COMPARISON OF PERTURB AND OBSERVE MPPT FOR PV SYSTEMS CONJUCTION WITH BUCK BUCK-BOOST CONVERTERS

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ABSTRACT :
To extract maximum energy from the photovoltaic(PV) systems maximum power point tracking (mppt)technique in conjunction with power electronic circuits is used .Because of low maintenance, suitable for all climates and wide power range photovoltaic power generation has become more important, main disadvantages in PV systems are high initial cost and low energy conversion efficiency .To improve energy efficiency it is required to run PV system always at maximum power point .so ,far different methods are proposed by researchers for extracting maximum power. This paper presents detail implementation of perturb and observe mppt using buck and buck –boost converters. Some results such as current voltage output power for each various combinations have been recorded. From the results it is observed that perturb and observe mppt conjunction with buck converter has less power loss from panel side to converter side out of all other converters . The simulation has been accomplished in software MATLAB math work

INDEX TERMS: *Maximum Power Point Tracking, Perturb and Observe, DC-DC Converters, Photovoltaic System*

1. Introduction

The use of advanced efficient photovoltaic solar cells (PVSCs) has featured as a better alternative of energy conservation, renewable power and demand-side management. Due to their initial high cost, PVSCs have not yet been an exactly a tempting alternative for electrical usage who are able to buy less expensive electrical energy from the utility grid. However ,they have been used widely for air conditioning in remote , water pumping and isolated or remote areas where utility power is not available or is high costly to transport. Although PVSC prices have decreased considerably during the last years due to new developments in the film technology and manufacturing process [1]. The harnessing of solar energy using PV modules comes with its own problems that arise from the change in insolation conditions. Those changes in insolation conditions strongly influence the efficiency and output power of the PV modules. A great research has been accomplished to improve the efficiency of the photovoltaic system. Different methods to track the maximum power point of a PV module have been suggested to solve the problem of efficiency and products using these methods have been made and now commercially available for consumers [2-3]

As the species of these MPPT flooded into the market that are intentional to improve the efficiency of PV modules under varying isolation conditions it is not known how many of these can actually provide on their promise under a diversity of field conditions. This research then seems at how a different kind of converter affects the output power of the module and also achieve if the MPPT that are said to be highly efficient and do track the true maximum power point under the different conditions. A maximum power point tracker is used for obtaining the maximum power from the solar PV module and conversion to the load. A non isolated DC-DC converter (step up/ step down) offers the purpose of conversion maximum power to the load. A DC-DC converter acts as an interface between the load and the module. By varying the ratio of duty cycle the impedance of load as it appears by the source is varied and matched at the peak power point with the source so as to conversion the maximum power [4-5].Therefore maximum power point tracker methods are required to maintain the PV module working at its MPP. Many MPPT methods have been suggested in the literature ; example are the Perturb and Observe (P&O) methods, Incremental Conductance (IC) methods and constant voltage methods.. etc. [6-12]. In this paper the most popular of MPPT technique (Perturb and Observe (P&O) method, Buck and Buck- Boost DC-DC converters will involve in Implementation study (Figure 1) [13].Some results such as current, voltage and output power for each various combination have been discussed. The MPPT technique will be implemented, by using Matlab tool Simulink, considering the variant of circuit combination.

