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Improving Electric Vehicle Drive Range Using Solar Energy

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Abstract: In our ecosystem mostly Gasoline engine cars are used by the public which have high cost of refueling that cause emission of greenhouse gases. In this way to reduce the automotive emission which causes the Greenhouse gases, an alternative technology is needed. The most convenient way is to use renewable energy sources. In this scenario we provide an alternative fuel for vehicles by using renewable energy resources. Among the various resources available, we design a solar power controlled motor device for automotive application. In this paper, the Electric Car is the way to alter the energy source. Sunlight is the main source of energy to obtain light energy which is converted into electricity. Amount of energy obtained from the source may vary from time-to-time. The vehicle chosen for the experiment is Marathi Omni. The solar panels are placed on the top of the car. Energy obtained from the solar panel is given to the charge controller. Charge controller can prevent overcharging and also the over discharging of the battery. Output of the charge controller is given to the Valve Regulated Sealed Lead-Acid Battery. Then the Valve Regulated Sealed Lead-Acid Battery is given to the Motor through Driver circuit which controls speed of the Motor. Battery charging time through charge controller is four to five hours and the Electric Car travels for the distance of about 150Km with the speed of 30 to 40 Km/hr. Thus the proposed system of automotive vehicle helps to achieve zero pollution, zero noise effect and fuel consumption.

Keywords: Electric Vehicle, Lead-acid battery, Solar panel, Charge controller.

I. INTRODUCTION

An electric car is an automobile that is propelled by one or more electric motors, using electrical energy stored in rechargeable batteries. Electric motors give electric cars instant torque, creating strong and smooth acceleration. They are also around three times as efficient as cars with an internal combustion engine. Electric cars are significantly quieter than conventional internal combustion engine automobiles. They do not emit harmful pollutants, giving a large reduction of local air pollution, and, can give a significant reduction in total greenhouse gas and other emissions. They also provide for independence from foreign oil, which in several countries is cause for concern about vulnerability to oil price volatility and supply disruption.

Electric Vehicles (EVs) like the Nissan Leaf, Chevy Volt, and Tesla Model S are becoming more and more popular because of their high MPG ratings, their convenient ability to be plugged-in and recharged, and the frustrating and unpredictably wild increases in the price of a gallon of gasoline. The cost of filling up your tank is decreased to charging your vehicle's batteries with electrical energy, and the savings are even more dramatic when that energy comes from your own solar power system. A solar car is a solar vehicle used for land transport. Solar cars only run on solar power from the sun. Solar thermal energy which converts solar energy to heat, PV cells directly convert sunlight into electricity. To keep the car running smoothly, the driver must monitor multiple gauges to spot possible problems. Cars without gauges almost always feature wireless telemetry, which allows the driver's team to monitor the car's energy consumption, solar energy capture and other parameters and thereby freeing the driver to concentrate on driving. Solar cars combine technology used in aerospace, bicycle, alternative energy and automotive industries. The design of a solar vehicle is severely limited by the amount of energy input into the car.

Most solar cars have been built for the purpose of solar car races. Some solar cars are designed also for public use List of prototype solar-powered cars. Solar cars depend on a solar array that uses photovoltaic cells (PV cells) to convert sunlight into electricity. Unlike solar thermal energy which converts solar energy to heat for either household purposes, industrial purposes or to be converted to electricity, PV cells directly convert sunlight into electricity. When sunlight strike PV cells, they excite electrons and allow them to flow, creating an electric current. PV cells are made of semiconductor materials such as silicon and alloys of indium, gallium and nitrogen. Crystalline silicon is the most common material used and has an efficiency rate of 15-20%. The design of a solar car is severely limited by the amount of energy input into the car. Solar cars are built for solar car races and also for public use List of prototype solar-powered cars. Even the best solar cells can only collect limited power and energy over the area of a car's surface. This

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limits solar cars to ultralight composite bodies to save weight. Solar cars lack the safety and convenience features of conventional vehicles.

As an alternative, a battery-powered electric vehicle may use a solar array to recharge; the array may be connected to the general electrical distribution grid. A solar vehicle is an electric vehicle powered completely or significantly by direct solar energy. Usually, photovoltaic (PV) cells contained in solar panels convert the sun's energy directly into electric energy. The term "solar vehicle" usually implies that solar energy is used to power all or part of a vehicle's propulsion. Solar power may be also used to provide power for communications or controls or other auxiliary functions.

