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Rechargeable Battery with DC-DC Boost Converter Powered by Solar based on P&O MPPT

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Abstract: This paper focuses on the employment of solar power as an influence supply in an exceedingly battery charging system. It becomes terribly tough for us to seek out a supply of power to charge the battery once running out of energy particularly being outside. As a result, charging the battery with a solar-powered device would be a lot of sensible. The system evaluates the management performance of the battery chargers in terms of voltage, current, and power output from solar energy. A 24V 12W solar battery is employed to power a battery that encompasses a 15Ah 24V charging output. This project methodology uses the MPPT boost device charge controller. However, this project uses perturb and observation methods to restore battery energy capability to most capability once recharged. as a result, it's supposed to charge a 24V, 15AH lead-acid battery, it's designed with 17V input voltage and 26.25V output voltage. The DC-DC boost device output voltage ought to be kept at 26.25V supported by the findings of the battery charging system simulation. to get a full charge, the battery needs 18000 seconds or five hours of charging time. For future work, the system is often achieved by performing MPPT using the Simulink model rather than putting code within the Embedded MATLAB operation or radiation and temperature are often provided as variable inputs within the Simulink model rather than constant values because of environmental changes.

Keywords: Battery Charger, Solar Power, P&O MPPT, Boost Converter

1. Introduction

Irradiation and temperature have a bearing on the voltage and power characteristics of a star PV system. As a result, PV panels are expensive, and most electrical outlet following (MPPT) is needed to trace the bulk of output power. The PV panel and therefore the battery are each connected via a DC-to-DC device [1,2]. The voltage, current, and power of the PV module rise because the solar irradiation will increase. On the opposite hand, once the temperature rises, they decrease. it's not permissible to use it to charge A battery directly during this instance. putting in a DC-DC boost device between the PV module and therefore the battery is usually recommended [3].

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A boost converter could be a dc-to-dc converter that's accustomed boost DC voltage magnitude. DC drives, DC power offer, rectifier input power issue adjustment, and star systems all use it. One every of the foremost well-liked applications for this converter is to charge the electric battery that needs a bigger voltage than the voltage supplies accessible. Boost converters have late been the topic of a lot of studies to form them usable in solar systems wherever battery charging is visible [4,5]. Additionally, electricity generating, which contains a lift converter, is employed in vehicles to charge batteries. Notwithstanding the sources utilized, the convertor wants a decent electrical device to spice up the voltage significantly [6,7].

After getting used as an associate energy supply, the battery's energy capability decreases, permitting it to come to its most capability when being recharged. So, we want to seek out an appropriate power supply to recharge the battery once the electrical devices run out of battery charge. It becomes terribly tough for us to seek out a supply of power to charge the battery when running out of energy. As a result, charging these batteries with a solar-powered charger would be a lot of sensible. For charging a 24-volt battery, employing a DC-DC boost device to boost PV output voltage is essential. As a result, the output from PV varies betting on the close temperature and environmental conditions, modeling such a device is important to make sure that the battery is charged often. MPPT systems are usually employed in systems with nonlinear power sources, like solar PV modules. The MPPT integrated boost device system is employed in solar PV applications with the charger attached to the whole PV system throughout this analysis. The first intention of charging a storage battery is to store electricity. If the energy originates from solar PV systems, the battery is sometimes charged quickly with the assistance of an associate MPPT-boost device charge controller. It's expected that a solar charge controller is developed.

The main objectives of this simulation study of simulation of solar battery charging system using MPPT and boost converter are to develop the rechargeable battery with dc-dc boost converter powered by solar based on P&O MPPT in MATLAB Simulink and evaluate the control performance for charging battery in terms of voltage, current, and power from solar power.

2. Material and Methods

In this section, an explanation of the proposed solar battery charging system will be presented. Research from previous relevant project is helpful to prevent necessary mistake and advance their project. The first subsection presents the design parameters used in the simulation. Then, followed by MPPT algorithm method and modelling circuit.