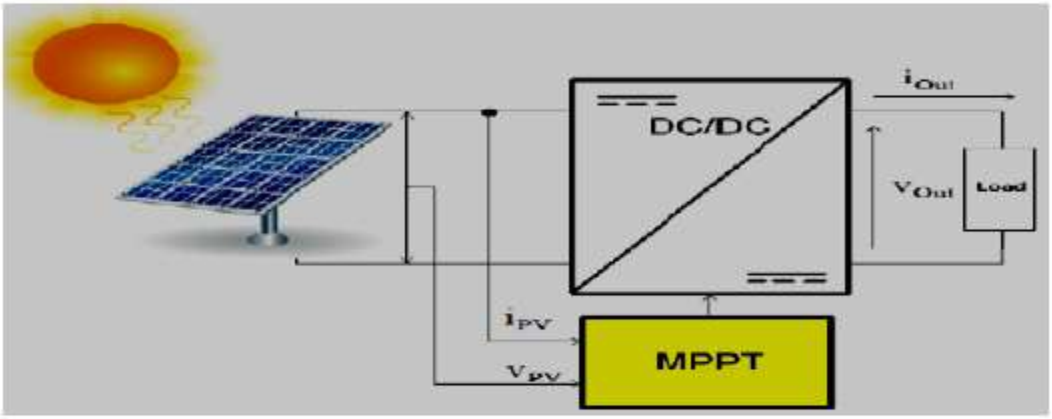

Figure 1. PV module and dc/ dc converter with MPPT

1 2. Photovoltaic Cell

Photovoltaic generators are neither fixed current sources nor voltage sources but can be approximated as current generators with dependant voltage sources. During darkness, the solar cell is not an active device. It produces neither a current nor a voltage. A solar panel cell essential is a p-n semiconductor junction. When exposed to the light, a current is generated (DC current).The generated current change linearly with the solar irradiance. Figure 2 show the equivalent electrical circuit of an ideal solar cell.

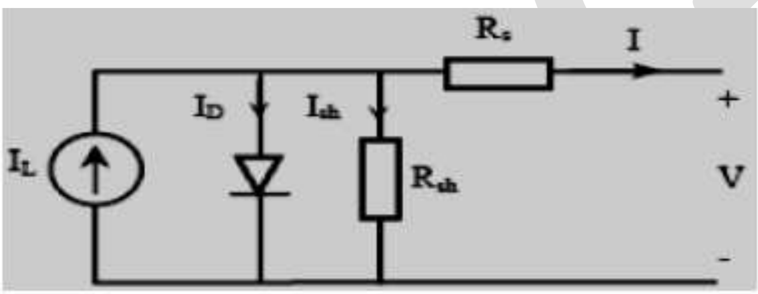

Figure 2. Equivalent circuit of a solar cell

The I-V characteristics of the solar cell circuit can be sets by the following equations . The current through diode is given by:

$$ID = IO\,[\exp(q\,(V + I\,RS)/KT)) - 1] \quad (1)$$

While, the solar cell output current:

$$I = IL - ID - I\,sh \quad (2)$$

$$I = IL - IO\,[\exp(q(V + I\,RS)/KT)) - 1] - (V + IRS)/Rsh \quad (3)$$

Where,

I : Solar cell current (A)
IL : Light generated current (A)
IO : Diode saturation current (A)
q : Electron charge (1.6×10^{-19} C)
K : Boltzman constant (1.38×10^{-23} J/K)
T : Cell temperature in Kelvin (K)
V : solar cell output voltage (V)
Rs: Solar cell series resistance (Ω)
Rsh: Solar cell shunt resistance (Ω)

Electrical Characteristics	Ranges
Maximum Power (P_{max})	325W
Voltage at P_{max} (V_{mp})	34.5V
Current at P_{max} (I_{mp})	7.35A
Open-circuit voltage (V_{OC})	44.1V
Short-circuit current (I_{SC})	8.95A
Temperature coefficient of I_{SC}	1.33mv/ ^{o}C
Temperature coefficient of V_{OC}	-160 ± 20 mV/ ^{o}C
Temperature coefficient of power	-0.5 ± 0.05 %/ ^{o}C
NOCT	47 ± 2^{o}C

3.DC-DC Converter Analysis

3.1 Buck Converter

A buck converter or voltage regulator is also called a step down regulator since the output voltage is lower than the input voltage. In a simple example of a buck converter, a diode is connected in parallel with the input voltage source, a capacitor, and the load, which represents output voltage .A switch is connected between the input voltage source and the diode and an inductor is connected between the diode and the capacitor, shown in Figure 3

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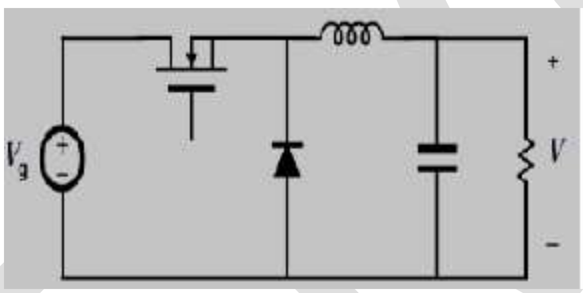


Figure 3. Basic buck converter

3.2 Buck-Boost Converter

The most important type of switching regulator is the buck-boost converter. In this converter, the buck and boost topologies covered earlier are combined into one. A buck-boost converter is also built using the same components used in the converters covered before. The inductor in this case is placed in parallel with the input voltage and the load capacitor. The switch or transistor is placed between the input and the inductor, while the diode is placed between the inductor and the load capacitor in a reverse direction, shown in Figure 4.The buck-Boost converter provides an output voltage that may be less than or greater than the input voltage .