Solar vehicles are not sold as practical day-to-day transportation devices at present, but are primarily demonstration vehicles and engineering exercises, often sponsored by government agencies. However, indirectly solar-charged vehicles are widespread and solar boats are available commercially. Recharging can take a long time and in many places there is a patchy recharging infrastructure. For long distance driving, many cars support fast charging that can give around 80% charge in half an hour using public rapid chargers. While battery cost is decreasing fairly rapidly, it is still relatively high, and because of this, most electric cars have a more limited range and a somewhat higher purchase cost than conventional vehicles. Drivers can also sometimes suffer from range anxiety- the fear that the batteries will be depleted before reaching their destination.

2.ELECTRIC CAR & SOLAR SYSTEM

Solar powered cars use sun for energy. They run by converting sunlight into energy. The electrical system is the significant system of the car because it converts sunlight into electrical energy.Solar powered electric car with four wheels and it can be charged from the source of sunlight which is converted to electricity and the electricity is stored in the recharged battery which powers the motor to attain locomotion. Solar powered cars are distinguished from electric cars which do not have a step through frame. Electric cars are classified according to the power that the chosen electric motor can deliver and the system how power from the battery is supplied to the motor. The classification of solar powered electric car is complicated because of legal reason which constitutes a car. The classification of solar powered electric car varies greatly across the Nation.Solar cars are beneficial because they do not use fossil fuels and they reduce pollution. But they are limited in speed and power. They are practically used only in areas with lot of sunlight.

2.1 TECHNICAL FEATURES

There are many types of solar powered electric motorized cars with several technologies available which varies in both complexity and cost. Charge controller and driver units are used. An electric power system is added to the differential motor.Differential motors are special purpose motor in which the axle is connected with differential of the motor. The power levels of motor used are influenced by available legal categories and but not limited below 500 Watts.

2.2 SOLAR PANELS

Solar panels are a panel design to absorb the sun’s rays as a source of energy generating electricity or heating. Solar cells are the building blocks of photovoltaic modules. A solar cell is an electrical device that converts the light energy into electricity by the photovoltaic effect, which is a physical and chemical phenomenon. It is a device whose electrical characteristics such as current, voltage or resistance vary when exposed to light.

A solar panel or module is a series of interconnected silicon cells and it is joined together to form a circuit. In greater number, the amount of power produced by these interconnected cells can be increased and used as an electricity production system.

Solar panels has different sizes for different purposes. The current standard offering in the market is a 60-cell panel, with larger 72-cell panels being used for larger-scale installations. Smaller panels are used in the off-grid market for layout more flexibility is required.

Solar cells are solid state semiconductor devices which converted light energy into electrical energy. Solar cell holds low voltages about 0.45 volts per cells are connected in series to increase voltage. Modules electrical connections are made in series to achieve a desired output voltage and in parallel to provide a desired current capability. Bypass diodes may use externally, in case of partial module shading to maximize the output of module.

The operation of a photovoltaic (PV) cell requires three basic attributes:

The absorption of light, generating either electron-hole pairs or excitons.
The separation of charge carriers of opposite types.
The separate extraction of those carriers to an external circuit.

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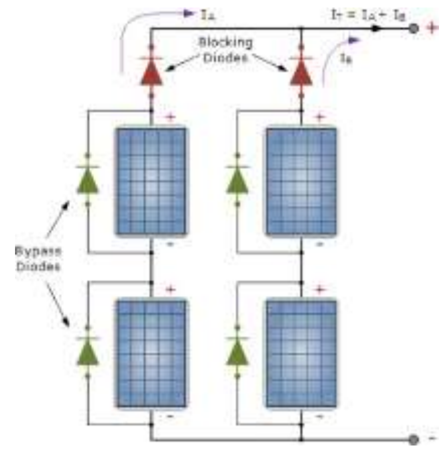

Figure 2.1 By-pass Diode

Table 2.1 Specification of Solar Panel

S.No.	Specifications	Range
1	Maximum Power (Pmax)	250W
2	Maximum Power Voltage (Vpm)	8.35V
3	Maximum Power Current (Ipm)	29.95A
4	Open Circuit Voltage (Voc)	37.25V
5	Short Circuit Current(Isc)	8.70A
6	Maximum System Voltage	1000V DC

2.3 Working Principle of Solar Panel

Solar panels harness the energy of the sun light and convert it into usable electricity. In this article, we are going to have a detailed look at the theory behind the basic principle used in the solar panel. The photons that are emitted from the sun (visible light) are captured by the solar panels is possible because of a principle called as photovoltaic effect.

