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Design and Implementation of Solar Photovoltaic and MPPT in Electric Vehicle

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ABSTRACT: Solar Photovoltaic (PV) systems are having increasing importance in present time of electrical power system due to its non-polluting nature, less maintenance, and free fuel characteristics. Solar photovoltaic technology is considered as oneof the pure and clean technologies to produce electricity, but seems unattractive towards the use of it as a complement of electricity due to its low efficiency and high initial cost. As a result of its low efficiency it is nearly impossible to exploit the maximum solar power coming out of array therefore at its highest energy conversion output it leads to the operational failure of the device. As the radiation and temperature has their effects on the maximum power point, it is likely impossible to provide power operation at optimum level during all radiation levels.The efficiency of commercially available solar PV module is very low in the range of 10-25 %. In order to maximize their operating efficiency and to reduce installation cost, maximum power point trackers (MPPT) are coupled with the system. In this paper we are presenting the design and implementation of solar PV and MPPT controller for electric vehicles

KEYWORDS: Solar PV system, MPPT controller, solar PV array

I.INTRODUCTION

Solar energy is a readily available, clean, and inexhaustible energy source considered as a sustainable alternative energy source for electricity generation. The contribution of solar energy to the world total electricity generation has been on increase in the past decades. The global installed capacity ofsolar photovoltaic (PV) system increased from below 10 GW in 2007 to over 100 GW capacity in year 2012. Solar energy system generates electricity by direct conversion of solar photon (light) energy to electricity using solar cells and indirectly using solar thermal to produce superheated steam for driving electrical turbines. Solar photovoltaic cells used in solar PV system are made of a light absorber materials of p-n junction semiconductorthat absorbs solar photons above certain minimum threshold energy called "energy gap" or "band gap" (*Eg*) to free electrons generate electricity.
A model of a 300 W (3*100 W) solar PV panel intended to be fed to a battery for storage purpose. This energy is then intented to fed to the motor to drive the vehicle. In the case of sun tracking where the PV modules are rotated mechanically to generate maximum power as the radiation intercepted by the module is maximum. For a vehicle it is not easy to mechanically arrange the solar panel according to the sun's direction. In this paper we are presenting the case of the case of maximum power point tracking (MPPT) technique, an electronic circuit is used to transfer the power to the load system. The main intention behind this is to transfer maximum power from PV system to load. By adjusting the duty cycle, input impedance can be varied which should be same as the solar PV module impedance in a given operating condition for maximum power transfer. The objective of this work is to implement MPPT technique with the solar panel.

The solar vehicle is a step in saving the non-renewable sources of energy. Solar poweredelectric vehicle is advantageous because of less noise, less pollution and reduces carbon dioxide emissions. It consists of PV panel, charger controller, battery, inverter and BLDC motor.[3] The basic principle of theproposed vehicle is the energy drawn from the solar panel that is used to charge a battery which in turn runs themotor of the vehicle. A boost converter

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is used as an interface between the solar panel and the battery to obtainthe required voltage and to extract maximum power from PV. The BLDC motor is preferred over DC motor becauseof high efficiency, low maintenance, long life, low weight and compact construction. The conventionalDC motor is relatively more expensive and needs maintenance due to the brushes and commutator, whereas,BLDC motor has a rotor and a stator, which is connected to a power electronic switching circuit.

II.SOLAR PV

A photovoltaic system, also PV system or solar power system, is a power system designed to supply usable solar power by means of photovoltaic. It consists of an arrangement of several components, including solar panels to absorb and convert sunlight into electricity, a solar inverter to change the electric current from DC to AC, as well as mounting, cabling, and other electrical accessories to set up a working system. It may also use a solar tracking system to improve the system's overall performance and include an integrated battery solution, as prices for storage devices are expected to decline. Strictly speaking, a solar array only encompasses the ensemble of solar panels, the visible part of the PV system, and does not include all the other hardware, often summarized as balance of system (BOS). Moreover, PV systems convert light directly into electricity and shouldn't be confused with other technologies, such as concentrated solar power or solar thermal, used for heating and cooling.

III. MPPT CONTROLLER

Maximum Power Point Tracking Solar Charge Controllers (MPPT) are different than the traditional PWM solar charge controllers in that they are more efficient and in many cases more feature rich. MPPT solar charge controllers allow your solar panels to operate at their optimum power output voltage, improving their performance by as much as 30%. Traditional solar charge controllers reduce the efficiency of one part of your system in order to make it work with another. Read our MPPT charge controller blog to learn more about how you can maximize your power output with MPPT Solar Charge Controllers.MPPT or Maximum Power Point Tracking is algorithm that included in charge controllers used for extracting maximum available power from PV module. The voltage at which PV module can produce maximum power is called ‘maximum power point’. Maximum power varies with solar radiation, ambient temperature and solar cell temperature. In this project we are using MPPT charge controller for the efficient use of solar PV and battery.