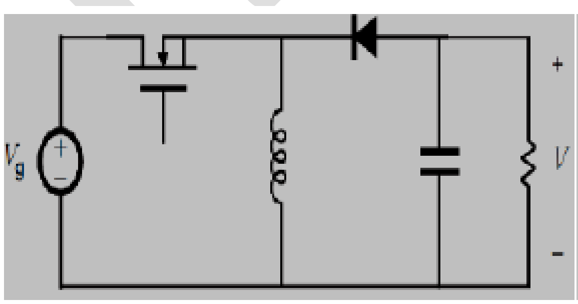


Figure 4. Basic buck-boost converter

4. Problem Overview

The MPPT method consider is to automatically find the current IMPP or voltage VMPP at which a PV module should work to extract the maximum output power PMPP under a given temperature and irradiance. Most of MPPT methods respond to variations in both irradiance and temperature, but some are precisely more useful if temperature is approximately constant. Most MPPT methods would automatically respond to various in the module due to aging, though some are open-loop and would require periodic fine tuning. In our context, module will typically be connected to a power converter that can vary the current coming from the PV module to the load .

5. MPPT Control Algorithm The MPPT algorithm operates based on the truth that the derivative of the output power (P) with respect to the panel voltage (V) is equal to zero at the maximum power point. In the literature, various MPP algorithms are available in order to improve the performance of photovoltaic system by effectively tracking the MPP. However, most widely used MPPT algorithms are considered here, they are:

Perturb and Observe (P&O)
Incremental Conductance (In Cond)
Constant Voltage Method.

5.1 Perturb and Observe (P&O)

The most commonly used MPPT algorithm is P&O method. This algorithm uses simple feedback arrangement and little measured parameters. In this approach, the module voltage is periodically given a perturbation and the corresponding output power is compared with that at the previous perturbing cycle . In this algorithm a slight perturbation is introduce to the system. This perturbation causes the power of the solar module various. If the power increases due to the perturbation then the perturbation is continued in the same direction. After the peak power is reached the power at the MPP is zero and next instant decreases and hence after that the perturbation reverses as shown in Figures 6(a) and 6(b).When the stable condition is arrived the algorithm oscillates around the peak power point. In order to maintain the power variation small the perturbation size is remain very small. The technique is advanced in such a style that it sets a reference voltage of the module corresponding to the peak voltage of the module. A PI controller then acts to transfer the operating point of the module to that particular voltage level. It is observed some power loss due to this perturbation also the fails to track the maximum power under fast changing atmospheric conditions. But remain this technique is very popular and simple .[14]