2.1 Materials

The first approach to improving photovoltaic solar panel performance is to employ a maximum power point tracker in quickly changing climatic circumstances and a DC-DC converter to optimize output power. When the solar panels are partially shaded, this system may function at the maximum power point MPP and provides the most electricity under diverse irradiance circumstances. With an output power of 20.06 watts, the design required just 20W, 17V solar size, which is adequate solar sizing to support the system's electrical supply. In the battery charging system design, it was completed with the PWM modulator circuit to control the charging operation automatically. To achieve a completely charged condition, the battery requires 18000 seconds, or 5 hours of charging time. The constant voltage approach is used by this charging system, which means that if the battery state of charge is less than 80%, the charging voltage will stay constant to prevent overcharging.

2.2 MPPT Algorithm Method

The P&O approach is applied in this study, as illustrated in Figure 1. The procedure begins by monitoring the PV output voltage, V(t), and current, I(t), and then calculating the power value as the product of the two. The difference between old and new power, as well as the difference between old and new voltage, was then measured. Because it is already at maximum power, if the difference between initial and prior power is equal to 0, it will return. If the difference is more than 0, it determines whether the voltage difference is less than or larger than 0 and whether the voltage should be increased or decreased.

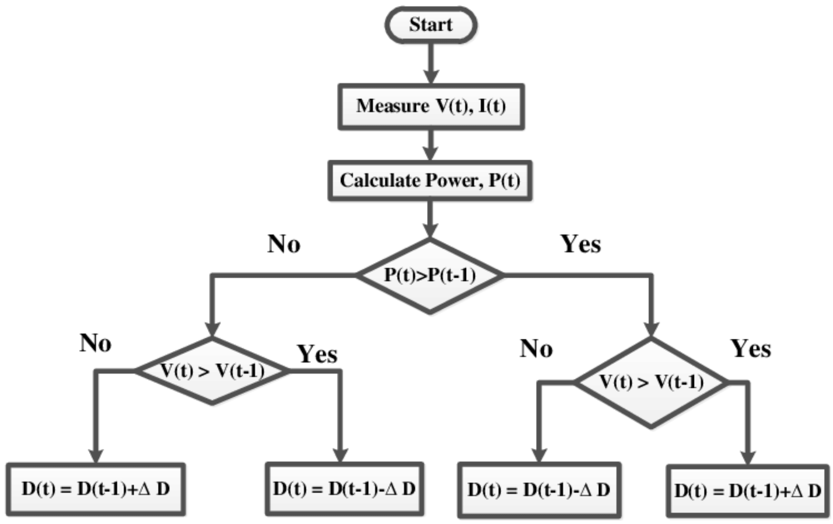

Figure 1: Flowchart of P&O MPPT Method

Initially, the solar source will direct energy directly to the developed photovoltaic arrays. When the solar arrays receive solar energy, the solar will serve as the system's primary power source, and the energy will be used to replenish the system's lead acid battery by stepping up the voltage to guarantee that the input voltage is larger than the battery's voltage.

This charging system, on the other hand, employs a constant voltage technique, which implies that even if the irradiance levels fluctuate, the charging voltage will remain constant to prevent overcharging, with the exception that a negative battery current signals that the battery is charging. As a result, the charging time required by the battery to reach a fully charged state is 18000 seconds, or 5 hours.

