ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

Literature Review on Design of MPPT Based Stand-Alone Solar PV System for Small Load Applications

Amruta Fulzele[1], Prashant Meshram[2]

Dept. of Electrical Engg., Dr. Babasaheb Ambedkar College of Engg. & Research, Nagpur, India [1-2]

ABSTRACT: The Renewable energy is important part of power generation system due to diminution of fossils fuel. Energy production from photovoltaic (PV) is widely accepted as it is clean, available in abundance, & free of cost.
This project deals with modeling of Stand-alone PV system for operating the load. This model consists of photo-voltaic PV module, DC to DC Buck converter and Boost converter, MPPT Controller, Battery Storage, and Load. MPPT controller operates on adjusting the voltage power and tracks the maximum power at certain point. The one of the DC to DC converter used in this project is buck converter which produce an output voltage lower than the input source voltage which the voltage is used to charge the battery and the other converter is Boost converter is used to step-up the voltage and will give output voltage to operate the load.Here the battery is interlinked between buck and boost converter to operate as when system is under normal-load i.e., less than full-load where the power used to charge by 30-40 % of input power entering battery and if the load requirement is more the battery will compensate power. To track maximum power point (MPPT) Perturb & Observe (P & O) algorithm is used which periodically perturbs the array voltage and compare PV output power with that of previous perturbation cycle which controls duty cycle of DC-DC Buck converter and Boost converter will be operate by internal pulse generator. The main objective of this model is that by working as a stand-alone PV- system absence of connecting grid, we want to operate the normal household loads like lights, fans, street lights, traffic signals in remote area where transmission of power from grid is not feasible like toll-gates, forest check-posts, hill stations etc. The performance of the proposed model and achievement of desired compensation are confirmed by the results of the simulation using MATLAB/Simulink.

KEYWORDS: PV cells, PV array, MPPT, dc-dc converter.

I. INTRODUCTION

It's certainly clear that fossil fuels are mangling the climate and that the status quo is unsustainable. There is now a broad scientific consensus that the world needs to reduce greenhouse gas emissions more than 25 percent by 2020 and more than 80 percent by 2050.

Renewable energy is the energy which comes from natural resources such as sunlight, wind, rain, tides and geothermal heat. These resources are renewable and can be naturally replenished. Therefore, for all practical purposes, these resources can be considered to be inexhaustible, unlike dwindling conventional fossil fuels. The global energy crunch has provided a renewed impetus to the growth and development of Clean and Renewable Energy sources. Clean Development Mechanisms (CDMs) are being adopted by organizations all across the globe. Apart from the rapidly decreasing reserves of fossil fuels in the world, another major factor working against fossil fuels is the pollution associated with their combustion. Contrastingly, renewable energy sources are known to be much cleaner and produce energy without the harmful effects of pollution unlike their conventional counterparts.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

II. PHOTO VOLTAIC MODULE

In solar power generation system number of solar cells is required to produce high power so they are connected in form of Solar Module or Solar panel and for higher capability form Array.

A solar panel or module is a group of connected solar photovoltaic cells electrically and mounted on a sustaining structure. A photovoltaic module is a systematical arranged series connection of solar cells.

A solar array is a group of solar photovoltaic panels or modules connected electrically together and mounted on a sustainable structure to produce higher amount of power. For this project the main task is to design a stand-alone power generation system for a small load like a house situated on hilly area or for any small load that is not connected to grid network. For this kind of loads design such a system that uses the power generated from PV Array and convert it into AC for AC loads or stores it in storage element with efficiently and paralleling supplies the load [9].