Photovoltaic effect

This effect is the creation of the electrical voltage or rather the electric current flowing in closed loop, here referred to in a solar panel. This process is somewhat related the photoelectric effect; although these are different process altogether. The electrons that are generated when the solar panel are exposed to a stream of photons are transferred between the different bands of energy inside the atom to which they are bound. Typically, the transition of the energy state of electrons takes place from valence band to the conduction band, but within the material that is used in the solar panels. This transfer of electron makes them accumulate in order to cause a built up of voltage between two electrodes.

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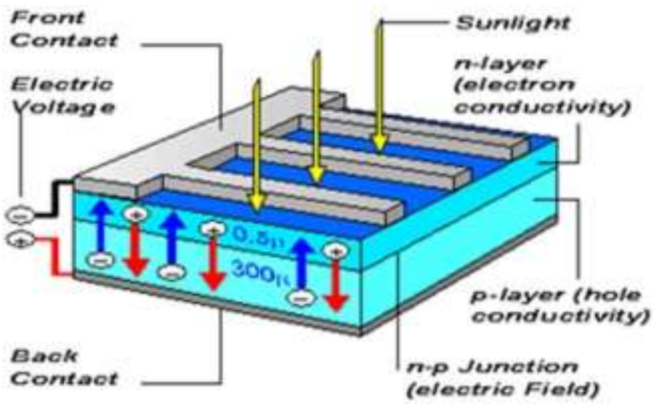

Figure 2.2 Working Principle

There is however another principle that guides the behaviors of solar panels. This refers to p-n junction solar cells used in solar panels. Here the material which is illuminated by the sun's energy is the source of current due to the separation of excited electrons and holes that are swept away in the different directions. This is caused due to the built in electric field of the p-n junction present at the depletion region.

Solar panels contain a system of solar cells that are interconnected so that they can transfer the induced voltage/current between one another so that the required parameters can pile up and a suitable throughout can be obtained. Series connections of the solar cells in solar panels help add up the voltage and the same is true for solar cells connected using parallel connection. Solar cells are protected from the mechanical damage as well as external factors like dust and moisture that can be serve to degrade their performance. Solar cells have materials that are mostly rigid. But when it comes to thin films, they need extra care as they are available in semi flexible nature.

3.FEATURES OF A SOLAR CHARGE CONTROLLER

- **Multistage charging of battery bank** - changes the amount of power set to the batteries based on its charge level, for healthier batteries.
- **Reverse current protection** - stops the solar panels from draining the batteries at night when there is no power coming from the solar panels.
- **Low voltage disconnect** - turns off attached load when battery is low and turns it back on when the lighting control turns attached light on and off based on dusk and dawn. Many controllers are configurable, allowing settings for a few hours or all night, or somewhere in between.
- **Display**- may show voltage of battery bank, state of charge, amps coming in from solar panel.

A charge controller, or charge regulator is basically a voltage and/or current regulator to keep batteries from overcharging. It regulates the voltage and current coming from the solar panels going to the battery. Most "12 volt" panels put out about 16 to 20 volts, so if there is no regulation the batteries will be damaged from overcharging. Most batteries need around 14 to 14.5 volts to get fully charged.

Generally, there is no need for a charge controller with the small maintenance, or trickle charge panels, such as the 1 to 5 watt panels. A rough rule is that if the panel puts out about 2 watts or less for each 50 battery amp- hours, then you don't need one.

3.1 TYPES OF CHARGE CONTROLLER

- PWM solar charge controller
- MPPT solar charge controller

3.1.1 PWM Solar Charge Controller

A PWM solar charge controller stands for "Pulse Width Modulation". These operate by making a connection

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directly from the solar array to the battery bank. During bulk charging, when there is a continuous connection from the array to the battery bank, the array output voltage is 'pulled down' to the battery voltage. As the battery charges, the voltage of the battery rises, so the voltage output of the solar panel rises as well, using more of the solar power as it charges.

