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

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

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 6, June 2018

Maximum Power Point (MPP) of a Consistently Irradiated Connected PV System using Incremental Conductance Scheme

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ABSTRACT: Global energy petition is growing exponentially. This growth in petition causes concern pertaining to the global energy crisis and similar environmental threats. The elucidation of these issues is seen in renewable energy sources. Solar energy is measured one of the chief sources of renewable energy, accessible in great quantity and also free of cost. Solar photovoltaic (PV) cells are used to convert solar energy into unregulated electrical energy. These solar PV cells unveil nonlinear characteristics and give very small efficiency. Therefore, it becomes important to extract extreme power from solar PV cells using maximum power point tracking (MPPT). Perturb and observe (P&O) is one of such MPPT outlines. The manner of MPPT schemes under continually changing atmospheric conditions is precarious. It tips to two conditions, i.e., quick change in solar irradiation and partial shading due to clouds, etc. Also, the conduct of MPPT schemes under changed load condition becomes significant to examine. This paper aims to discourse the problem of the conventional P&O MPPT scheme under increase solar irradiation condition and its conduct under changed load condition. The modified MPPT scheme is realized in the control circuit of a DC–DC converter. The simulation study is done using PSIM simulation software. A prototypical unit is tested with artificial light setup on a solar PV panel to simulate the altered solar irradiation condition. The model is capable of function of Maximum Power Point Tracking (MPPT) which can be used in the dynamic simulation of grid connected PV systems. The comparison is done between outcomes of the modified MPPT scheme and existing schemes. The modified MPPT scheme works fast and gives enhanced outcomes under change of solar irradiation. Moreover, the steady state oscillations are also reduced.

KEYWORDS: MPPT, photovoltaic, power electronics, Incremental Conductance (INC), RES.

I.INTRODUCTION

Global energy calamity and atmosphere discrepancy threats are amongst the chief concerns provoked by the present civilized world. The insufficient reservoirs of fossil fuels and release of greenhouse gases are the chief identified reasons for the above concern. Renewable energy sources (RES) such as solar, wind, and tidal are well-thought-out the explanation to overcome these concerns. Amongst these RES, solar energy is well-thought-out one of the probable sources to resolve the crunch as it is accessible in plenty and free of cost [1].
Photovoltaics (PV) is a term which shields the alteration of light into electricity using semiconducting materials that exhibit the photovoltaic effect .A typical photovoltaic system services solar panels, each containing a number of solar cells, which produce electrical power. Solar PV has precise advantages as an energy source: once installed, its action generates no pollution and no greenhouse gas emissions.

PV systems have the main drawback that the power output is reliant on on direct sunlight, so about 10-25% is lost if a tracking system is not used, since the cell will not be directly facing the sun at all times [2]. Dust, clouds, and other hindrances in the atmosphere also reduce the power output.[3][4] .

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Due to these problems, it becomes vital to researchers to extract maximum power from solar PV cells under flexible atmospheric circumstances.

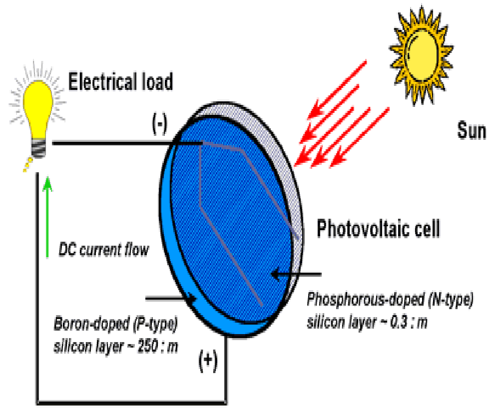

Fig. 1: Working of Photovoltaic cell

Maximum power point tracking (MPPT) scheme is used to extract maximum power from solar PV cells. Numerous types of MPPT schemes are projected by researchers [5] namely open circuit, short circuit, perturb and observe (P&O)/hill climbing, incremental conductance, and so forth.