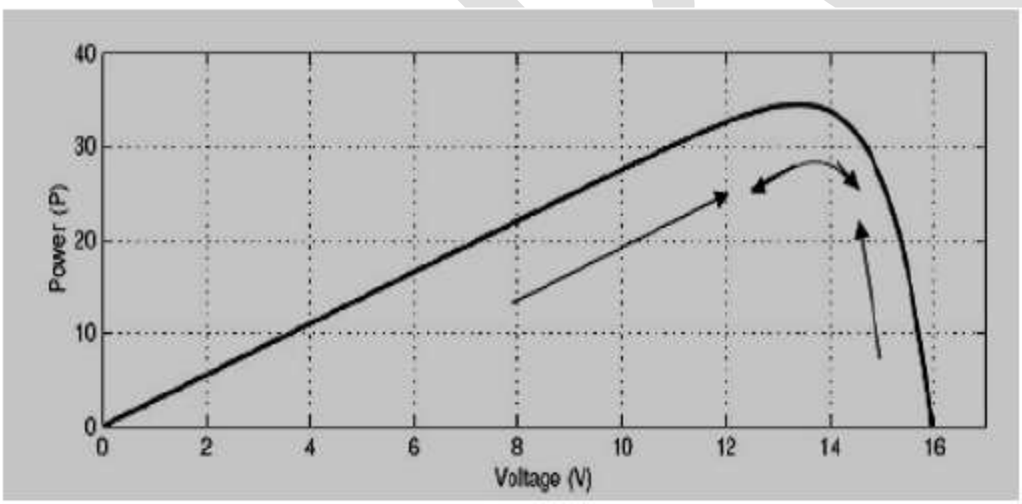


Figure 6(a). Graph Power versus Voltage for Perturb and Observe Algorithm

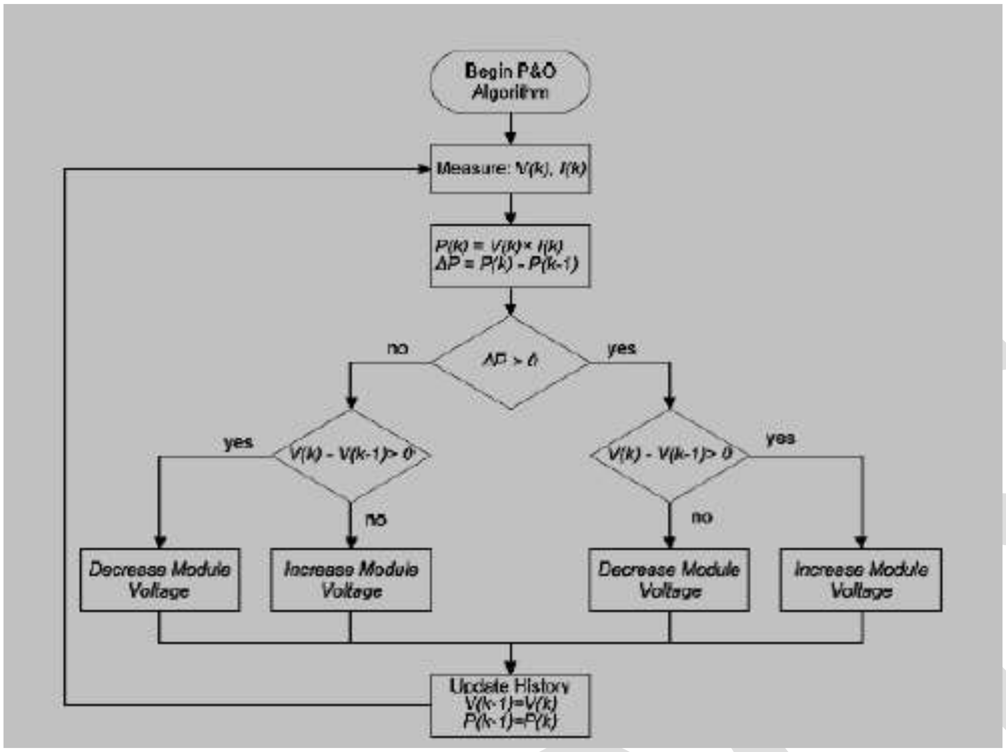
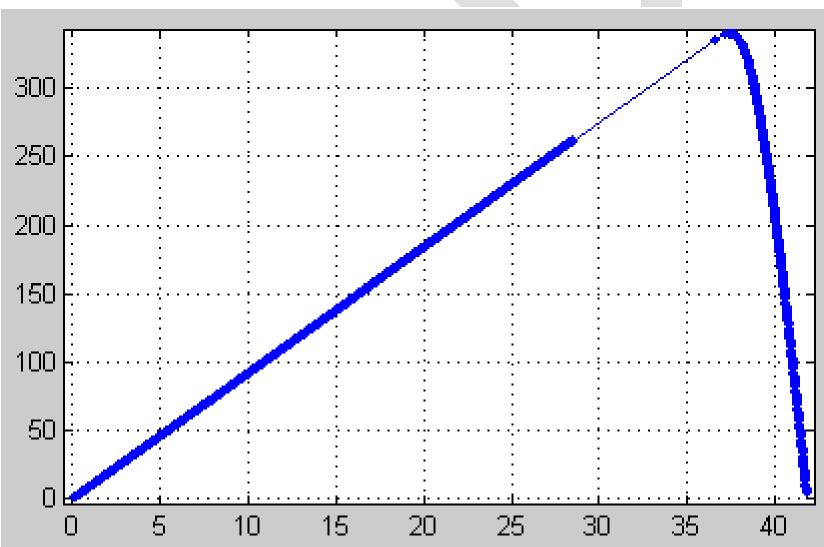
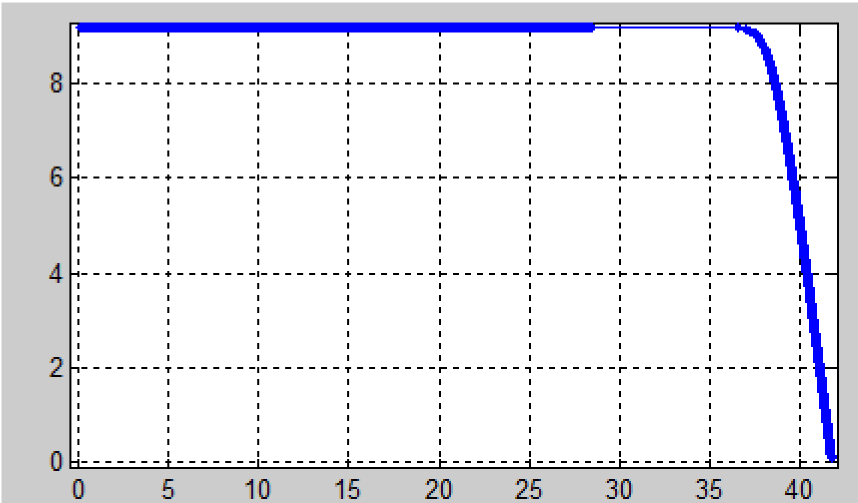


