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ABSTRACT

This article describes a batteries bank that tested under sun irradiance, where this bank play a role of the power source at sunset. The control process of photovoltaic battery charging are given in this work besides. The influence of irradiance on the electrical energy storage in batteries, that used with a PV system. During sunshine hours the power will be given to the load infra carting environment circumstances. This work relies with the demands, vacancies, models and the mechanism of battery protection. The performance of PV regime relies on the battery schema and operating terms. Finally, this article will help to give an notion periphery batteries bank (charging and rating), of PV application. A new control techniques are presented such as maximum power point tracking (MPPT) this techniques have good features and abolition the problems and limitation of the traditional controllers.

Keywords: photovoltaic, boost converter, MPPT, battery charger, sun irradiance.

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Photovoltaic-Battery System Tested Under Sun Irradiance

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I. ABSTRACT

This article describes a batteries bank that tested under sun irradiance, where this bank play a role of the power source at sunset. The control process of photovoltaic battery charging are given in this work besides. The influence of irradiance on the electrical energy storage in batteries, that used with a PV system. During sunshine hours the power will be given to the load infra carting environment circumstances. This work relies with the demands, vacancies, models and the mechanism of battery protection. The performance of PV regime relies on the battery schema and operating terms. Finally, this article will help to give an notion periphery batteries bank (charging and rating), of PV application. A new control techniques are presented such as maximum power point tracking (MPPT) this techniques have good features and abolition the problems and limitation of the traditional controllers.

Keywords: photovoltaic, boost converter, MPPT, battery charger, sun irradiance.

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List of Symbols

PV: Photovoltaic.
I-V: Current-voltage.
P-V: power-voltage.
MPPT: Maximum power point tracing. V_{pv} : Photovoltaic voltage (V).
I_{bat} : Battery charging current (A).
V_{bat} : Battery charging voltage (V).
I_{ph} : Photo generated current (A).
I_D : Diode's dark saturation current (A).
v_L : load voltage (V).
A: Diode ideality factor.
k: Boltzmann's constant (1.3806503×10^{-23} J/K).
$\Delta i_L = inductor\ current\ ripple$.
I_m : Maximum power point current (A).
V_m : Maximum power point voltage (V).
i_C : Boost charging current (A).
I_D: Diode current (A).
Isc: Short circuit current (A).
V_{OC} : Open circuit voltage (V).
P_m : Maximum power (W).
q: Electron charge (1.60217646×10^{-19} C).

T: Temperature of the PN junction (K). G: Irradiation (W/m²).
Rs: Series resistance (Ω).
V: Steady state output voltage (V).
D: Duty Cycle.
T_S: Switching time period (Sec).
Δv = Capacitor voltage ripple.

II. INTRODUCTION

The production of PV systems have hefty outlay and low energy conversion efficiency because of their atom-sphere and non-linear current-voltage (I-V) and power-voltage (P-V) characteristics. The peak amplitude of power variation with respect to the weather conditions and sun ray incident. The operation of (MPPT) must be cursory to handle with the variation of temperature and irradiance [1]. The (MPPT) may change blow-out and quacking with partia shading like clouds, trees and building cover the sun partially. There are two function per obtaining the maximum power locomotion from the PV bank array. The first function is tracing the max. powerpoint very rapid to maintain this point at the (MPPT) always times. The second function is meiosis the battery carting time. Solar cell represents a type of renewable energy for all types of electric power applications.

III. SYSTEM DESCRIPTION AND OPERATION

Figure 1, depicted the serial common: cation, a boost converter, batter bank, micro controller and composed with PV array. The tracking process can be improved by utilizing the new MPPT algorithm controller.