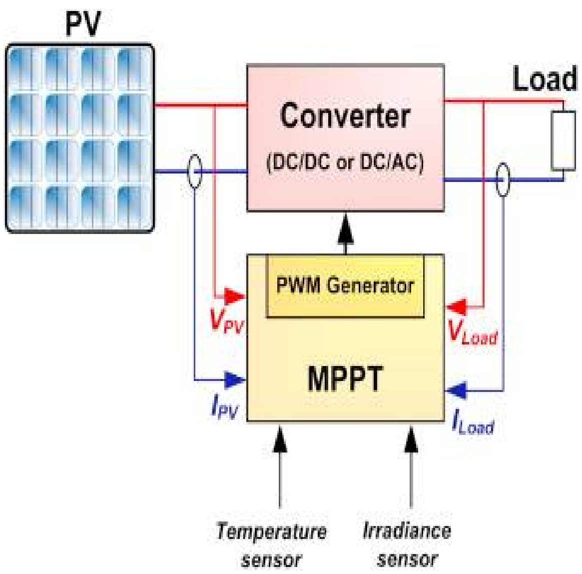

Fig. 2: Block diagram of Typical MPPT system.

II.OBJECTIVE

As the solar radiation fluctuates throughout the day, the power output also fluctuates. The principle of maximum power tracking can be explicated with the help of Fig. 1, where the line having slope I/Ro signifies a constant load Ro. If this load is linked directly across PV cell, it will control a power Pa differs from the maximum Pb, in spite of the fact that maximum power is available from the array.

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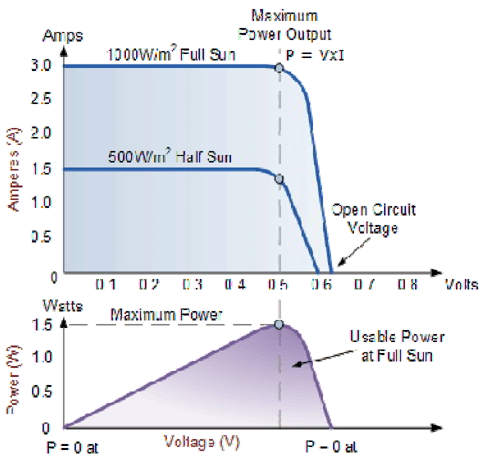

Fig. 3. Intersection between the load line and the power – voltage and current – voltage curve.

Thus, a power conditioner or DC-DC converter is presented between the solar PV module and the load. This converter acclimatizes the load to the array so that load characteristics are transformed along locus of maximum points and maximum power is transformed from the array. The duty cycle, D, of this converter is altered till the peak power point is obtained [6].A solar cell basically is a p-n semiconductor junction. When exposed to light, a dc current is generated. The generated current varies linearly with the solar irradiance. The standard equivalent circuit of the PV cell is shown in Fig.4.

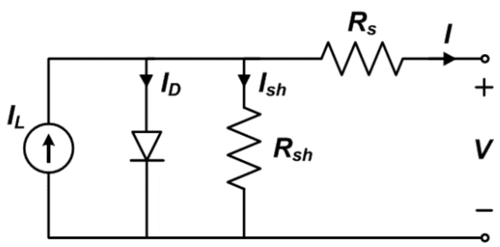

Fig. 4. Standard equivalent circuit of the PV cell

The basic equation that describes the I-V Characteristics of the PV model is given by the following equation

$$I = I_L - I_0\left(e^{\frac{q(V+IR_S)}{kT}} - 1\right).\left(\frac{V + IR_S}{R_{SH}}\right)$$

I	Cell Current (A)
I_L	Light Generated Current (A)
I_0	Diode Saturation Current
Q	Charge of Electron = 1.6x10-19 (Coul)
K	Boltzmann Constant (J/K)
V	Cell Output Voltage (V)
R_S, R_{SH}	Cell Series and Shunt Resistance (Ohms)

Table. 1. Terms in Characteristics of the PV model equation

III.INCREMENTAL CONDUCTANCE MPPT SCHEME

The incremental conductance (IC) method is established on the fact that the slope of the PV array power curve at the MPP is zero, positive on the left, and negative on the right of the MPP, Fig. 5.