III. BLOCK DIAGRAM OF PROPOSED MODEL

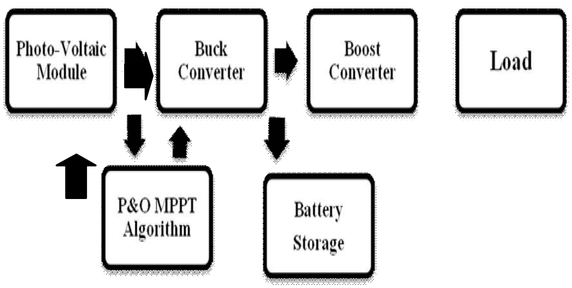


FIG.1 Block diagram of Proposed Model

The above schematic presents the configuration used in this project. Here PV module of maximum rating 8.5V, 0.35A and 3Wp is used as source. The MPPT algorithm is used for extracting the maximum power from solar PV module and extracted power is supplied to load. Here two stages of conversion is implemented one is step-down and another one is step-up, why we are using two stages of conversion is that by step-down the input we charge a lead-acid Battery which is used to charge under normal load conditions and to compensate the power when output load requires more power.

IV. MODELING OF PHOTO-VOLTAIC MODULE IN MATLAB

Typically a solar cell can be modeled by a current source and an inverted diode connected in parallel to it. It has its own series and parallel resistance. Series resistance is due to hindrance in the path of flow of electrons from n to p junction and parallel resistance is due to the leakage current.

When irradiance hits the surface of solar PV cell, an electrical field is generated inside the cell as shown in the figure this process separates positive and negative charge carriers in an absorbing material (joining p-type and n-type). In the presence of an electric field, these charges can produce a current that can be used in an external circuit. This generated current depends on the intensity of the incident radiation. The higher the level of light intensity, the more electrons can be unleashed from the surface, the more current is generated.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

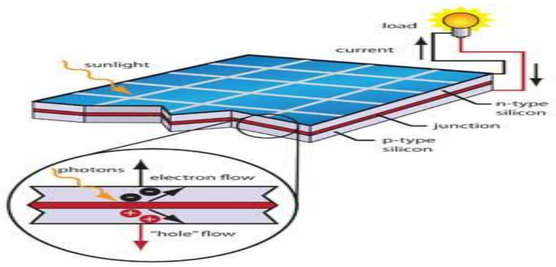


Fig 2: Photo-voltaic effect and current generation

The most important component that affects the accuracy of the simulation is the PV cell model. Modeling of PV cell involves the estimation of the I-V and P-V characteristics curves to emulate the real cell under various environmental conditions. An ideal solar cell is modeled by a current source in parallel with a diode. However no solar cell is ideal and thereby shunt and series resistances are added to the model as shown in the Figure.

Ideal diode equation describes the operation of the solar PV cell. Sun light exposure of a solar PV cell results in the creation of an electric current.

$$I_d = I_{o,cell}\left[exp\left(\frac{qV}{aKT}\right) - 1\right] \quad (1)$$

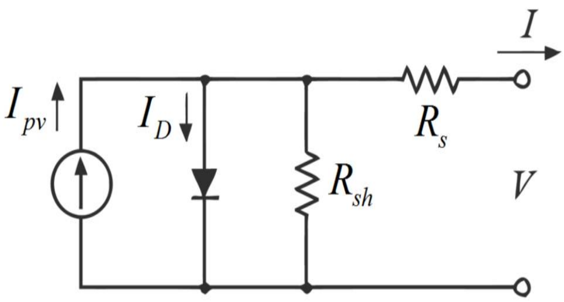


Fig 3: Equivalent Circuit for Photo-Voltaic Module

The basic equation from the system that mathematical the ideal photovoltaic cell is

$$I = I_{pv,cell} - I_d \quad (2)$$

$$I = I_{pv,cell} - I_{o,cell}\left[\exp\left(\frac{qV}{aKT}\right) - 1\right] \quad (3)$$

Where,

$I_{pv,cell}$ is current generated by incident light [A]

$I_{o,cell}$ is reverse saturation current diode [A]

q is the electron charge [1.60217646 x 10-19C]

k is the Boltzmann constant [1.3806503 x 10-23 J/K]

T is the temperature of the p-n junction [K] and

a is the diode ideality constant ($1 \leq a \leq 1.5$)

In practical devices, PV cell have parameters like parasitic series resistance (Rs) and parasitic shunt resistance (Rp). Rs represent the resistance of the semiconductor material and Rp accounts for the loss caused by a slight leakage current which penetrates through the parallel resistive path to the device.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