As a result, you need to make sure you match the nominal voltage of the solar array with the voltage of the battery bank. The actual voltage of a 12V solar panel, when connected to a load, is close to 18 Vmp (Volts at maximum power). This is because a higher voltage source is required to charge a battery. If the battery and solar panel both started at the same voltage, the battery would not charge.

A 12V solar panel can charge a 12V battery. A 24V solar panel or solar array (two 12V panels wired in series) is needed for a 24V battery bank, and 48V array is needed for 48V bank. If you try to charge a 12V battery with a 24V solar panel, you will be throwing over half of the panel's power away. If you try to charge a 24V battery bank with a 12V solar panel, you will be throwing away 100% of the panel's potential, and may actually drain the battery as well.

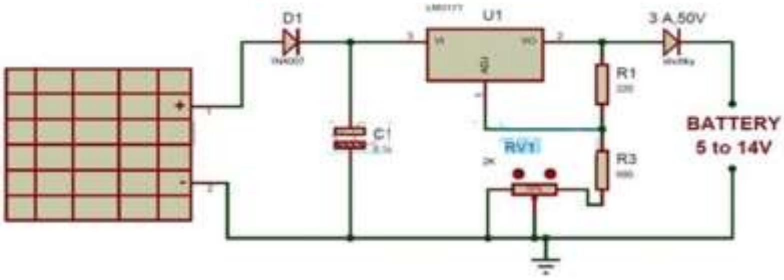

Figure 3.1.1 PWM Circuit Diagram

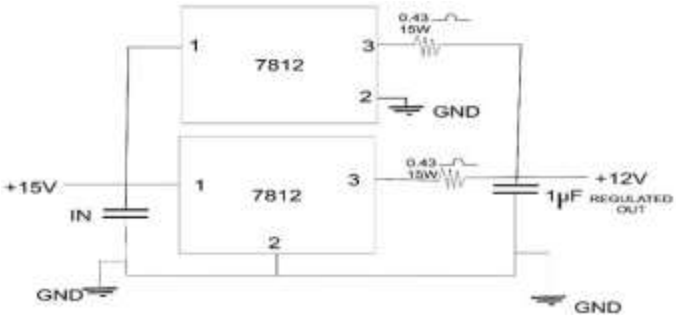

Figure 3.1.2 PWM Pin Diagram

4. DRIVER CIRCUIT

Driver is an electrical circuit or electronic component used to control another circuit, such as a high-power transistor, liquid crystal display (LCD). They are used to regulate current flowing through a circuit. Often used, for a specialized integrated circuit that controls high-power switches in switched- mode power converters. An amplifier can also be considered a driver for loudspeakers, or a constant voltage circuit that keeps an attached component operating within a broad range of input voltages. The driver stage of a circuit requires different characteristics to other circuit stages. For example in a transistor power amplifier, the driver circuit requires current gain, for the ability to discharge, and low output impedance to avoid distortion

4.1 Using Transistor

- **Single direction control**

To rotate your motor in only one direction, then this is the easiest way to do so. Power transistor is used as a switch to turn a motor on or off depending upon the applied voltage at base. The circuit is shown in Figure

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4.1. The same motor driver circuit is used in making a simple line follower robot.

- **Working**
  - Check the rating of the transistor you are using. It must be greater than the maximum current drawn by your motor.
  - A normal DC motor as shown below draws 250mA current. D880 transistor has a max collector current rating of 3A.
  - Gear-head motor use power transistors, as chances of their damage is less in case of a short circuit due to the heat sink attached to them. If the current requirement is higher, then use Relays.

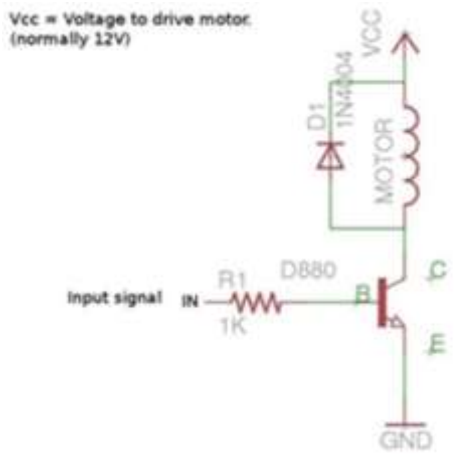

Figure 4.1 One Direction Motor Control

- **Both Direction Control (H-bridge Circuit)**

For controlling motor in both directions H bridge circuit is used. Its working is very simple and is described below.