Figure 6(b). P&O Algorithm

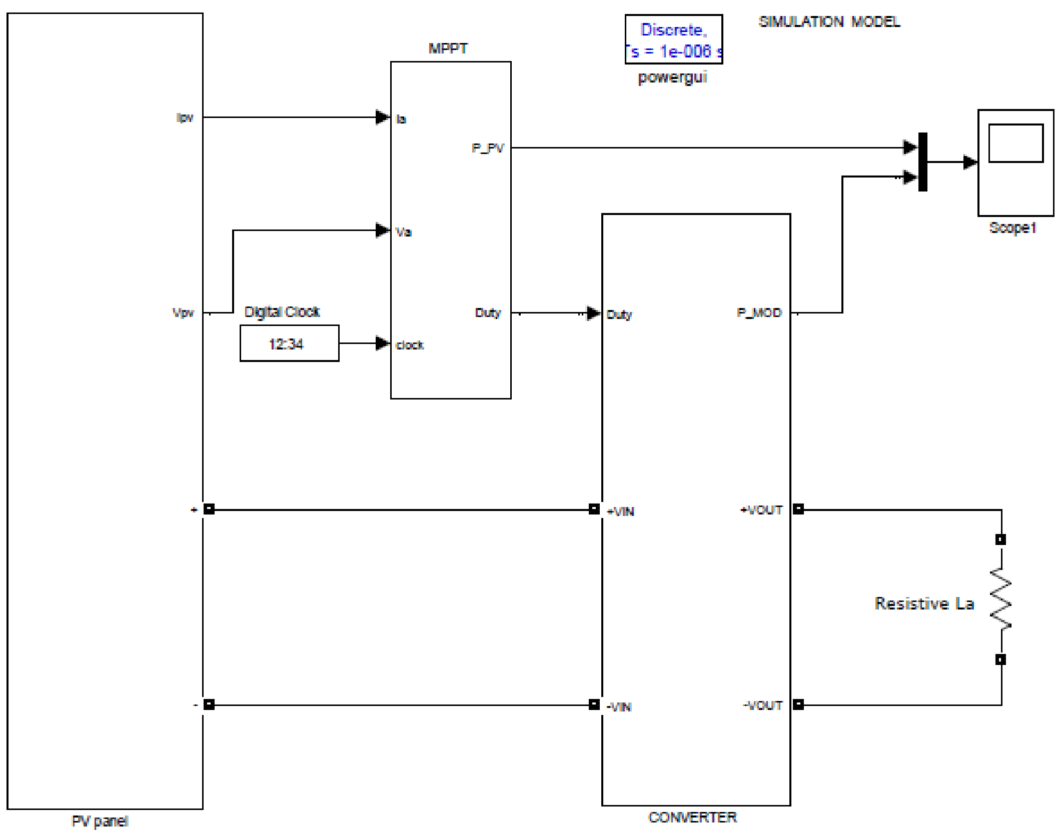
6.MATLAB-SIMULINK Environment The model shown in Figure 7a 7b represents P-V and I –V curves of the pv panel