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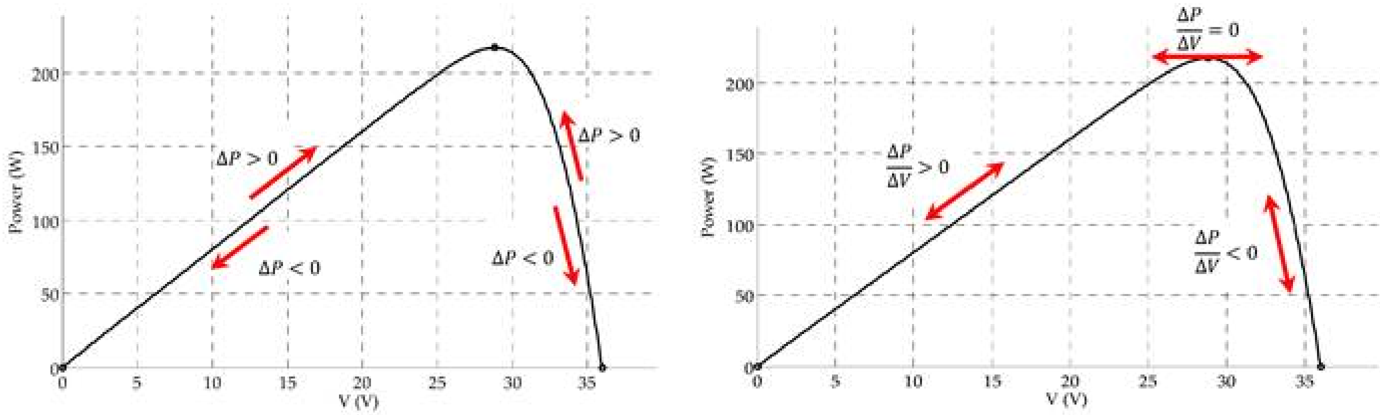

Fig. 5. PV Array Power Curve

The mathematical relationships are shown below;

$$\frac{dP}{dV} = 0 \; at\ MPP$$

$$\frac{dP}{dV} > 0 \; left\ of\ MPP$$

$$\frac{dP}{dV} < 0 \; right\ of\ MPP$$

Since

$$\frac{dP}{dV} = \frac{d(IV)}{dV} = I + V\frac{dI}{dV} \cong I + V\frac{\Delta I}{\Delta V}$$

So, equation (1) can be written as

$$\frac{\Delta I}{\Delta V} = -\frac{I}{V} \; at\ MPP$$

$$\frac{\Delta I}{\Delta V} > -\frac{I}{V} \; left\ of\ MPP$$

$$\frac{\Delta I}{\Delta V} < -\frac{I}{V} \; right\ of\ MPP$$

The MPP can thus be traced by equating the instantaneous conductance term (I/V) with the incremental conductance term ($\Delta I/\Delta V$) as shown in the flowchart of Fig. 6. V_{ref} is the reference voltage at which the PV array is enforced to operate. At the MPP, V_{ref} equals the voltage value at the MPP, V_{mpp}, once the MPP is reached, the operation of the PV array is maintained at this point unless a change in ΔI is noted or indicating a change in atmospheric environments, this MPPT method is also commonly used and numerous researches explained it in gravity details [7][8].

IV.INCREMENTAL CONDUCTANCE MPPT ALGORITHM

This method exploits the supposition of the ratio of change in output conductance is equivalent to the negative output Conductance Instantaneous conductance. We have,

P = V I

Applying the chain rule for the derivative of products yields to

$$\partial P/\partial V = [\partial (VI)]/ \partial V$$

At MPP, as $$\partial P/\partial V = 0$$

The above equation could be written in terms of array voltage V and array current I as

$$\partial I/\partial V = - I/V$$

The MPPT controls the PWM control signal of the dc – to – dc boost converter until the condition:

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Vol. 7, Issue 6, June 2018

$$(\partial I/\partial V) + (I/V) = 0$$

is satisfied. In this method the peak power of the module lies at above 98% of its incremental conductance. The Flow chart of incremental conductance MPPT is shown in Fig. 6.

V.ISSUE RELATED TO THE INCREMENTAL CONDUCTANCE MPPT SCHEME

The cost of INC scheme is high owing to requirements of high sampling compliance and speed control as a result of composite structure. Typically, INC method is the frequently used technique as a part in Hill Climbing algorithm, but it has the disadvantage in choice making as the speed increases in proportion to the step size of the error. Though, higher error step size decreases the efficiency of MPPT and direction errors under quick atmospheric changes [9]. One of the chief difficulties implementing the INC method is the choice of the fixed voltage change step size for concurrently satisfying the tracking speed and maintaining the MPP. A large step size of the voltage change helps the system rapidly approach the MPPs. On the other hand, this enormous value generally induces persisting oscillations around the MPP if no other superior countermeasures were taken. The issues using a small step size of voltage change are the opposite.