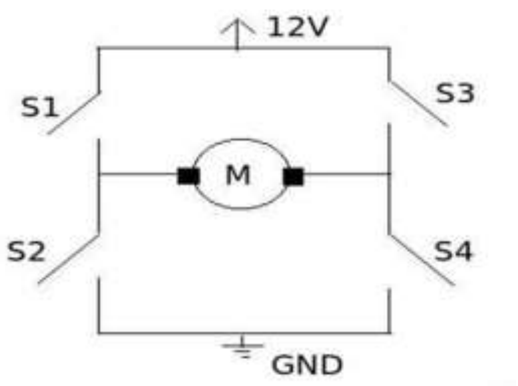

Figure 4.2 H-Bridge Working

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4.2 BLOCK DIAGRAM

We decided to do something that would be benefited to the world environment. The greater importance of the environment in the world lead to an opportunity for students. With the economy trying to get out of the worst depression, there are plenty opportunities for us to help out. This is our opportunity to contribute a greener and more efficient planet. The main aim of our project is to save our environment from pollution.

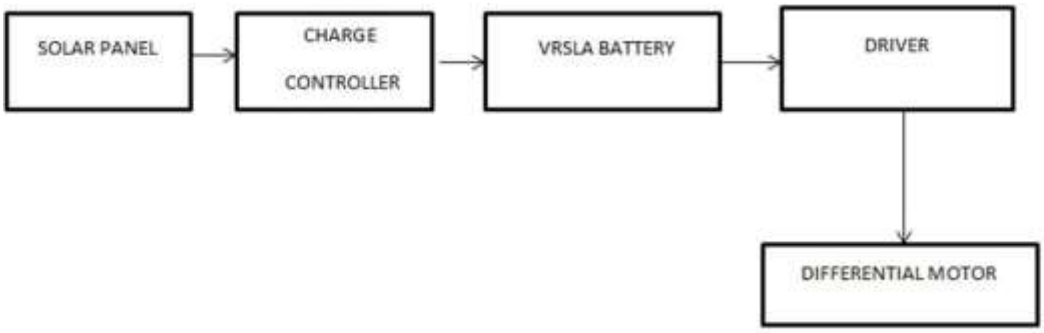

Figure 4.3 Block Diagram of Proposed system

For that, electric car would be the best fit. This electric car has zero pollution, zero noise effected and no fuel consumption. In the recent years, India has increasing encouraged a cleaner environment and less dependence on foreign oil. Block diagram of proposed system is show in figure 4.3

The price of fuel has increased significantly over the past few years and there seems to be no turning back. In our ecosystem, most gasoline cars are used by the public which have high cost of refuelling that causes emission of greenhouse gases. To reduce the automotive emission, an alternative technology is needed. The environment has also been more focus throughout the worlds in past few years and it seems that cleaner alternative have been steadily on the rise with no end in sight.

In this paper, the electric car is the way to alter the energy source. In this project we are using solar panel, charge controller, VRSLA battery, Driver circuit and Differential motor. Source of energy obtained from light energy is converted into electricity.

In this paper, the electric car is been charged through renewable energy. Energy obtained from the solar panel is given to the charge controller. Instead of internal combustion engine, solar car uses the combination of solar panel and electric motor powered by stored battery system. In our project, we are using a VRSLA (Valve Regulated Sealed Lead Acid Battery). The motor used here is the Differential motor. The motor gets supply from batteries and vehicles moves. The battery is discharging upto 90% and the battery is been charged through solar and it is used to run the motor and at the same time battery can be charged from solar. An extra benefit to building the electric car is that, it can also show how much it is cheaper it would be to convert regular car into an electric car rather than driving in the gasoline engine.

4.3 VALVE REGULATED SEALED LEAD-ACID (VRSLA) BATTERY

VRSLA battery stands for Valve Regulated Lead-Acid Battery commonly known as Sealed lead-acid battery, gel battery or maintenance free battery which is a type of lead-acid rechargeable battery. There are three primary types of VRSLA batteries such as Sealed VR wet cell, AGM (Absorbed Glass Mat) and gel. Due to their construction the Gel and AGM types of VRSLA can be mounted in any orientation and do not require constant maintenance. Maintenance free batteries are used in large portable electrical devices and off-grid systems even though they require regular functional testing. The outer view of VRSLA battery is shown in the figure 4.2

Figure 4.4 Valve Regulated Sealed Lead Acid Battery

4.4 DRIVER CIRCUIT

Driver is an electrical circuit or electronic component used to control another circuit, such as a high-power transistor,

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liquid crystal display (LCD). They are used to regulate current flowing through a circuit. Often used, for a specialized integrated circuit that controls high-power switches in switched- mode power converters.