The P-V characteristics as shown in Figure7a. The point indicated as MPP is the point at which the panel power output is maximum



I -V characteristics of solar cell only for a certain insolation Ga and a certain cell temperature Tc are illustrated. Figure 7b



In Figure 8 show a mat lab SIMULINK® of complete diagram of a boost buck and buck-boost converters

while Figures 9 and 10 show a SIMULINK® of complete diagram of both

buck and buck-boost converters

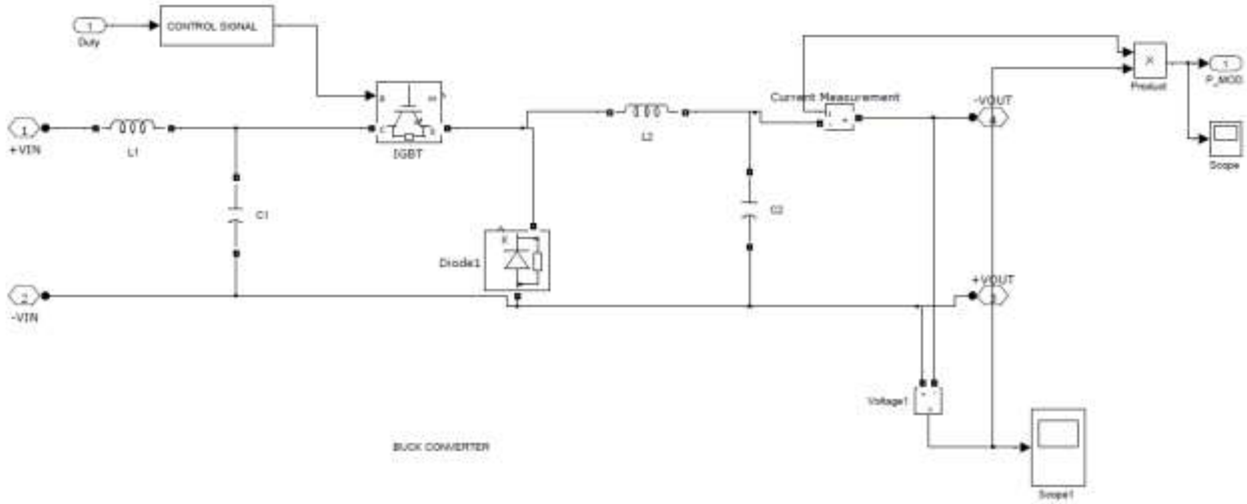


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Figure 10 Buck converter design in matlab SIMULINK®