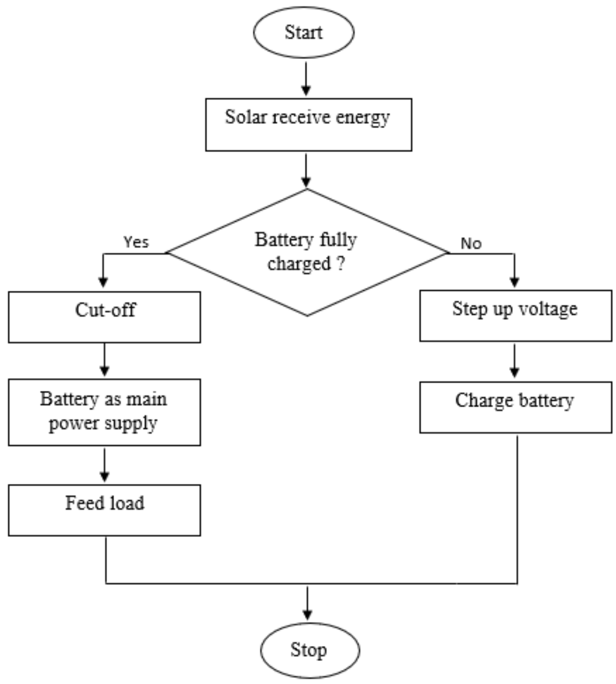

Figure 2: Flowchart of the system

The electricity from the source will be switched off after the battery is fully charged. A lead acid rechargeable battery can be utilized as a backup or primary power supply for the system as an alternative. As the main power supply, the battery will last 8-12 hours, allowing the load to continue operating normally. Figure 2 shows the block diagram of the system.

3. Results and Discussion

The performance of the battery charge controller is shown in this part by charging the battery via a pattern of constant voltage absorption charging phases to prove the charger's one-stage charging capability.

3.1 Performance of PV module for battery charging system

A 20W, 17V PV module is designed, evaluated, and demonstrated according to its requirements. An error percentage is utilized as a signal in the validation to indicate that the PV module modelling may be used as the DC voltage source of the DC-DC boost converter. Table 1 presents the validation of the PV module simulation results and data sheet.

Table 1: Validation of 20W, 17V PV module

Parameters	Data sheet	Simulation	Error percentage
Maximum power, Pmax	20W	20.06W	0 %
Voltage at maximum power point, Vmpp	17V	17.01V	0.06 %
Current at maximum power point, Impp	1.18A	1.179A	0.08 %

Table 1 demonstrates that the maximum power datasheet and simulation result are both 20.06W, indicating that the PV module has no maximum power error %. For simulation, the voltage and current at the maximum power point of a 20W, 17V PV module are 17.01V and 1.179A, respectively. It indicates that the voltage and current error percentages at the maximum power point for a 20W, 17V PV module are 0.06% and 0.08%, respectively. It can be seen that all error percentages are in the 0.1% range. It demonstrates that the PV module modeling may be used in a DC-DC boost converter.

The voltage-time, current-time, and power-time curves are shown in Figures 3, 4, and 5, respectively, under standard test conditions (STC) of 1000 W/m² and 25ºC. For the voltage at the maximum power point, Vmpp, current at the maximum power point, I_{mpp}, and maximum power, P_{max}, The 24V to 26.25V DC-DC boost device is intended to have a 100% efficiency and a 100W output power. It indicates the output power is the same because of the input power. For the current ripple of 50 of the inductor currents, the capacitance-voltage ripple is 0.5 % of the capacitance-voltage, and also the duty ratio is 0.3, the inductance is 20µH and also the capacitance is 500µF.