An amplifier can also be considered a driver for loudspeakers, or a constant voltage circuit that keeps an attached component operating within a broad range of input voltages. The driver stage of a circuit requires different characteristics to other circuit stages. For example in a transistor power amplifier, the driver circuit requires current gain, for the ability to discharge, and low output impedance to avoid distortion.

5. ELECTRIC CAR USING SOLAR SYSTEM & IT'S BENEFITS

ELECTRIC CAR USING SOLAR SYSTEM

The fuel consuming vehicle causes pollution, emission of greenhouse gases like carbon monoxide. To avoid those kind of emission of gases, an alternative technology is been adapted in our project. The most easiest way is using of Renewable energy sources. In our project we are using solar power for vehicle as shown in the figure 5.1

For solar, sunlight is the major source of energy to obtain light energy which is converted into electricity. The vehicle chosen is Maruthi Omni. Solar panels are fixed on the top of the car in a flat manner. There are 4 solar panels are fixed in which each panel constitute maximum power of 250W voltage of 24V and current 8A.

By using the monocrystalline cells materials the solar panels are made and it attains higher efficiency at 55degreeCelsius and generate power upto 55degreeCelsius. The solar cells are made up of silicon and they are kept in layer manner.

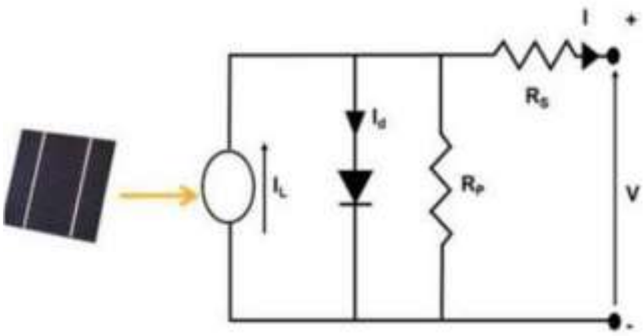

Figure 5.1 Solar Panel Circuit Diagram

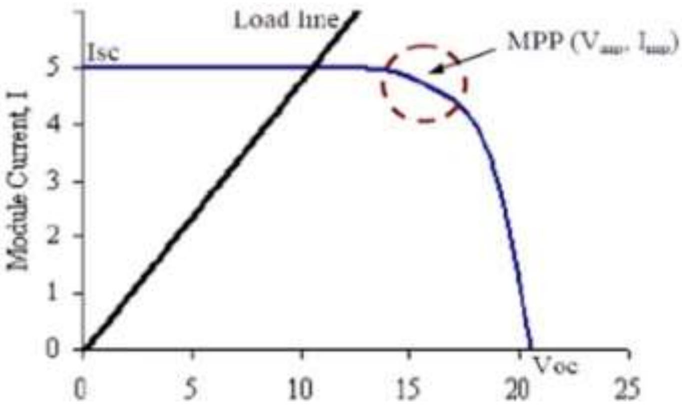

Figure 5.2 Waveform During Radiation

The size of solar panel is 1649mm in length 992mm in breadth. The 4 panels are classed as 2sets such as set A and set B. This set A and set B constitute of A_1,A_2set and B_1,B_2 set. The A_1,A_2,B_1,B_2 sets are connected in series condition then both these sets are connected in parallel. Because of photons from sunlight falls on solar panel, silicon layer affect the layer by layer alignment of the silicon and thus electron flow takes place because bus bar is connected to the backside of the panel which generates power.To prevent the reverse current flowing to the solar panel, a 10A diode is connected to the panel which acts as bypass diode. Now, the output of the panel is given to a charge controller.