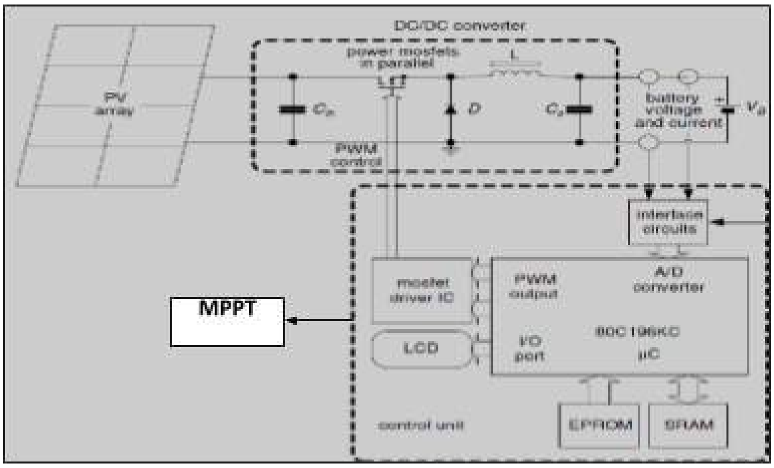


Fig. 1: Block diagram of solar battery charger

3.1 PV panel modeling

PV devices describe a non-linear I-V characteristic, the output current with respect to I_{ph} *and* I_D is given in equation (1). Figure 2, describes the equivalent circuit of a solar cell with a single diode.

$$I = I_{ph} - I_D \left(e^{\frac{V+I\,Rs}{V_t}} - 1\right) \qquad \text{.........(1)}$$

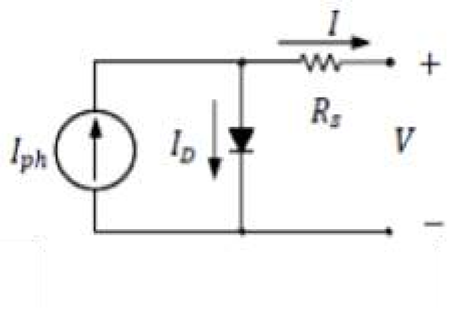


Fig. 2: PV equivaleny model.

3.2 Improving the maximum power point tracking

This way give an algorithm as optimization for data training firstly include some sign up forward out of fact measurements and it burgeons by registration every modern status[3]. Each values contain the maximum power with respect to peak power point, current (I_m) and voltage (V_m).

From MPPT algorithm the process is repeated many times in order to reach the target MPPT. To inspect hundreds of dots in the imitative linear survey ways, only four interactions required to reach the target point. The pulse width modulation signal that generated by the microcontroller is used to control with a duty cycle of the boost converter [4]. The pulse width is scanted according to the vales of system coefficients like, irradiance (G), panel current (I_{pv}), voltage (PV), battery charging current (I_{bat}) and battery voltage (V_{bat}). The software programs of the system includes the (MPPT) algorithm.

The electrical energy that generated from the PV panel depending on the sunlight that applied on this panel. The output voltage varies due to varies the sunlight along the day to acquires a constant or stable voltage for the carry, the energy from PV panel has to be bonding in a battery, which allow absorb by the carry at reasonable fixed voltage. This enable batteries charged from the solar PV panel, which is abstruse by the changing of PV output voltage [5]. A prototypic PV panel generate voltage up to 25V. The battery particular that used in this research are a 12V deep cycle lead-acid that requires 14V from agreeable charge rate. The switching frequency for IGBT is 100KHz, lofty efficiency protection unit, quickly transient response, better reliability, good stability and low cost. Figure 3 represents the MPPT searching.

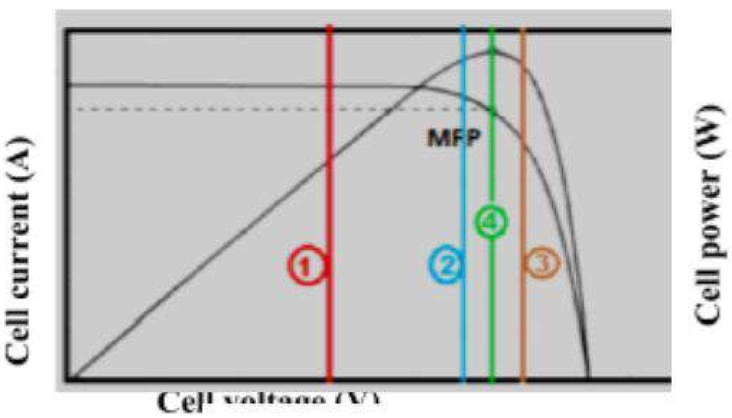


Fig. 3: MPPT searching process.

