A COMPREHENSIVE COMPARISON OF MPPT ALGORITHMS WITH DC-DC CONVERTERS FOR SOLAR PV ARRAY

[1]U.SRIKANTH, [2]P.PAVAN KUMAR, [3]K.V.V.PRASAD
[1]P.G.STUDENT, [2]ASSISTANT PROFESSOR, [3]ASSISTANT PROFESSOR
[1]Department of Power Systems (EEE),
[1]M.V.G.R. College of Engineering,Vizianagaram,Andhra Pradesh,INDIA.

Abstract:- This paper focuses on the comparative study of Maximum Power Point Tracking (MPPT) algorithms, with different combinations of DC-DC converters. Due to poor efficiency of Photovoltaic (PV) system and having a non-linear V-I characteristics, with changes in irradiance and temperature, different MPPT algorithms were proposed by many researchers. All MPPT methods follow the same goal that is maximizing the PV system output power by tracking the maximum power on every operating condition. In this paper maximum power point tracking techniques (Perturb& Observe Incremental Conductance) for photovoltaic systems were introduced to maximize the power produced. The MPPT algorithm is very effective, electronic means to operate the PV array at its MPP regardless of changing environmental conditions. The effectiveness of the MPPT algorithm in standalone PV system with different types of dc-dc converters is represented through simulation results in this work.

Keywords:- Buck, Boost, Cuk, Perturb and Observe method, Incremental Conductance, Maximum power point tracking, Solar PV Array.

1. INTRODUCTION

The electrical energy supplied by national grid is not enough to meet demand. But human being needs electricity for sustainable development and poverty reduction. It affects practically all aspects of social and economic development including: livelihoods, water, agriculture, population, health, education, job creation and environmental concerns. Due to the awareness of global warming and climate change, nations are concerned of the planet's carbon emissions from fossil fuel used. Renewable energy is a natural energy which does not have a limited supply, can be used again and again, and will never run out [2].As the solar energy is non-conventional and large amount of availability without pollution. Unfortunately, PV generation systems have two major problems: the conversion efficiency of electric power generation is very low (9-16%), especially under low irradiation conditions and the amount of electric power generated by solar arrays changes continuously with weather conditions. Moreover, the solar cell V-I characteristic is nonlinear and changes with irradiation and temperature. In general, there is a point on the V-I or V-P curve only, called the Maximum Power Point (MPP), at which the entire PV system operates with maximum efficiency and produces its maximum output power. The location of the MPP is not known, but can be located, either through calculation models or by search algorithms. MPPT techniques are used to maintain the PV array's operating point at its MPP. In the survey, the maximum energy extracted from the sun without MPPT is only about 30-40 %. MPPT's are most effective under these conditions Winter, and/or cloudy or hazy days - when the extra power is needed the most the natural DC-DC converters to be applied as MPP Trackers are Buck, Boost and Cuk.

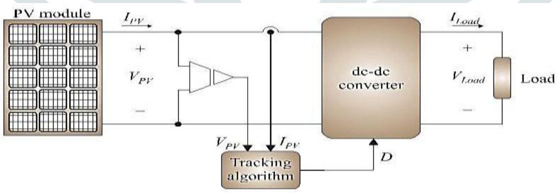

Fig 1: PV Module and DC- DC converter with MPPT

2. THE PHOTOVOLTAIC POWER SYSTEM

Photovoltaic system mainly consist of three parts first is solar panels or module (solar irradiation energy to electric energy), second is interface part or desire power section ,to manages and induces electric energy obtained from photovoltaic system which are designed proportion to need of consumer and third one is electric load.

The building block of PV array is the solar cell, which is basically a p-n semiconductor junction [8]. The V-I characteristic of a solar array is given by eqn.(1)

$$I = I_{sc} - I_O \left[exp\left\{\frac{q(V+I*R_S)}{nKT}\right\} - 1\right] - \left(\frac{V+I*R_S}{R_{SH}}\right) \quad (1)$$

Where:

- V and I represent the output voltage and current of the PV, respectively.
- R_s and R_{sh} are the series and shunt resistance of the cell.
- q is the electronic charge.
- $I_{SC}$is the light-generated current.
- Io is the reverse saturation current.
- n is a dimensionless factor.
- k is the Boltzman constant, and
- T is the temperature in K.

Equation (1) was used in computer simulations to obtain the output characteristics of a solar cell. This curve clearly shows that the output characteristics of a solar cell are non-linear and are crucially influenced by solar radiation, temperature and load condition. Each curve has a MPP, at which the solar array operates most efficiently.