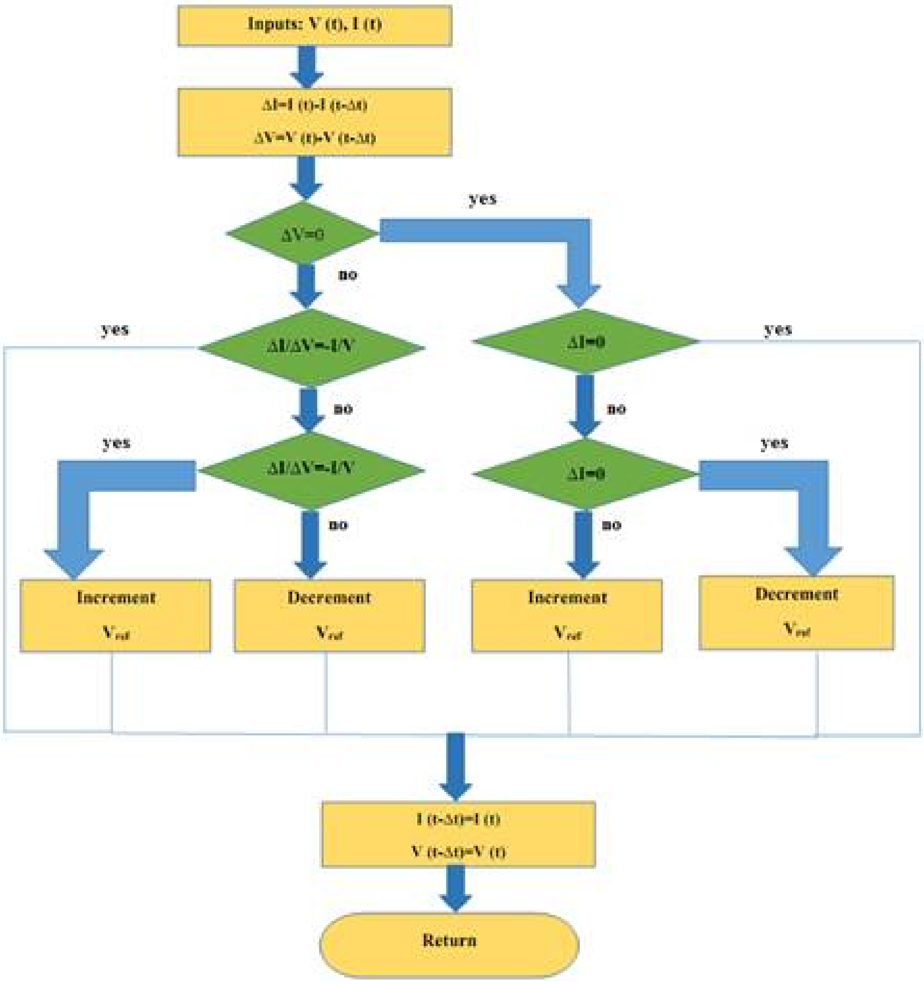

Fig. 6. Algorithm of incremental conductance MPPT

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VI. SIMULATION AND RESULT

A) SIMULATION MODEL

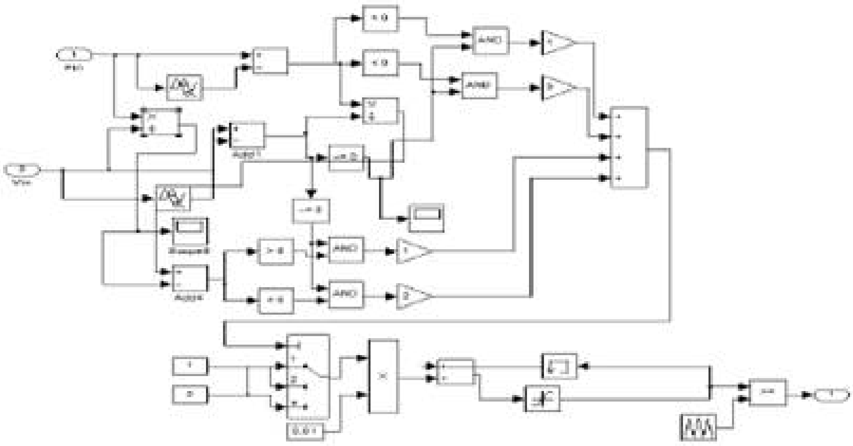

Fig. 7. A simulation model of PV using INC method.