3.3 Battery charger method

A Lead-acid battery should be charging is fixed current charge, the current applicables the bulky of the charge and takes up circa half of the coveted charge time. Also at a lower charge current the topping charge continues and provides saturation, the float charger indemnify for the loss due to self-discharge [6]. The charging process of lead-acid battery can be illustrated in the figure below.

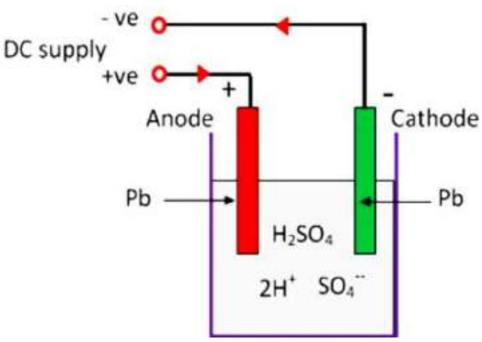
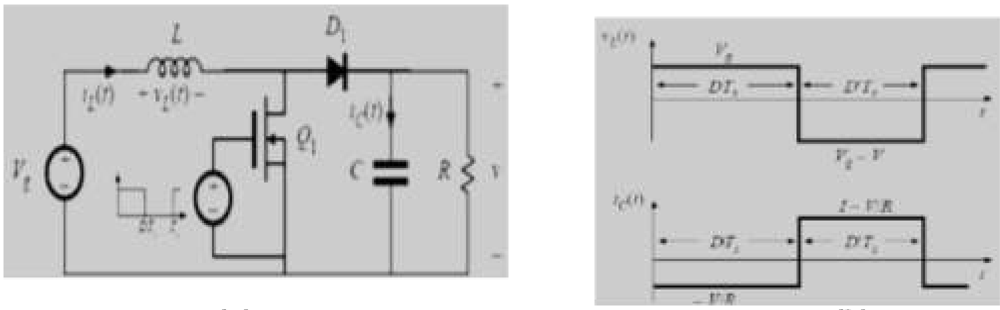


Fig. 4: Battery Charger.

3.4 DC/DC Boost Converter

There are two functions of DC/DC converter one can be used as the step up PV voltage and another can be used as the step down PV voltage. The boost converter circuit with $N_L(t)$ and $i_C(t)$ is given in figure 5.



(a) **(b)**

Fig. 5: DC/DC boost.
(a) Circuit diagram and (b) waves.

The operation mode of boost converter circuit is illustrated by two subintervals:

- *Subinterval 1*

In this case:

Q_1 conducts
D_1 reverse biased
Where,

$$V_L = V_g \quad \text{.........(2)}$$

$$I_C = -v/R \quad \text{.........(3)}$$

Applying a small ripple approximation gives:

$$V_L = V_g \quad \text{.........(4)}$$

$$I_C = -V/R \quad \text{.........(5)}$$

- *Subinterval 2*

In this case:

Q_1 Not conducts

D_1 Conducts

Where,

$$V_L = V_g - v \quad ....(6)$$

$$I_C = i_L - v/R \quad ....(7)$$

Applying a small ripple approximation gives:

$$V_L = V_g - V \quad ....(8)$$

$$I_C = I - V/R \quad ....(9)$$

Combining equations (4), (5), (8) and (9) to give a waveform of V_L(t) and i_C(t).

$$L(t)\,dt = V_g DT_S + (V_g - V)D' T_S = 0 \quad ....(10)$$

$$V = V_g / D' \quad ....(11)$$

$$\left[\frac{di_L(t)}{dt}\right] = \frac{V_L(t)}{L} = \frac{V_g}{L} \quad ....(12)$$

$$dt = DT_S \text{ and } di_L(t) = 2\Delta i_L \quad ....(13)$$

$$\left[\frac{dV_C(t)}{dt}\right] = \frac{i_C(t)}{C} = -\frac{V}{RC} \quad ....(14)$$

The parameters of best elements are given in table 1.

Table 1: Boost Converter Parameters.

Parameter	Value
Pulse width	ON-time
Period	$1e^{-5}$ s
Inductance	$1000e^{-6}$ H
Capacitance	$2000e^{-4}$ F

3.5 Battery

12 V lead-acid battery are used in the batter model bin. The battery parameters that used in this simmlion are give in table 2.

Table 2: Battery Parameters.