Practical arrays are composed of several photovoltaic cells that are connected in series and parallel. Cells connected in parallel increase the output current and cells connected in series provide greater output voltages. The observation of the characteristics at the terminals of the photovoltaic array requires additional parameters to the basic equation. So it can be expressed as

$$I = I_{pv} - I_o \left[\exp\left(\frac{V+R_s I}{V_t a}\right) - 1\right] - \frac{V+R_s}{R_p} \quad (4)$$

The I-V characteristic of the photovoltaic device depends on the internal characteristics of the device (Rs, Rp) and on external influences such as irradiation level and temperature. It can be expressed in (5):

$$I_{pv} = \left(I_{pv,n} + K_I \Delta T\right)\left(\frac{G}{G_n}\right) \quad (5)$$

Where,

Ipv is the light-generated current at the nominal condition (Usually 25 C and 1000 W/m2)

$$\Delta T = T - T_n$$

(T and Tn the actual and nominal temperatures [K})

G is the irradiation on the device surface [W/m2], and

Gn is the normal irradiation [W/m2].

It is difficult to determine the light-generated current (Ipv) of the elementary cells without the influence of the series and parallel resistances. The diode saturation current I0 to improve photovoltaic model is described by:

$$I_o = (I_{sc,n} + K_I \Delta T)/(\exp\left((V_{oc,n} + K_V \Delta T)/a V_{t,n}\right) - 1) \quad (6)$$

The saturation current Io is strongly dependent on the temperature. Current and voltage coefficients KI and KV in (6) are introduced to achieve the best possible I-V curve fitting for different nominal temperatures. This equation simplifies the model and minimizes the model error.

V. MAXIMUM POWER POINT TRACKING

A typical solar panel converts only 30 to 40 percent of the incident solarirradiation into electrical energy. Maximum power point tracking technique is usedto improve the efficiency of the solar panel. The efficiency of a solar cell is very low and also when solar cells are connected together to form a panel then its efficiency is still not increased. In order to increase the efficiency (η) of solar cell or solar panel we have to use maximum power transfer theorem.

The maximum power transfer theorem says that the maximum power is transfer when the output resistance of source matches with the load resistance i.e. solar cell or solar panel impedance. So all MPPT technique's principles are based on maximum power transfer theorem that always trying to matching the impedance of load to source. The maximum power point tracking (MPPT) is now habitual in grid-connected PV power generation system and it is becoming more popular in isolated or stand-alone power generation systems as well because of the V-I characteristics in PV power generation systems is nonlinear, So it is difficult to supply a constant power to a certain load. the MPPT is an electronic device that extracts maximum possible power from solar panel. A solar panel generates power by using the photovoltaic effect then obvious a solar panel has a P-V characteristic that means for a different operating point of the solar panel, a different power output can be achieved. Therefore the maximumpossible power is obtain from the solar panel when it operates at only for one specific operating point of the P-V characteristic of solar panel. This point in the P-V characteristic is called the Maximum Power Point (MPP). This MPP changes when the solar irradiation changes or temperature changes or when the solar panel is partially shaded. So when these three factor changes, the solar panel operating point is also changes. To track that constantly changing MPP a device is needed called Maximum Power

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

Point Tracker (MPPT). In PV power generation system MPPT performs a very important role thatit extracts maximum possible power from panel by varying the duty cycle of DC/DC converter and that duty cycle is controlled by different MPPT techniques and its algorithms. Some are listed.

- Open Circuit Voltage
- Perturb and Observe
- Incremental Conductance
- Intelligence MPPT Techniques
- Fuzzy Logic Based
- Artificial Neural Network Based

In this project very famous Perturb and Observe is chosen by considering the above features of MPPT techniques specially simplicity, number of sensors required and cost effective.

Perturb and Observe

The Perturb and Observe (P&O) technique is also known as “Hill Climbing” method. It is most popular and commonly used. The faction of basic form of P and O algorithm is as follows. In figure a PV panel's output power curve as a function of voltage (P-V characteristics) is shown in figure.