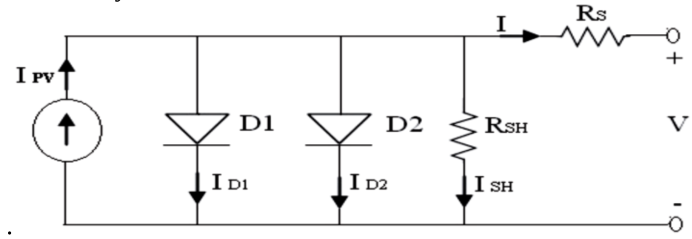

Fig.2: Equivalent circuit of PV array

V-I and P -V Characteristics of the PV Cell:

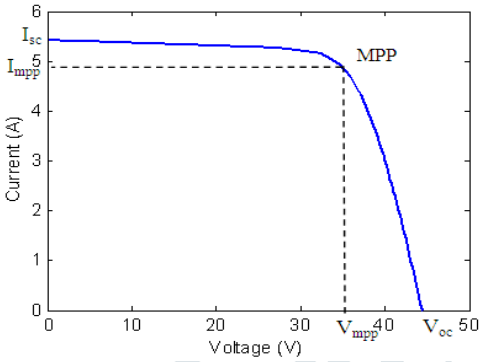

Fig.3: V-I Characteristic of a Solar cell

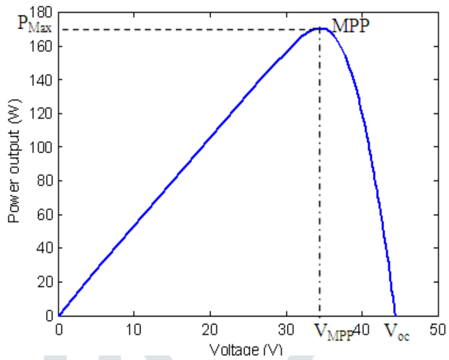

Fig.4:V-P Characteristic of a Solar cell

As the P-V characteristic is constantly varying by changing the irradiance and temperature, the MPP must be tracked at the changed moment to maximize the output power from the panel. Therefore, both a tracking speed and accuracy are required to the PV system. The characteristic curve closely and define two of the points. First one is the short circuit current I_{sc} and the second one is the open circuit voltage V_{oc}. Short circuit current is the current where the cell voltage is zero. Open circuit voltage is the voltage at which the cell current is zero. The point at which Imp and V_{mpp} meet is the maximum power point. This is the point at which maximum power is available from the PV cell. If the load line crosses this point precisely, then the maximum power can be transferred to this load.The value of this load resistant would be given by [7]:

$$R_{mp} = \frac{V_{mp}}{I_{mp}} \qquad (2)$$

The quality of solar system depends upon the fill factor of solar panels. To find the quality of the solar panel fill factor is used. A good panel has fill factor in the range of 0.7 to 0.8 for a bad panel it may be as low as 0.4. Factor (FF) can be calculated as follows [7]:

$$F.F = \frac{V_{mp} * I_{mp}}{V_{oc} * I_{sc}} \qquad (3)$$

Ideally, the fill factor should be 1 or 100%. However, the actual value of FF is about 0.8 or 80%.

Table1: Solar Cell Parameters

PARAMETERS	DESCRIPTION OF PARAMETER
I	Output current(ampere)
V	Output voltage(volts)
I	Photo current(ampere)
Id1,Id2	Diode 1 current and Diode 2 current(ampere)
Ish	Shunt resistance current(ampere)
Tref	Reference temperature of cell(c^o)
Ki	Short circuit temperature coefficient(0.003A/c^o)
G	Solar irradiation (w/m^2)
Is1,Is2	Saturation current of diode D1 and diode D2 (ampere)
n1,n2	Ideality factor of D1,D2(n1=n2=1)
Q	Electron charge(1.6*10^-19 c)
K	Boltzman's constant (1.38*10^-23 j/k)
Voc	Open circuit of solar panel (21.6 volts)
Isc	Short circuit current of solar panel (5 ampere)

3. DC-DC CONVERTER ANALYSIS

3.1 Buck Converter:

A Buck DC-DC Converter chops or attenuates the input voltage and a lower amplitude voltage is obtained at the output The figure 5 below shows the circuit of a Buck Converter which includes a switch; diode; inductor; capacitor and R-load. On tuning ON the switch; the voltage at the input is applied to the load. During the ON period the diode becomes reverse biased and therefore it is off the energy gets stored in the inductor during ON period. On turning OFF the switch; the output voltage becomes zero. The diode is forward biased i.e. it conducts in OFF period and hence the energy which was stored in the inductor during ON period discharges across it.[1]