Parameter	Value
Par Voltage	12V
Standardized Capacity	5.5 Ah
Fully Fraugh Voltage	14V
Par Current	1.5 A

3.6 System software

The software program is depended on new MPPT tracking techniques, the PID controller and charging algorithm. The flow chart of the program is illustrated in figure (6). The parameters of the system are initialized then the corer loop program is begin the sensors are scanned and making updating for system variable and check it with any variation in the irradiance [6]. In each loop, it searches about the learning data base that must be nearest the maximum MPPT values of current, voltage and power.

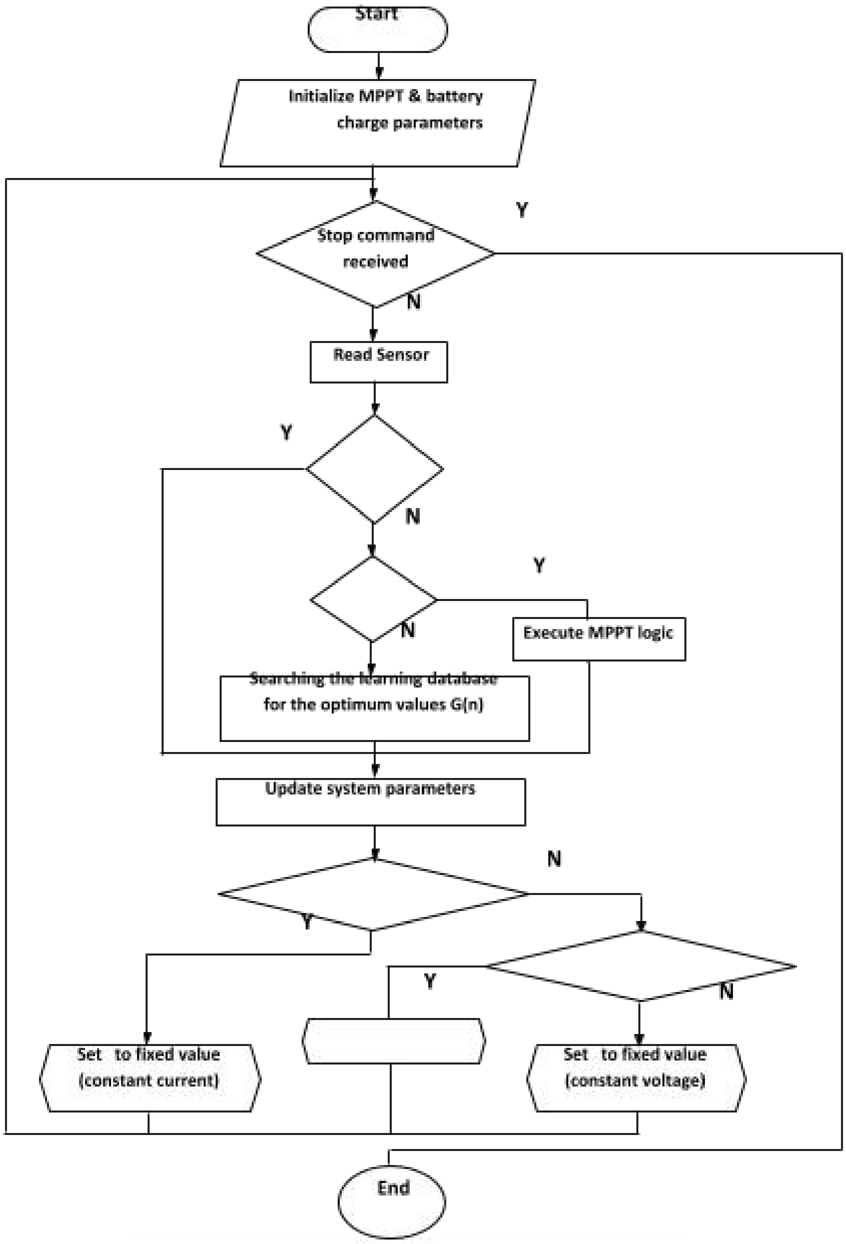


Fig. 6: Flowchart steps for battery charger

In each loop, it inspects the battery potential and prescribe to the level of charging. If battery potential does not arrive the reference voltage, then the constant value of current can be charge the mode then, system parameters are updating accordingly and the algorithm steps is repeated in each scan cycle.