IV.SYSTEM DESCRIPTION AND MODELLING

A.Overall Structure of the system:

The overall structure of the hybrid power system is shown in fig. 1(a). two power surces are pvovided in the system, battery and solar PV.The part in the red ellipse is the photovoltaic power system, which is the key innovation of this paper.the detailed structure is shown in fig. 1(b). This system is made up of PV cells and MPPT controllers that connect PV cells with the load and a control system based on DSP.

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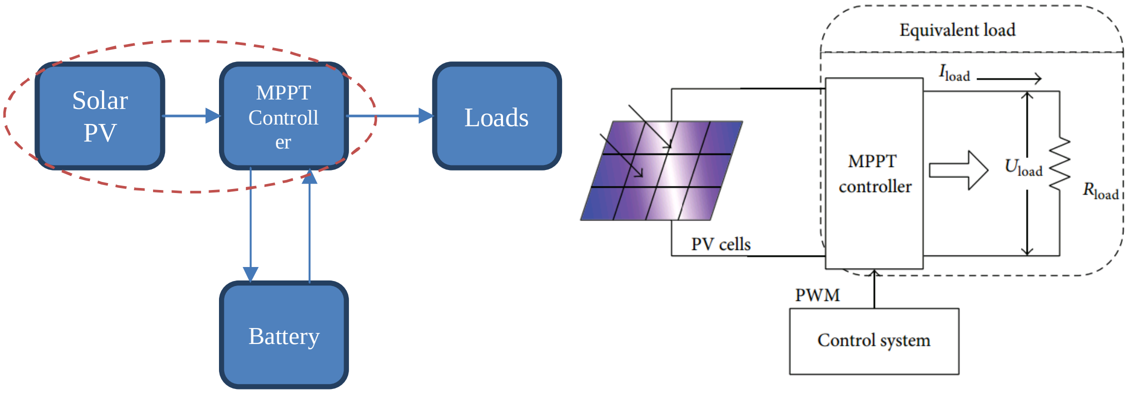

Fig. 1(a) Hybrid power system structure, (b) Photovoltaic power system structure

B. Photovoltaic Cell Modelling:

Solar pv cell is the basic unit of solar PV array/panel, they are combined in series to achieve required voltage and current level. A PV cell is a pn junction semiconductor that generate current when exposed to light. A simplified equivalent circuit of PV cell with 5 parameters is presented in Fig. 2. A cell series resistance (Rs) is connected with call photocurrent (Iph), exponential diode (d), and shunt resistance (Rsh). Ipv and Vpv are the PV cell's current and voltage respectively.

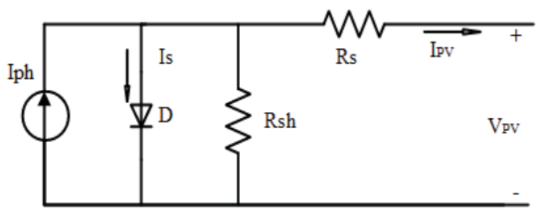

Fig 2. Pv cell equivalent circuit

The PV cell output current Ipv is expressed as:
Ipv=Iph-Is

$$\mathrm{Ipv} = \mathrm{Iph} - \mathrm{Is}\left(e^{q\left(\mathrm{Vpv}+\mathrm{pvI}*\frac{\mathrm{Rs}}{\mathrm{nKT}-1}\right)}\right) - (\mathrm{Vpv} + \mathrm{Ipv} * \mathrm{Rs})/\mathrm{Rsh} \ldots\ldots\ldots (1)$$

Where:
Iph = Solar-induced current
Is= Diode saturation current
q= Electron charge (1.6e^-19 C)
K = Boltzmann constant (1.38e^-23J / K)
n = Ideality factor (1~ 2)
T =Temperature K

To show the non-linear characteristics of PV array under different irradiance and temperature, a 300 W solar panel comprises of 3 modules with each module having 36 cells connected in series. The electrical specifications of the solar panel based on standard test conditions (STC) is presented in table I. Theparameters of PV panel used for the power system are shown in Table 1. The *I-V*and *P-V*characteristics of the PV panel were tested under different solar radiation