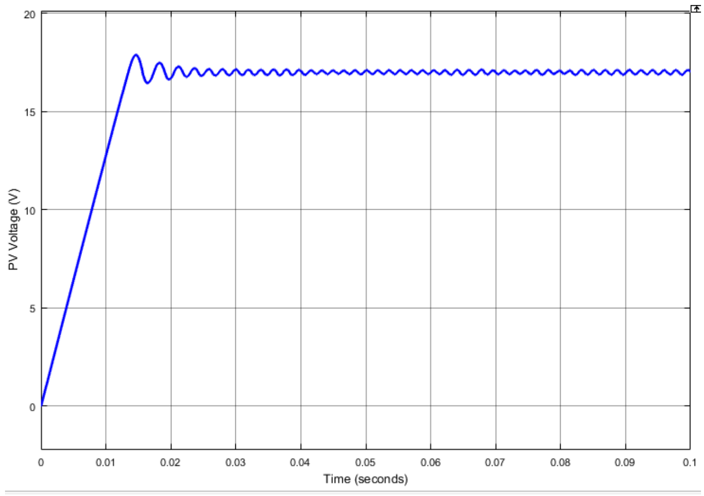

Figure 3: Curve of 20W, 17V PV module voltage

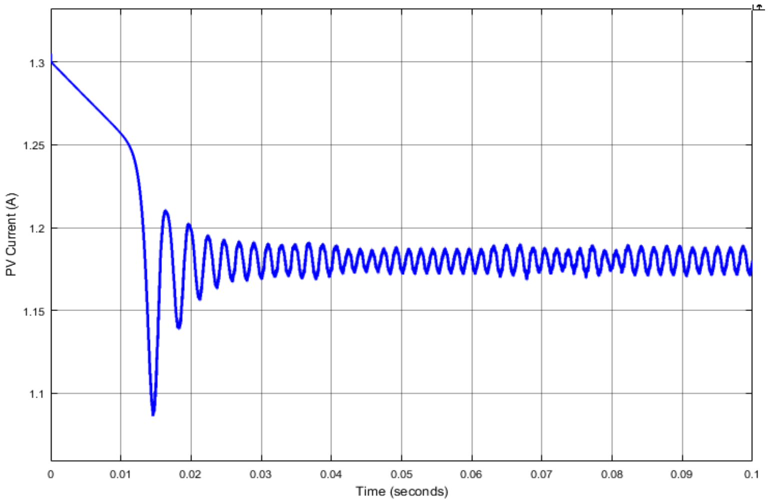

Figure 4: Curve of 20W, 17V PV module current

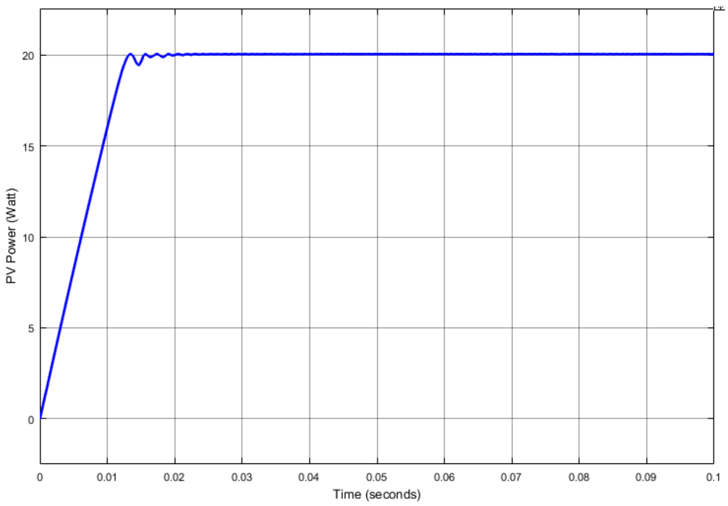

Figure 5: Curve of 20W, 17V PV module power

To entirely cut back the resistance load of 8, a 24V, 15Ah lead-acid battery is hooked up to the DC-DC boost converter's output line. During this situation, the initially charged battery features a voltage of 22.87V at a 25% initial state of charge (SOC) and is totally charged to a value of 26.25V at 100% SOC. The modeling of a PV-powered DC-DC boost device supported associate MPPT star controller is run for 0.1 seconds whereas the battery is charging to observe and analyses the voltage of the PV module (Figure 3), the battery power (Figure 6), the battery voltage and current (Figure 7), and also the battery state of charge (Figure 8).

Figures 7 and 8 depict the battery voltage, current, and state of charge. The output voltage of a DC-DC device is often adequate a battery voltage of 26.25V. Even once absolutely charged, the battery features a very excellent constant-maintenance value. The output voltage is likewise comparable to the 26.25V battery voltage, with the distinction that the battery current activity, as shown in Figure 8, shows that the battery is charging. The battery begins charging at a SOC of 25% (22.08V), and when 0.1 seconds of charging, the SOC reaches 25.63%. This means that when 0.04 seconds, the battery charging method boosts the SOC by 0.63 percent. As a result, the charging time necessary to totally charge the battery is 18000 seconds or 5 hours.

The figures are derived using simulation curves at a standard irradiance level, as shown in Figure 9, wherever the results are consistent and match the required values. The net impacts of weather amendment circumstances are compared to standard test settings using varying degrees of insolation (see Figure 9). Figure 9 shows that the battery voltage will increase and therefore the battery current decreases which means it starts charging from 0.08 seconds at an associate degree irradiation level of 1000 W/m². Although the battery state of charge is a smaller amount than 80%, this charging technique employs a continuing voltage approach, which suggests that though the irradiance is alert to external factors, the charging voltage can keep constant to prevent overcharging. The battery is then charged, with the voltage and current changing in response to a fixed degree of irradiation. Figures 5 and 8 show that the facility on the electrical device is increasing and therefore the power on the battery is decreasing because of the charging method.