IV. MODELING OF THE SOLAR BATTERY UNIT

The simulation circuit solar deep cycle batteries charging process gives in figure 7.

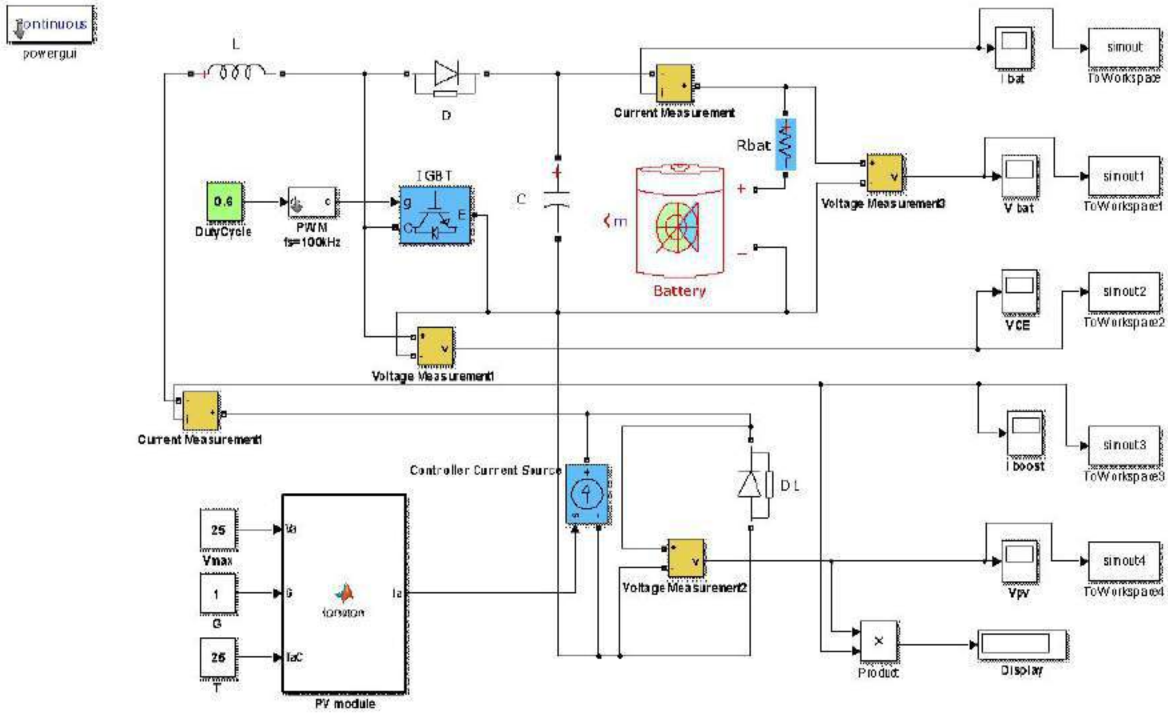
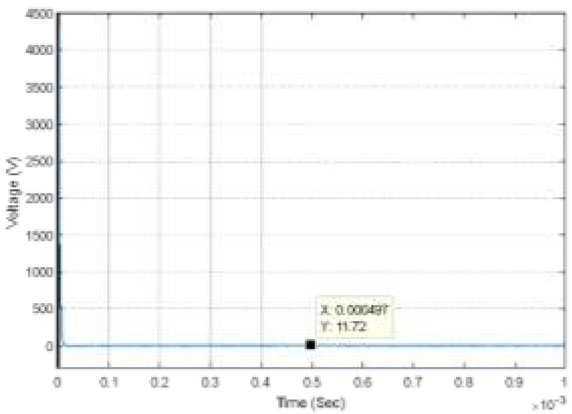


Fig. 7: Battery charger modelling.