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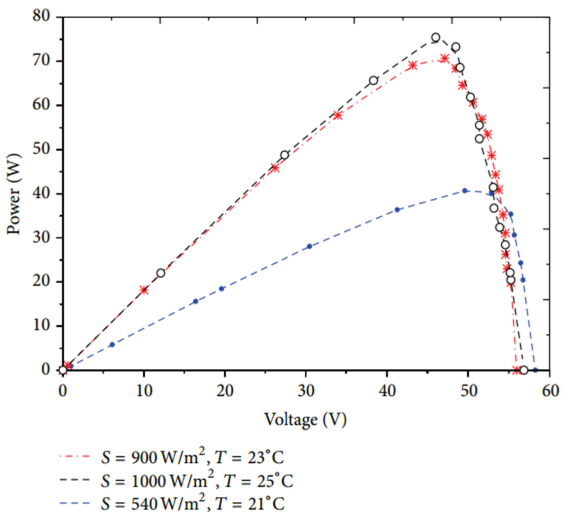
intensities andtemperatures. The curves are shown as in Figure 3. Here, *S*is measured by using a TBQ-2 pyranometer to measure the total solar radiationintensity from 0.3 to 3.2 micron.

Table 1. Parameters of PV panel

Parameters	**Symbol**	**Value**
Rated power	Pmp	100W
Open circuit voltage	Voc	22.34 V
Short circuit current	Isc	5.9 A
Voltage at maximum power	Vmp	18.1 V
Current at maximum power	Imp	5.53 A
Total number of cells in series	Ns	4
Total number of cells in parallel	Np	9

C. MPPT System:

Figure 3(a) and 3(b) shows that the output voltage changes when power and current of PV cells are changed along with the ambient temperature and illumination intensity. Under a certain condition there is only one MPPT if the surface of the PV panel is not in shadow. According to the structure of the photovoltaic power system in Figure 1, the actual load, together with MPPT controller, can be recognized as an equivalent load, as shown in Figure 4(a). Here, Us is the voltage of PV cells, r is the essential resistance of PV cells, and $R1$ is the resistance of the equivalent load. The tracking process of maximum power poit is shown in figure 4(b).



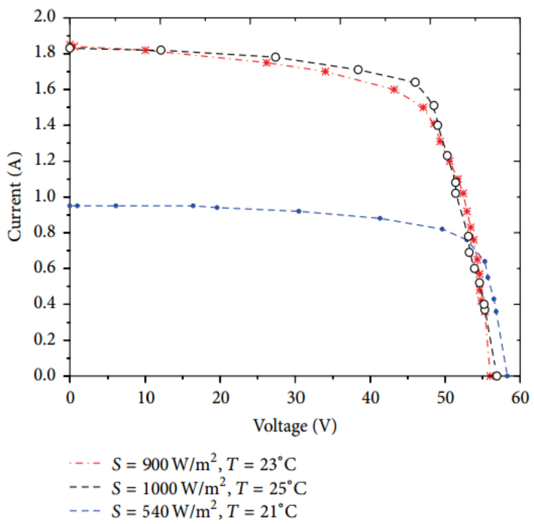


Fig 3. (a)P-V characteristic curve under different conditions. (b) I-V characteristic curve under different conditions.

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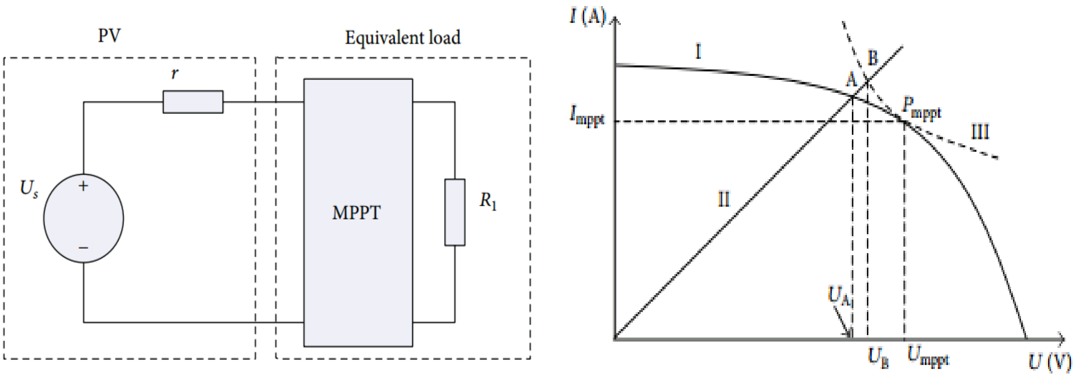

Fig 4. (a) Equivalent model of PV and load, (b) Process of tracking MPP.