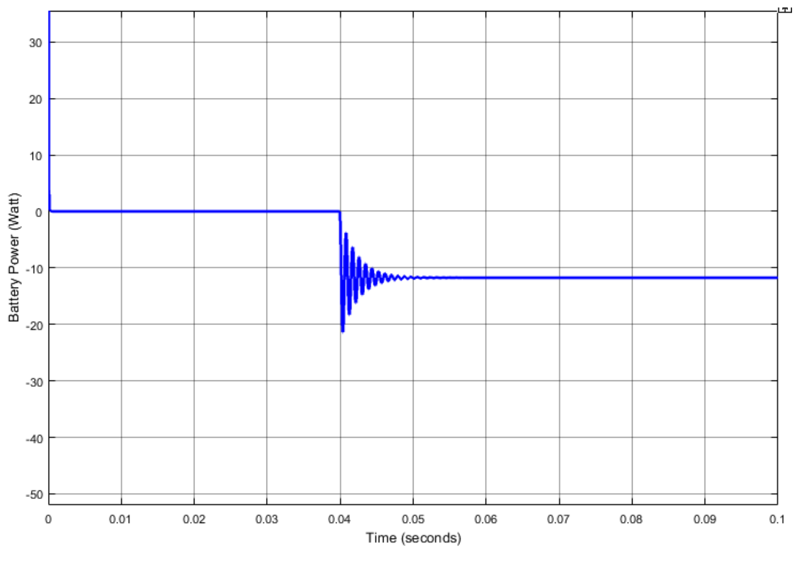

Figure 6: Battery power curve at 1000W/m² irradiance level

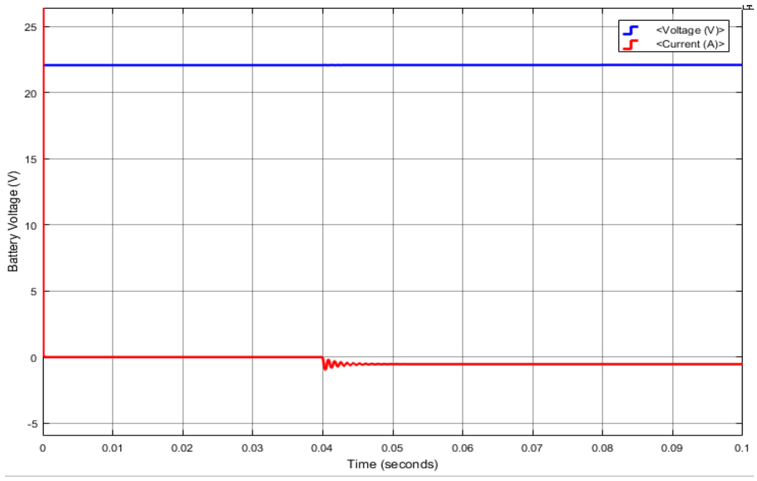

Figure 7: Battery Voltage & Current curve at 1000W/m² irradiance level

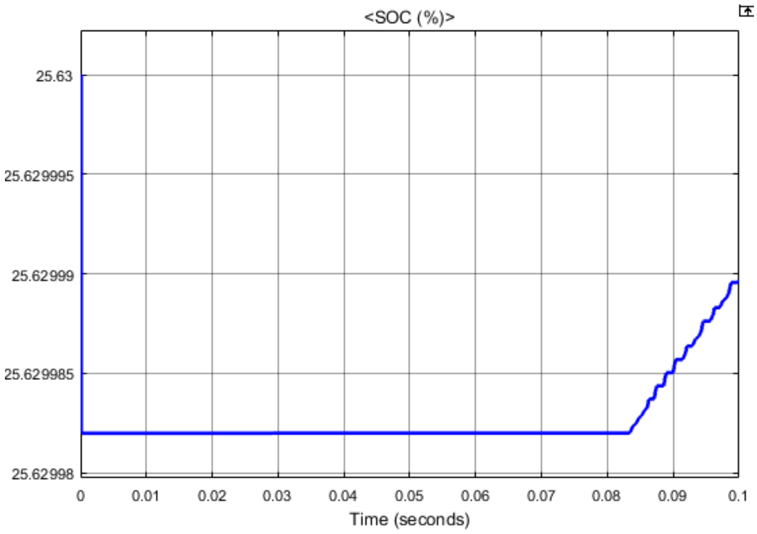

Figure 8: Battery State of Charge (SOC) curve at 1000W/m² irradiance level

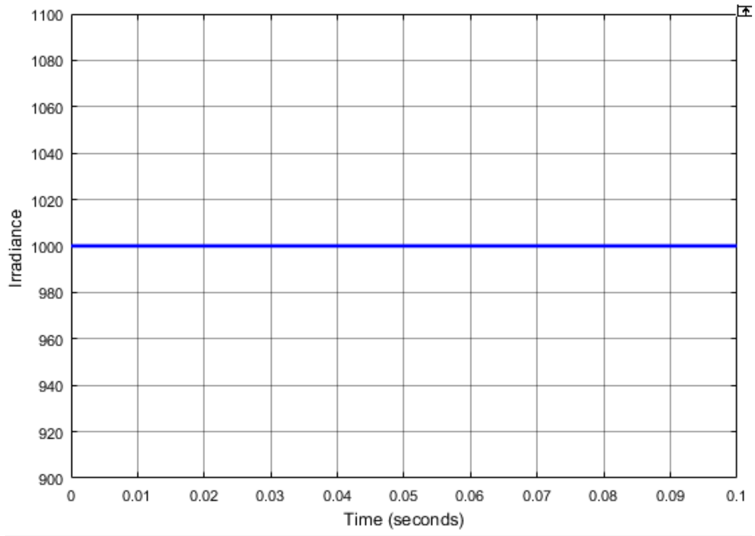

Figure 9: The 1000W/m² irradiance level at the PV module

3.2 Performance of DC-DC Boost Converter and MPPT for battery charging system

The P&O algorithm monitors the maximum power point and keeps the average voltage at the peak point constant. Table 2 shows the battery charging system according to different levels of irradiance at a 25% initial state of charge for a charged battery. Table 3 shows the battery charging system according to different levels of irradiance at 100% state of charge for a fully charged battery. When the irradiance level of 1000W/m², the battery is in 22.08V at 25% initial state of charge and fully charged to a voltage of 26.25V at 100% state of charge. This charging system uses a constant voltage approach, which means that even if the irradiance levels change, the charging voltage will stay constant to prevent overcharging. The only difference is that a negative battery current shows that the battery is charging. As a result, the charging time required by the battery to reach a fully charged state is 18000 seconds or 5 hours.