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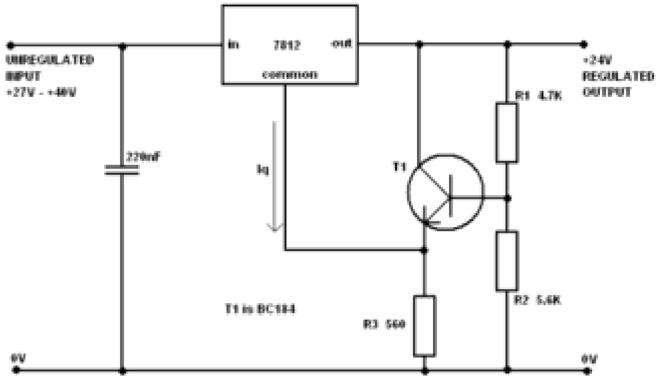
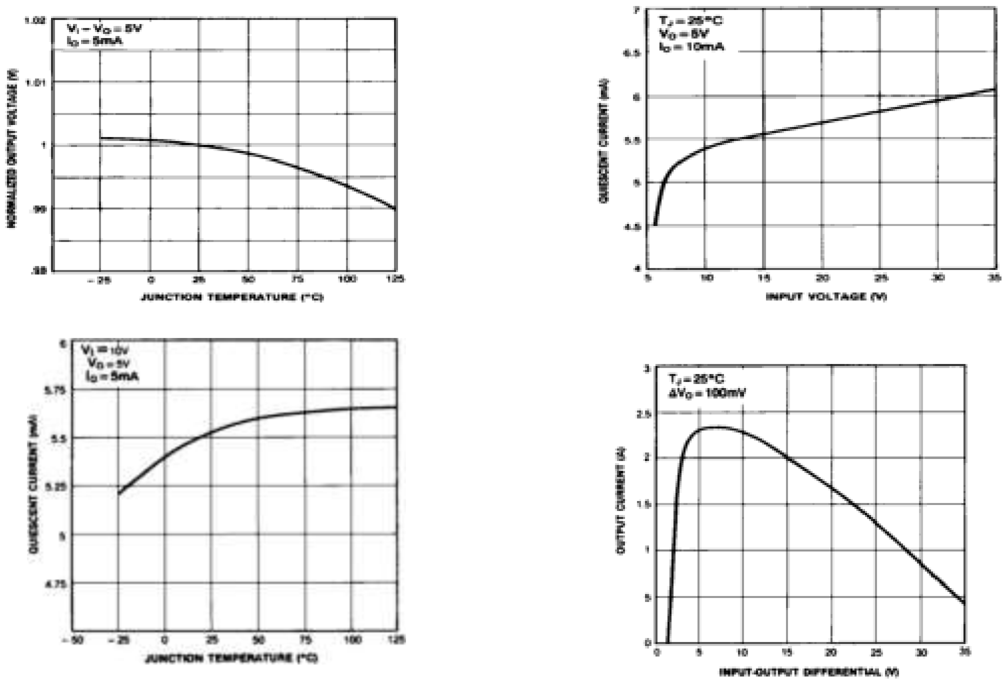


Figure 5.3 Circuit Diagram of Transistor 7812

As shown in the figure 5.3 the internal structure of the charge controller consists of two 7812 transistors and IC358. Charge controller has 6 terminals . Output of the solar panel is given to the first 2 terminals and this is the input of the charge controller. The next 2 terminals are the output of the charge controller which is given to the battery as input and the last 2 terminal acts as excess load.

QUIESCENT CURRENT   OUTPUT PEAK CURRENT



OUTPUT VOLTAGE   QUIESCENT CURRENT

Figure 5.4 Waveform of LM7812

6. CONCLUSION & FUTURE SCOPE

CONCLUSION

The solar cell based electric vehicle has developed and validated through hardware model. The solar cell produces 1000 watts power which is applied to differential dc motor. The differential dc motor rating of 1250W, 2500 RPM is controlled by driver circuits. The driver circuit perform with high ripple rejection which is controlled by pulse width modulation technique. In Battery simultaneously, both charging and discharging takes place. when the battery of the vehicle is fully charged, it can run continuously at an average speed of 30-40 Km/h.. The Electric Vehicle has been

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satisfactorily completed the prototype that vehicle can run in normal surface with an entire power of 660Kg. Through this project, we increase the mileage of the vehicle. Our project is eco-friendlily and causes no air pollution.

FUTURE SCOPE

The performance of the proposed Electric Vehicle will be improved in driver circuit by using artificial intelligent techniques such as Fuzzy logic control, Neural network control. It can be further reduce the ripple frequency and control the differential dc motor in smooth manner.

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