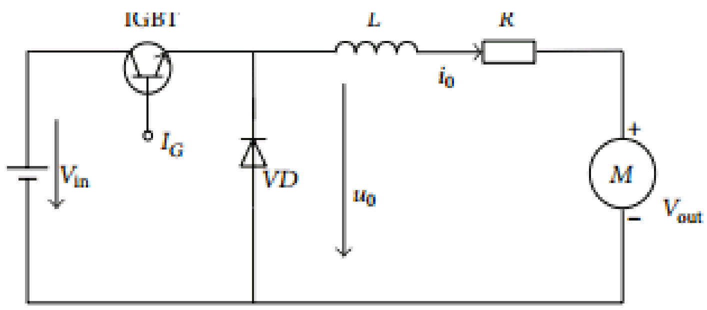

Fig 5. Buck chopper circuit

MPPT Control Technique:

PV arrays exhibits non linear varying IV characteristics during operations based on solar irradiance and temperature at particular type.Inorder to ensure that PV arrays operates at maximum power point under different operating conditions,maximum power point tracker (MPPT) are incorporated. This will improve the PV panel efficiency and reduce the system installation cost.MPPT automatically finds the voltage at which the PV array outputs maximum power and ensure that it maintains the system operation at the point under difference irradiance, temperature and load current.

In this work, a DC-DC booster converter is used at power stage to achieve the source to load impedance matching controlled by variable switching duty cycle.A buck chopper circuit is shown in figure 5. The perturb and observation MPPT algorithm is used for duty cycle controlled to obtain reference voltage for maximum power point. The power is stepped by varying the voltage, it increase voltage the power also increased ,then the duty cycle is increased in same ration otherwise duty cycle decreases with a step. The iteration continues until maximum power point is reached and the converter output voltage is maintained at the point. The output voltage of the controller is maintained constant by varying the duty cycle which determines the output voltage value from the solar PV at every switching cycle.

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V. FUTURE SCOPE

Now we are living in a world driven by IC engines. Most of the vehicles uses IC engines for their propulsion and fossil fuels as their energy source. The combustion of fossil fuels will cause pollution and these fuel sources are not completely dependable because they are depleting day by day. Another problem while using the conventional vehicles is their low efficiency ie upto 55%-65%. The remaining energy is wasted in the form of heat. By considering these facts, the world has now decided to change the conventional transportation system by introducing “Electric Vehicles”.
The energy crisis and pollution problems in the long term continue to worry vehicle manufacturers. In order to resolve the negative problems caused by automobiles, researching and applying new alternative energy in the field of automobile are attracting people’s attention. Electric vehicles (EVs), fuel cell vehicles, and solar vehicles are emerging on a large scale. In the Proposed project, a proposal is presented for a photovoltaic power system used in a small-size electric scooter, which contains three power sources that are PV cells, super capacitor, and battery. The hardware circuit of the system was designed and built using an MPPT controller and some secondary circuits such as isolated drive circuits, assistant power circuits, and peripheral circuits of DSP. Moreover, a novel MPPT algorithm called “sectional variable step climbing” (SVSC) algorithm is proposed. The experimental results show that the MPP of PV cells is tracked perfectly and that the SVSC algorithm achieved a higher efficiency.

VI. RESULT

We are using solar panel as an additional means for charging the battery. Normal back up of an EV battery (48V, 60 Ah) is 1.5 hour. By implementing MPPT to the solar panel the back up increases to 2 hours.

VII. CONCLUSION

The project is mainly concentrated on solar PV and MPPT design for the solar based electric vehicle. We are using 300W 5Amps solar PV module which gives a voltage of 54V to charge 48V battery. We are using MPPT with solar PV to increase the efficiency. The electrical energy supplied by four 12V,49 Ah batteries connected in series. Vehicle can attain a maximum speed of 50 Kmph .The motor has a rated output power of 2000 watts and an input voltage of 48V.The rated torque is 30Nm.We are using transmission for the propulsion for improving efficiency, mileage and speed regulation. Overall cost of the BLDC motor with controller is lesser than the induction motor. This work aims at contributing towards the application of electric vehicles and also bringing Vehicle to Grid (V2G) concept to support the grid during different requirements. Another specialty of our electric vehicle is that the vehicle will support another vehicle as a donor. Also by implementing V2G concept we can reduce the peak time load on grid. So in short we aims at a pollution less transportation and utilization of non-conventional energy.

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