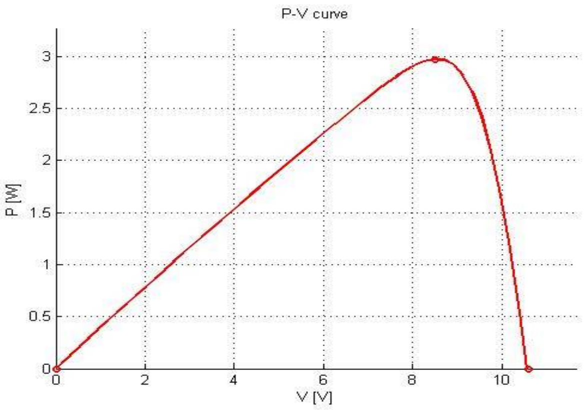


Fig 4: Power vs. Voltage Curve of Panel PV module

(1KW/$m2$, 25oC)

At a constant irradiance and constant temperature on PV panel assuming the PV panel is operating at a point which is away from the maximum power point. In this algorithm first PV panel terminal voltage and current are measured and corresponding power P(k-1) is calculated after that small increment on operating voltage or in duty cycle of the dc/dc converter in one direction is perturbed and hence the corresponding power P(k) is calculated. By comparing P(k-1) and P(k), ΔP is calculated. If ΔP is positive then the perturbation is directed in the correct direction and it is moving the operating point nearer to the MPP. Then further voltage perturbations or i.e. duty cycle perturbations in the same direction will move the operating point toward the MPP; if ΔP is negative then perturbation direction should be reversed. In this way the maximum power point is recognized.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

VI. OPERATION OF BUCK CONVERTER:

The operation of the buck converter is simple, with an inductor and two switches (usually a MOSFET and a diode) that control the inductor. It alternates between connecting the inductor to source voltage to store energy in the inductor and discharging the inductor into the load.

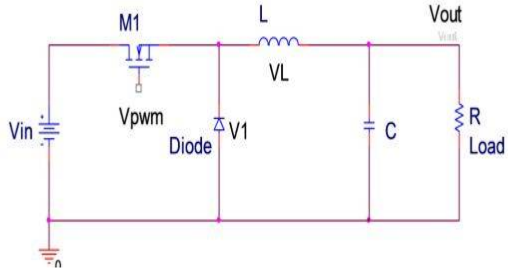


Fig: 5 Buck Converter Operation

Figure shows the circuit diagram of a Buck-converter. The MOSFET M1 operates as the switch, which is turned on and off by a pulse width modulated (PWM) control voltage VPWM. The ratio of the on time (ton) when the switch is closed to the entire switching period (Tsw) is defined as the duty cycle.

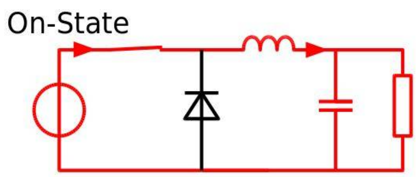


Fig 6: when the switch is closed

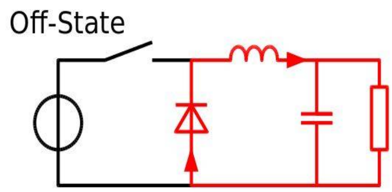


Fig7: when the switch is open

The equivalent circuit in on-state Figure is valid when the switch is closed. The diode is reverse biased, and the input voltage supplies energy to the inductor, capacitor and the load. When the switch is open as shown in Off-Figure the diode conducts and the capacitor supplies energy to the load, and the inductor current flows through the capacitor and the diode. The output voltage is controlled by varying the duty cycle. In steady state, the ratio of output voltage to the input voltage is "D", given by Vout/ Vin.

VII. OPERATION OF BOOST CONVERTER:

Here the boost converter is designed to step up a Constant or variable input voltage to a constant output voltage of 19-25v with input range of 3.5-5.5v. The 4V input voltage is from the battery storage equipment and the 24V output

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

voltage serves as to run a load like a LED light or motor fan. In designing process, the switching frequency, f is set at 20 kHz and the duty cycle, D is 75%.