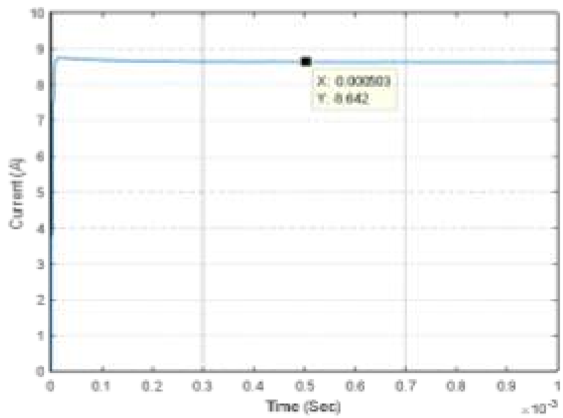
V. SIMULATION RESULTS

5.1 Mode 1

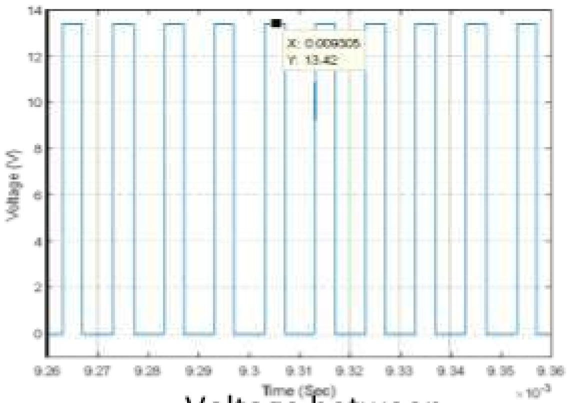
The simulation results that obtained from battery charger circuit at duty cycle (0.4) are given in the figure below.



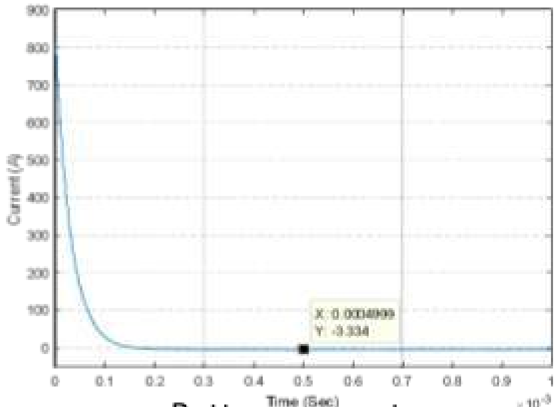
- PV voltage vs time.



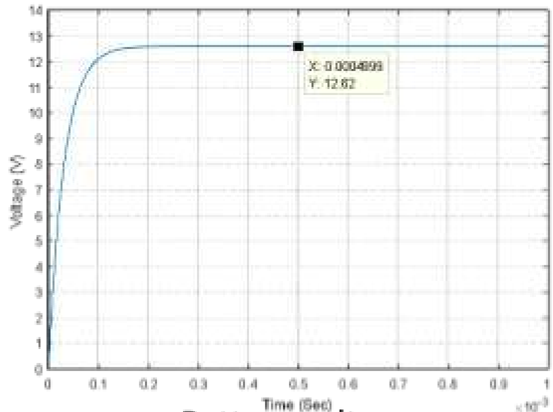
- Boost current vs time.



- Voltage between Collector-Emitter.



- Battery current vs time.

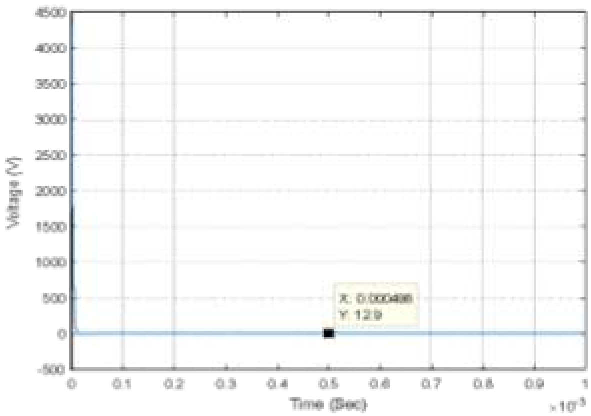


- Battery voltage vs time.

