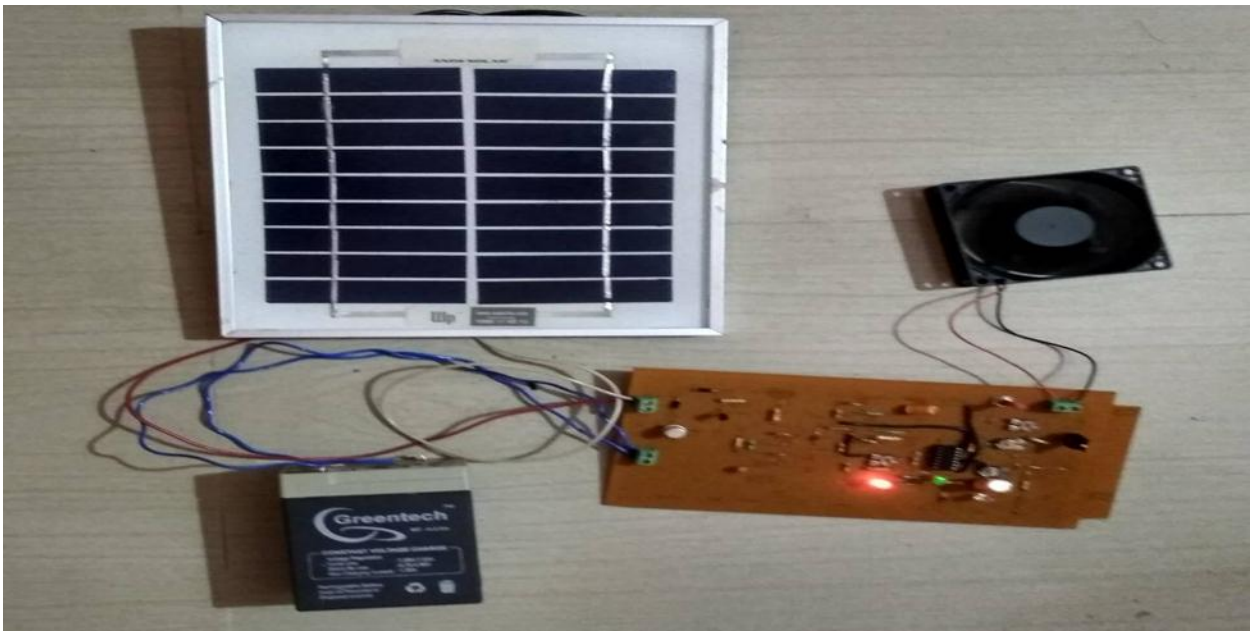
In this paper, a solar power charge controller has been discussed effectively i.e how rechargeable battery is used to store energy with the help of solar energy through a solar panel and how it can be used in order to supply power when there is no sun. It also includes protection methods for the battery 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 has an output.

Further the project can be 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.

This work has produced a low cost, reliable and functional solar charge controller, using locally sourced and available components. The product worked satisfactorily and can be used in a solar home system to solve problems of power supply in Nigeria.



PCB Board



Full project

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