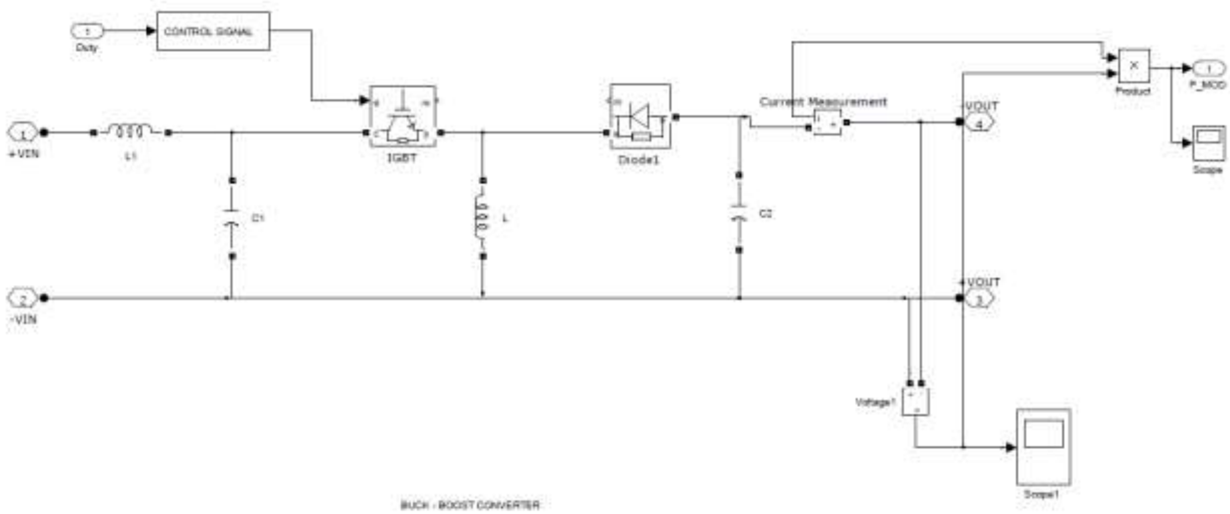


Figure 11 Buck-Boost converter design in matlab SIMULINK®

6.1.Results and Simulation

The models shown in the above figures were simulated using MATLAB® / SIMULINK® .Simulation and results for buck, boost and buck-boost converters have been recorded to make sure that comparison of the circuit can be obtained accurately. The voltage, current and output power is the main points of comparison to take into account. The complexity and simplicity of the circuit have been set based on the literature.

Buck-Boost Converter Simulation With Perturb and Observe Controller

The simulation result at constant temperature (T=50 degree) with changes in the isolation

(S=1000 to 850 w/m²)

It can be seen from Figures that the outputs of the PV panels and buck –boost converter clearly changes due to the change of the insolation as that variation of the converter affects the output of the PV panel the results below including current, voltage and power:

AT 1000w/ m²

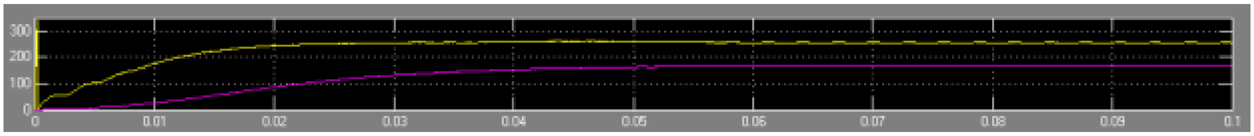
At T=50 degree and S=1000w/ m²

I= 9.20Ampere, V=27.298 volt and P=250 watt

output of the buck- boost converter with P&O algorithm that results below including current, voltage and power

At T=50 degree and S=1000 w/ m^2

I=-4.087Ampere,V=-40.87voltandP=280w

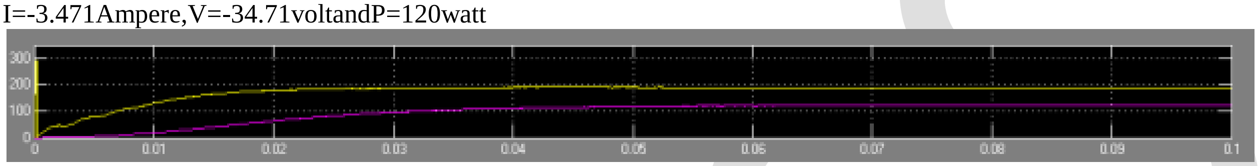


AT 850 w/ m²
From the Figure , the results below current, voltage, power of pv panel
At T=50 degree and S=850 w/ m²
I=7.82Ampere, V=24.15 volt and P= 180 watt,

the results below current, voltage, power of the buck- boost converter with P&O algorithm