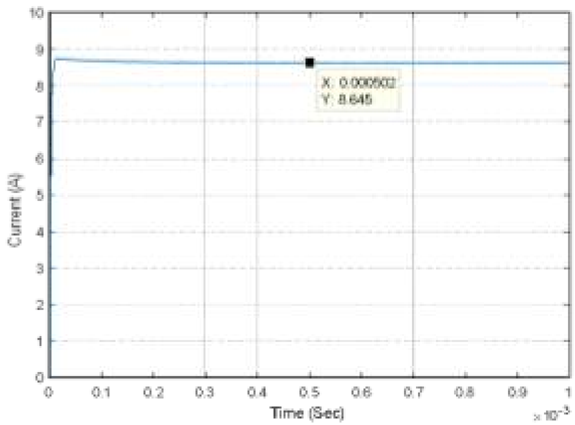
Fig. 8: Simulations results at a duty cycle (0.4)

5.2 Mode 2

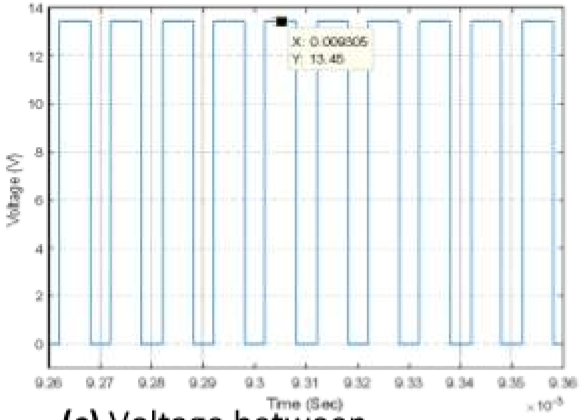
The simulation results that obtained from battery charger circuit at a duty cycle (0.6) are given in the figure below.



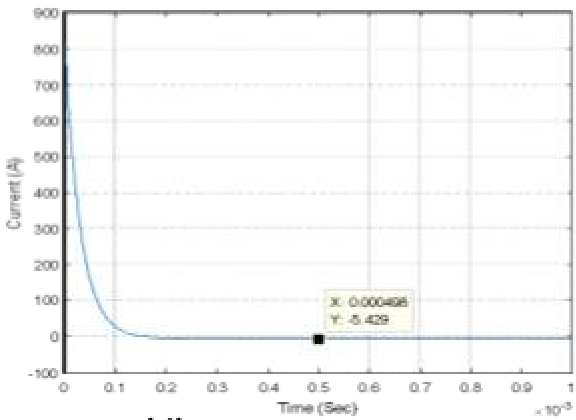
(a) PV voltage vs time.



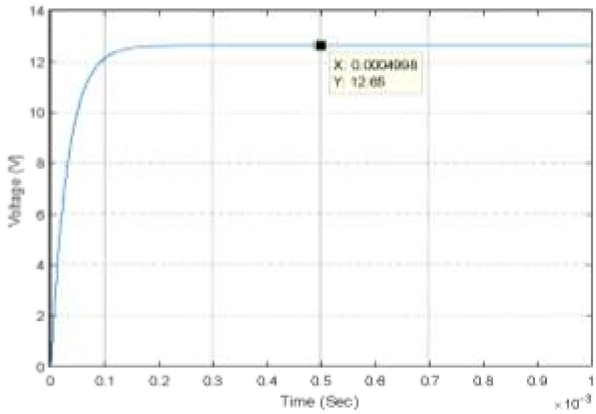
(b) Boost current vs time.



(c) Voltage between Collector-Emitter.



(d) Battery current vs time.