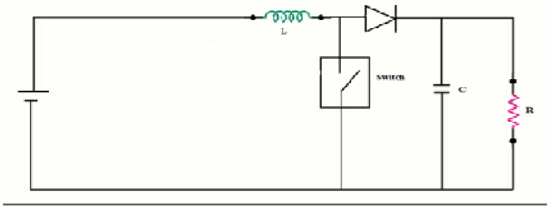


Fig 8: Boost converter Diagram

MODE 1: OPERATION OF THE BOOST CONVERTER

When the switch is closed the inductor gets charged through the battery and stores the energy. In this mode inductor current rises (exponentially) but for simplicity we assume that the charging and the discharging of the inductor are linear. The diode blocks the current flowing and so the load current remains constant which is being supplied due to the discharging of the capacitor.

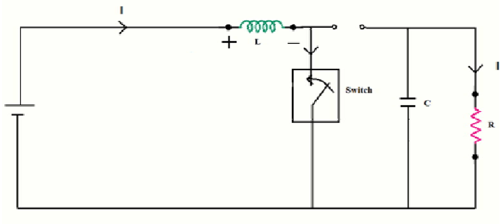


Fig 9: Boost Converter ON-State

MODE 2: OPERATION OF THE BOOST CONVERTER

In mode 2 the switch is open and so the diode becomes short circuited. The energy stored in the inductor gets discharged through opposite polarities which charge the capacitor. The load current remains constant throughout the operation. The waveform for a boost converter is shown in figure.

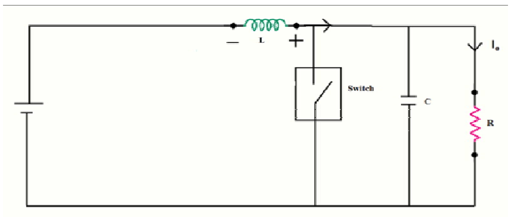


Fig 10:Boost Converter OFF-State

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

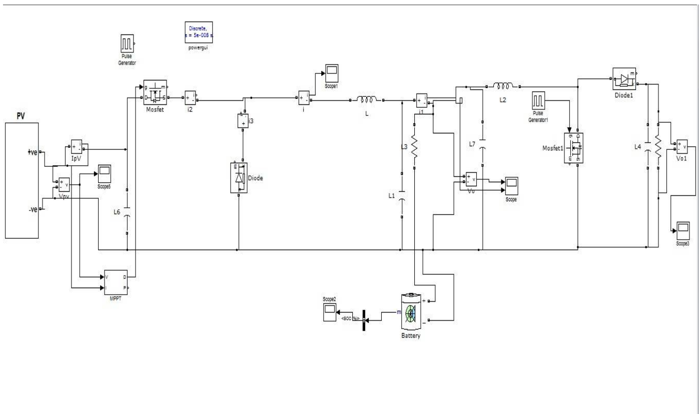
International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

VIII. SIMULINK MODEL



IX. SIMULATION RESULTS

The Simulation of PV module of maximum rating 8.5V, 0.35A and 3Wp is carried out for 1Watt load in MATLAB/Simulink.