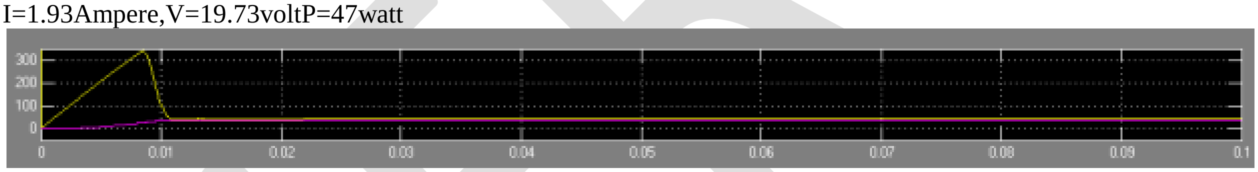
At T=50 degree and S=850 w/ m²

I=-3.471Ampere,V=-34.71voltandP=120watt

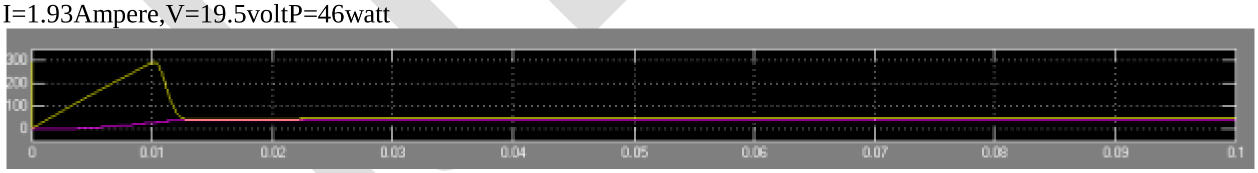


6.2. Buck Converter Simulation With Perturb and Observe Controller

The simulation result at constant temperature (T=50 degree) with changes in the insolation (S=1000 to 850 w/m²).
AT 1000w/ m²
Output current, voltage and power of PV panel
At T=50 degree and S=1000 w/ m²
I= 1.88 Ampere, V=41.1 volt and P=49 watt
Output current, voltage and power of buck converter with P&O algorithm
At T=50 degree and S=1000 w/ m²
I=1.93Ampere,V=19.73voltP=47watt



AT 850 w/ m²
The results below including current, voltage and power pv panel
At T=50 degree and S=850 w/ m²
I=1.076 Ampere, V=41.37 volt and P= 48 watt
Output current, voltage and power of buck converter with P&O algorithm
At T=50 degree and S=850 w/ m²
I=1.93Ampere,V=19.5voltP=46watt



At T=50 degree and S=1000w/ m²

CONVERTER	I_{in}	V_{in}	P_{in}	I_{out}	V_{out}	P_{out}
BUCK	**1.088A**	**41.4V**	**49W**	**1.943A**	**39.43V**	**47W**
BUCK-BOOST	**9.20A**	**27.92V**	**250W**	**-4.087A**	**-40.87V**	**170W**

Table 1

At T=50 degree and S=850 w/ m²

CONVERTER	I_{in}	V_{in}	P_{in}	I_{out}	V_{out}	P_{out}

BUCK	1.076A	41.37V	48W	1.937A	38.5V	47W
BUCK-BOOST	7.82A	24.15V	180W	-3.471	-34.71V	120W

Table 2

From Tables 1&2, once the converters transfer the electrical power from the solar panel to the load and the controller start function, output value of the solar panel do not provide same input voltage value to controller (Vin). This is because the controller function that varies the value of duty cycle will change the input value that sense by the controller. The input voltages of this controller show a different each other. Input voltage of Buck that connected with P&O is 41.4 V(41.37V at 850 w/ m²) while input voltage of buck-boost that connected with P&O is 27.92V (24.15Vat 850 w/ m²). while input voltage of boost that connected with P&O is 38.38V (36.25Vat 850 w/ m²). The output value behaves as Buck, boost and buck-boost converters behave. The buck voltage will drop from 41.4V to 19.73V (41.37V to 19.5V at 850 w/ m²),
This system show that perturb and observe controller will work better with buck controller than buck-boost converter

7.CONCLUSION: P&O MPPT method is implemented with MATLAB-SIMULINK for simulation. Through simulation it is observed, that the system completes the maximum power point tracking successfully despite of fluctuations. Maximum power point changes with change in external environment quickly. Buck and buck-boost converters have succeeded to track the MPP but, buck converter is much effective because There is a small loss of power from the solar panel side to the buck converter output side compared with other converter.

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