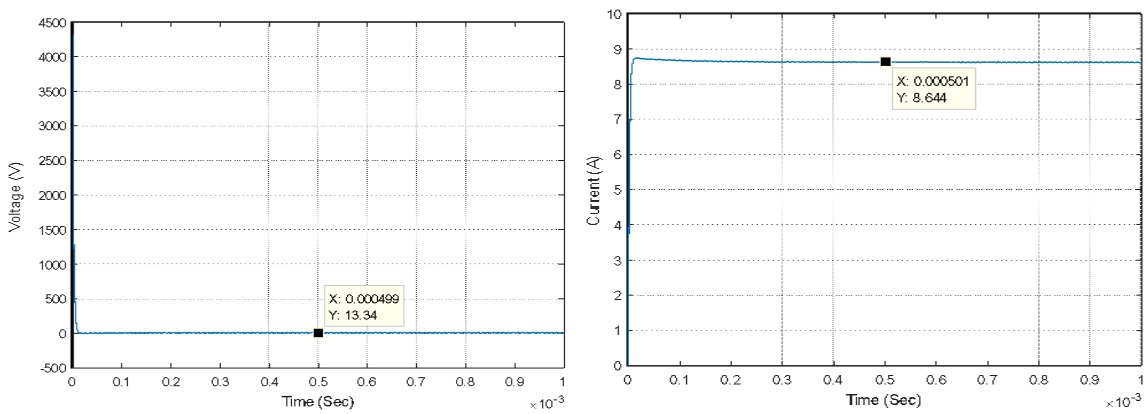


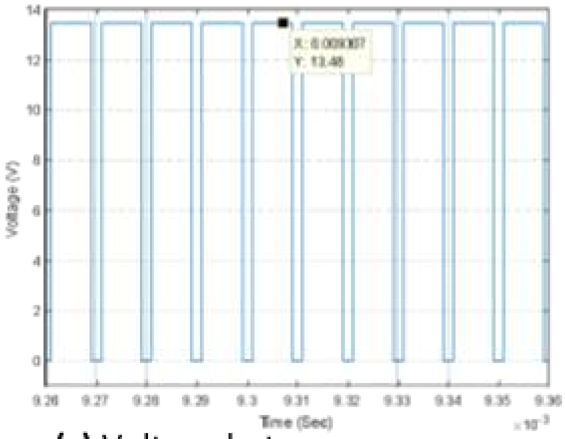
(e) Battery voltage vs time.

Fig. 9: Simulations results at duty cycle = 0.6

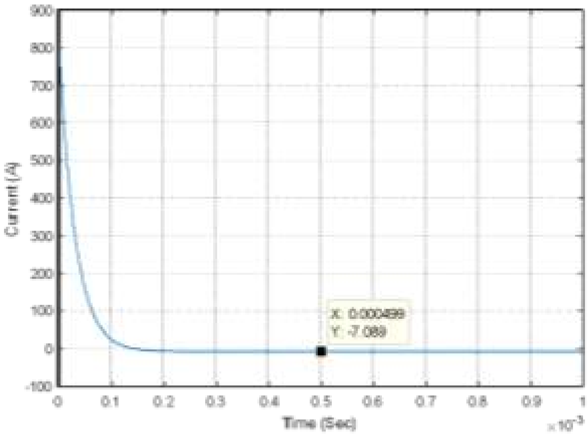
5.3 Mode 3

The simulation results that obtained from battery charger circuit at a duty cycle (0.8) are given in the figure below.

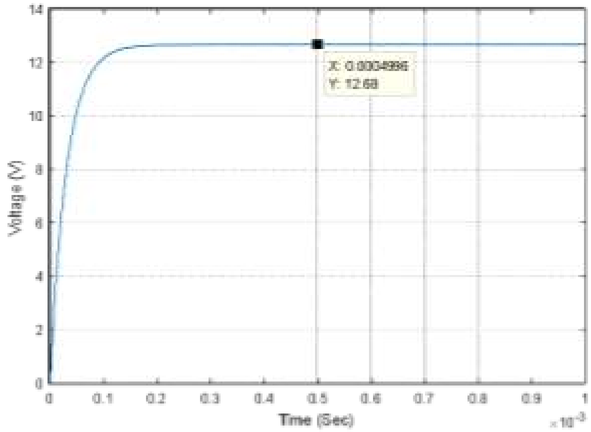




(c) Voltage between Collector-Emitter.



(d) Battery current vs time.



(e) Battery voltage vs time.

Fig. 10: Simulations results at duty cycle (0.8)

The output battery voltages with respect to variable duty cycle are given in the table below.

Table 4: Relationship between duty cycle and battery voltage.

Duty cycle (D) (%)	Battery voltage (V)
0.4	12.62
0.6	12.65
0.8	12.68

VI. CONCLUSION

The PV voltage is increased as sunlight (irradiance) increased. The voltage battery is increased as a duty cycle increased. The overall cost of a stand-alone PV system can be reduced with proper battery-charging control techniques, which achieve high battery state of charge and life time. The MPPT techniques employed in the control algorithm assures maximization of the energy transferred to the batteries bank.

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