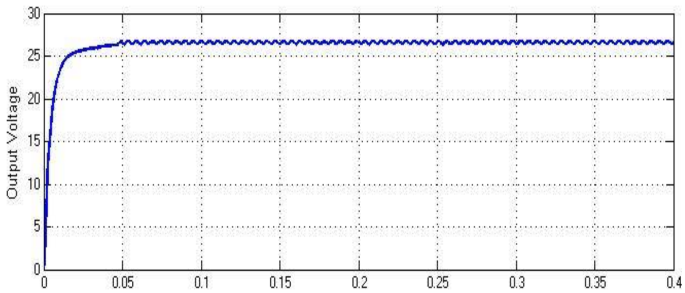


Fig 11:. Output Voltage of Proposed Model

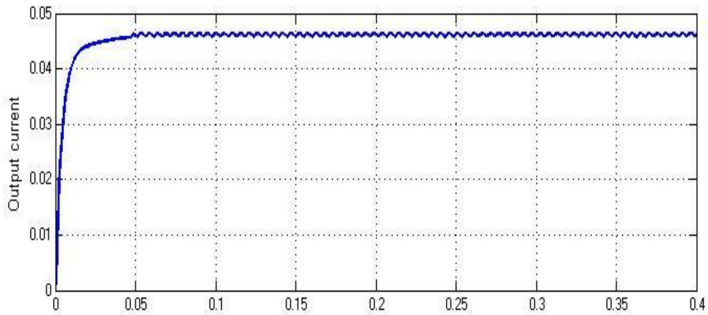


Fig 12:. Output Current of Proposed Model

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

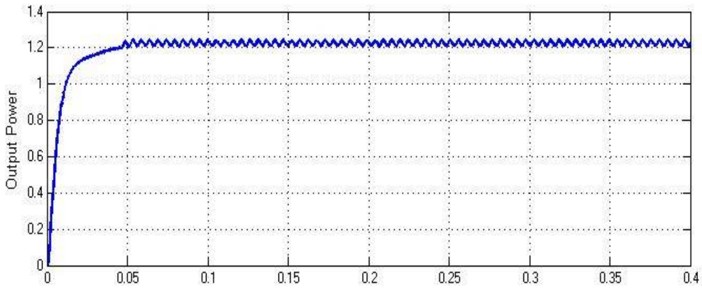


Fig 13: Output Power of Proposed Model

X. COMPARISONS OF OUTPUT SIMULATION WAVEFORMS FOR OUTPUT LOAD CHANGE

Load at 1W

Voltages of Solar input, Buck converter and Boost Converter

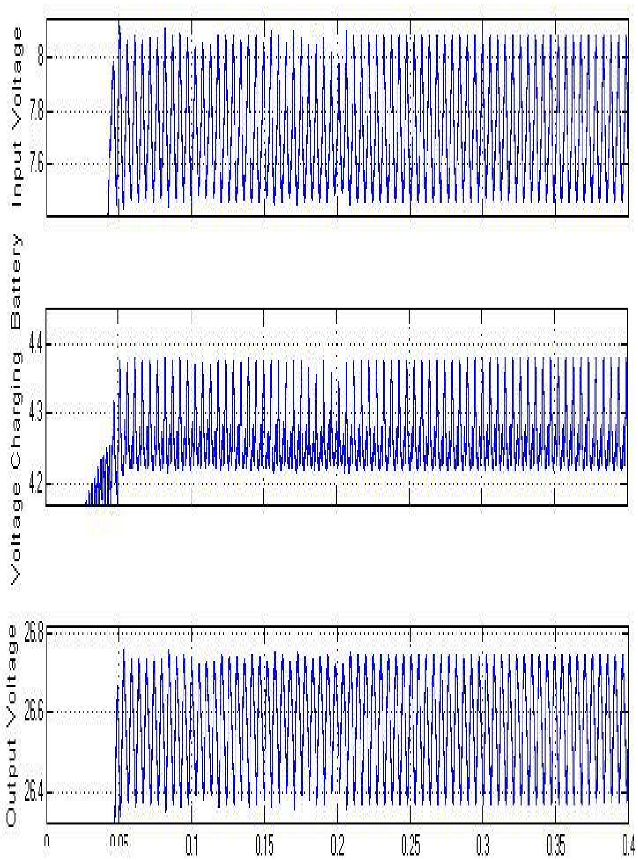


Fig: 14 Output Voltages of operating 1W Load

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

Currents of Solar input, Buck converter and Boost Converter

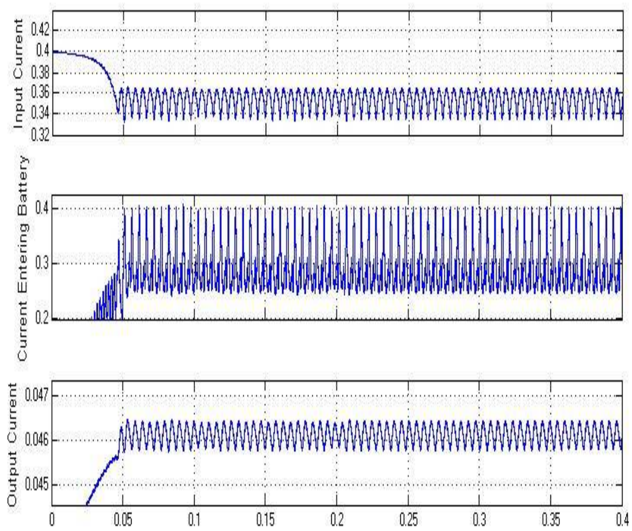


Fig: 15 Output Current of operating 1W Load

Powers of Solar input, Buck converter and Boost Converter

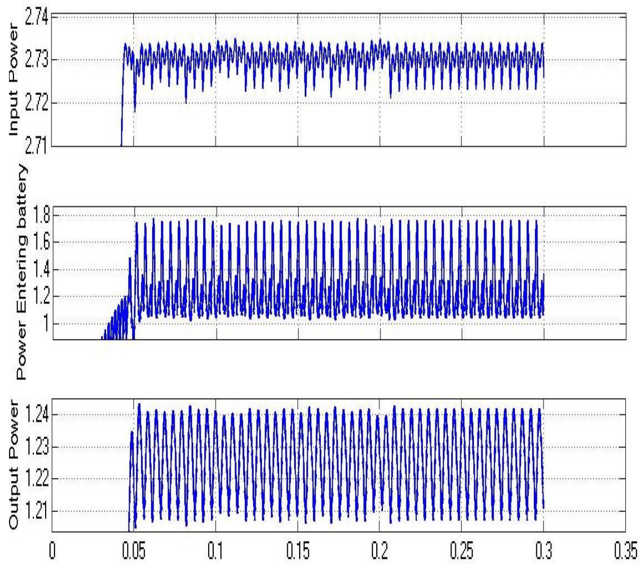


Fig: 16 Output Powers of operating 1W Load

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

Load at 4W

Voltages of Solar input, Buck converter and Boost Converter

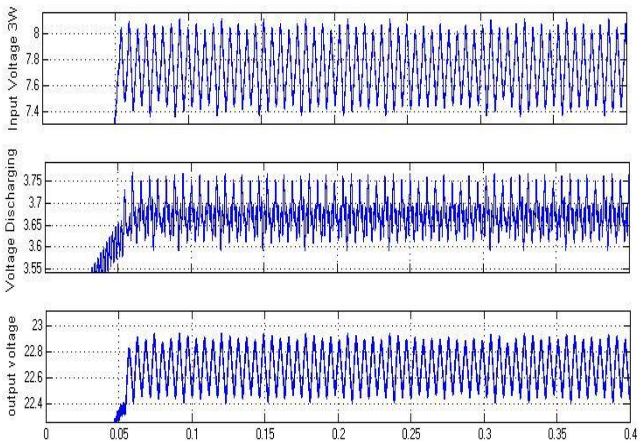


Fig: 17 Output Voltages of operating 4W Load

Current of Solar input, Buck converter and Boost Converter

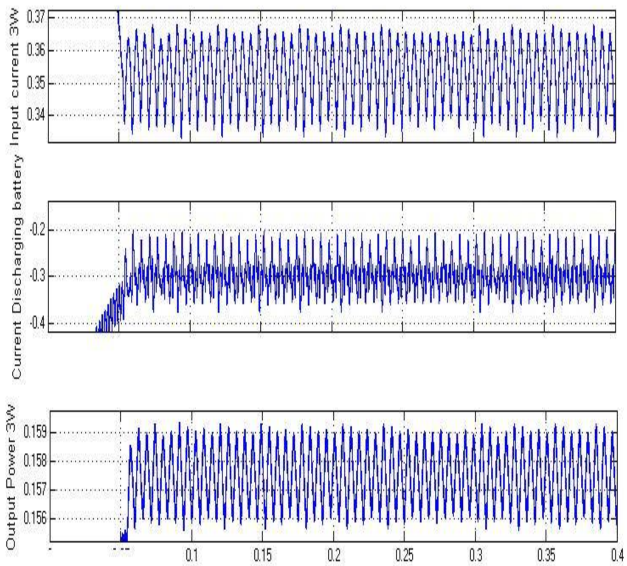


Fig:18 Output Currents of operating 4W Load

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