B) RESULT

The performance of INC method is calculated and linked through theoretical analysis and digital simulation under two conditions by using Matlab/Simulink. The PV module is connected to the load through converter which in turn control by INC algorithm.

VII. RESULT ANALYSIS

A) STEADY CONDITION

First, this technique is evaluated under steady weather conditions i.e. 1000W/m^2 irradiance and 25^0C temperature. Fig. 8 shows the comparative simulation result of (INC) algorithm for Power achieved by PV module and boost converter. The output of the PV module is represented by the blue line while orange line is used to represent the output of the boost converter. It can be seen from Fig. 8 that INC method has decent and less response time and it has nearly slight oscillations in power around MPP.

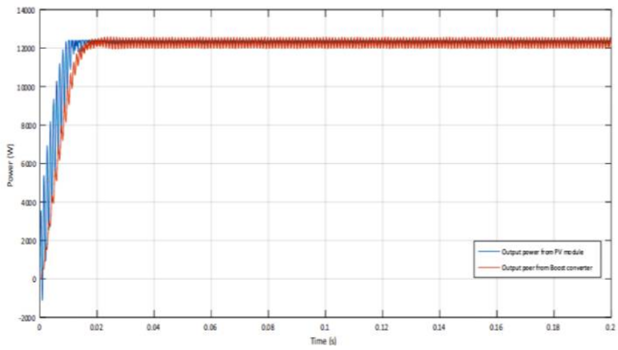

Fig. 8. Output power from PV module and Boost Converter underSteady Condition

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B) DYNAMIC CONDITION

In this section of simulation, INC) MPPT method is analysed and tested under dynamic weather conditions. Figure 9 shows the simulation result of INC algorithm for Power achieved by PV module and boost converter under dynamic condition. The output of the PV module is represented by the blue line while orange line is used to represent the output of the boost converter. This shows that the PV module maximum power declines, when the irradiance decreases and also current declines significantly when the irradiance decreases. So from above discussion, we can say that the PV array MPP varies with variations in shading, temperature and radiation. It has been seen that the PV system output power boosts with rise in amount of solar irradiance and drops in cell temperature. Consequently, the proficiency of the PV cell is better in winter than summer season.

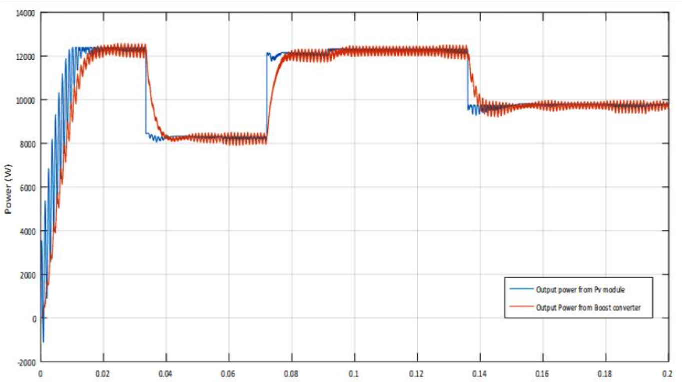

Fig. 9. Output power from PV module and Boost Converter underDynamic Condition

VIII.CONCLUSIONS AND SCOPE FOR FUTURE WORK

This paper gives the thorough analysis about a MPPT algorithm under uniform and non-uniform conditions of temperature and irradiance in the Matlab/Simulink background. The INC shows the superlative proficiency technique and has high response speed and can be controlled precisely. It shows the flawless efficiency and response time in steady as well as in dynamic conditions of weather. So, INC algorithm is great. However, it has multifaceted hardware design and needs specific sensors. The features of this method includes huge response speed, working under rapid changes in atmospheric conditions. The work that had been carried out by the researchers, the designing of MPPT controller, should be protracted by tracking larger number of input parameters which are changing with respect to the time such as parameters variations of the system. In order to get accurate MPPT point, the modern mathematical algorithms such as Z-infinity algorithms should be applied.

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BIOGRAPHY

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