Table 2: The battery charging system according to different irradiance levels at 25% battery state of charge (SOC)

Irradiance Level (W/m²)	PV Voltage (V)	PV Current (A)	PV Power (W)	Battery Power (W)	Battery Voltage (V)	Charging Current (A)
100	12.82	0.1260	1.616	-0.0005	22.06	-0.000024
500	12.92	0.5966	10.100	-0.1526	22.07	-0.006913
1000	16.90	1.1870	20.050	-2.1670	22.08	-0.098120

Table 3: The battery charging system according to different irradiance levels at 100% battery state of charge (SOC)

Irradiance Level (W/m²)	PV Voltage (V)	PV Current (A)	PV Power (W)	Battery Power (W)	Battery Voltage (V)	Charging Current (A)
100	1.616	0.1260	12.83	-0.0008	26.18	-0.00003
500	10.100	0.5959	16.94	-2.0220	26.20	-0.0772
1000	17.010	1.179	20.06	-5.6010	26.25	-0.2134

4. Conclusion

Overall, in this project, the solar battery charging system design is successfully developed with the help of the MPPT-boost device charge controller. Based on the result analysis, the higher the level of solar irradiation, the greater the output of the PV array, the less the output of the battery with the only difference being that a negative value of the battery current reading indicates that the battery is being charged. Therefore, further research with MPPT using Simulink models by supply solar irradiation and temperature variable inputs can be done to improve the level accuracy data.

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