Power of Solar input, Buck converter and Boost Converter

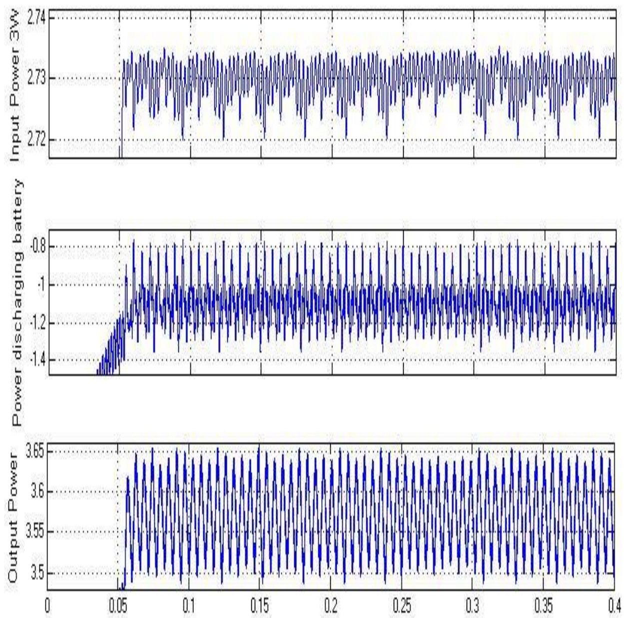


Fig: 19 Output Powers of operating 4W Load

Comparison of parameters at 1W and 4W

Connected Load	Voltage	Current	Power	Battery status
1 Watt	24.7 V	0.05 A	1.5 W	Charging
3 Watt	22.12 V	0.15 A	3.95 W	Discharging

Table 1: Comparison of parameters with load change

XI. CONCLUSION

Here we used mathematical model of Stand-alone PV system for operating the load in simulation and 8.5V, 3W solar PV- panel is used in hardware implementation. The main objective this project is to reduce the rating of the components utilized in PV-system. In this project it is shown that as it been used as stand-alone system as there are several model in market where PV-system will come with a battery storage but as the load demand increases proportionally the storage equipment rating and cost also increased. So this project shows that without changing the rating of storage equipment we are implemented two stages of conversion. Here the load demand increases we increase the input PV-module rating but the storage is kept constant. If there is any fault occurs in the battery storage for higher rating equipment replacement we have to disconnect entire PV-system, but in this projectit shows that in place of higher rating storage equipment by using smaller rating storage we can easily replace them and if storage demand increase we

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

can connect them in parallel with the existing storage equipment.

REFERENCES

1. Rabeb Abid ,Ferdaous Masmoudi,Fatma Ben Salem,and Nabil Derbel , “Design and realization of photovoltaic system controlled by MPPT algorithm,” IEEE Trans. On STA Dec. 2015-PID3718-REC,21-23 Dec 2013,pp 664-671.
2. Ahmed M Atallah ,Almoataz Y Abdelaziz,and Rahian S Jumah, “Implementation of P&O MPPT of PV System with Direct Control Method using Buck & Buck-Boost Converters,” EEIEJ Trans.Vol.1 Feb.2014.,pp31-43
3. Rakesh Singh and Mouni Pandit, “Analysis of PV cells with closed loop Boost Converter”, IJAET trans. Vol.6 Issue 1,Mar 2013, pp304-315
4. Mahesh Gowda N M,Yadu Kiran,Dr S S Parthasarthy, “Modelling of Buck DC-Dc converter using Simulink”,IJIRSET trans. Vol.3,Issue 7 ,July 2014,pp 14965-75.
5. Williams K.Francis,Prof.Shanifa Beevi S,Prof.Johnson Mathew , “MATLAB/SIMULINK PV Module Model of P&O and DC Link CDC MPPT Algorithm with Labview Real Time Monitoring and Control Overr P&O Technique.” IJAREEIE Trans Vol.3 Spl.Issue.5 Dec 2014,pp92-101.
6. R Prakash ,B Meenakshipriya,R Kumaravalen, “Modelling and design of MPPT controller using stepped P&O Algorithm in Solar PV system,” IJECEECE Trans.Vol.8,no.3,.2014,pp 602-608.