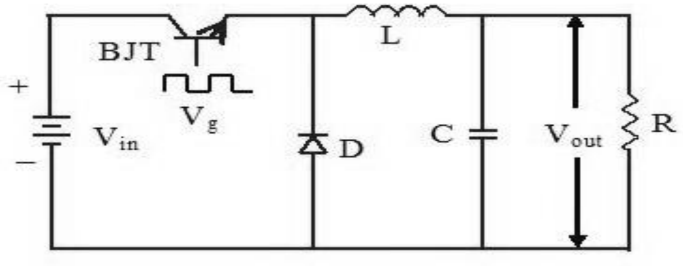

Fig 5: Buck converter circuit

The output voltage across the load is obtained by the following equation:-

$$V_O = \alpha V_{in} \tag{4}$$

Where: V_o-Output Voltage in Volt, V_{in}-Input Voltage in Volt, α -Duty cycle = ton/T.

In the simulation diagram of the Buck Converter used in this paper the value of inductor L is 0.0293H and capacitor C is 1.46×10^{-8}F for a duty cycle of 0.61.

3.2 Boost Converter:

A Boost DC-DC Converter boosts or increases the input voltage to a higher value of voltage at the output [1].

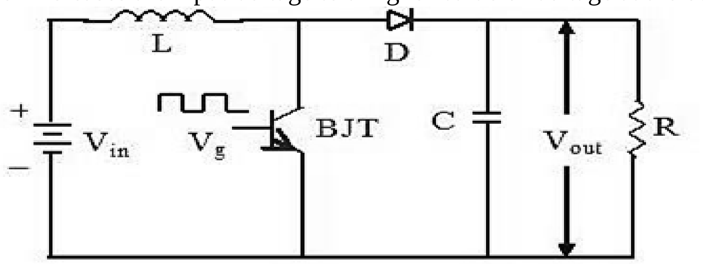

Fig. 6: Boost converter circuit

The figure 6 above shows the circuit of a Boost converter which includes an inductor; switch; diode; capacitor and R-load. In this converter on turning ON the switch the inductor starts storing energy. As no current flows through the load; the output voltage is zero. On turning OFF the switch the voltage at the input gets applied to the load. In the OFF period the energy stored in inductor during the ON period also discharges through the load. Hence the output voltage becomes more than the input voltage. The output voltage across the load is obtained by the following equation.

$$V_O = \frac{V_{in}}{1-\alpha} \tag{5}$$

In the simulation diagram of the Boost converter used in this paper; the value of inductor L =0.017794H and capacitor C is 0.766×10^{-6}F for a duty cycle of 0.3.

3.3 Cuk Converter:

The cuk converter has an additional one inductor and one capacitor compared to a buck-boost converter. When the switch is in OFF state, the capacitor C1 is being charged by the input source Vin through the inductor L1. During this time, the capacitor C1 transfers the energy to the output capacitor C2 through the inductance L2. C1 gets connected to the source and the load by the turn off of transistor and the diode and it transfers the energy stored in it. DC input voltage and the output voltage source through C1 are converted to current sources by the inductors L1 and L2 respectively. The parasitic resistance limits the current in case if the capacitor gets connected to the voltage source and subsequently energy loss. Figure 8 shows the circuit cuk converter connected to a load. The diode will reduce the ripple of the solar voltage. The average voltage of the converter when it is operated in continuous mode of operation.[8]

$$\frac{V_o}{V_i} = \frac{D}{1-D} = T_{vv} \tag{6}$$

where, D = The duty cycle, V_o = The output voltage , V_i = The input voltage , T_{VV} = The voltage transfer ratio

Neglecting the converter losses, the input dc current is given by:

$$\frac{I_o}{I_s} = \frac{D}{1-D} \tag{7}$$

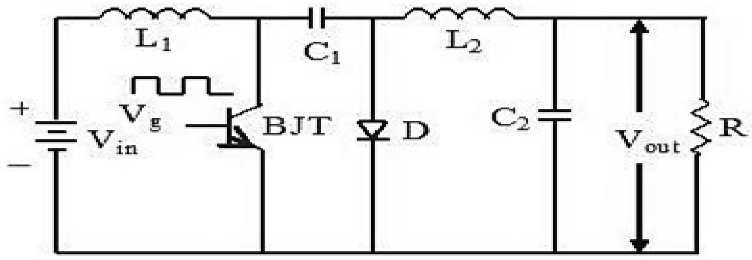

Fig 7: Cuk converter circuit

In the simulation diagram of the Cuk converter used in this paper, the value of inductor L1 = 0.0176H, L2=0.03009 H and capacitor C1 is 3.332×10^{-6} F and C2 is 7.81×10^{-9}F for a duty cycle of 0.62.

Table 2: Comparison of DC-DC converters

BUCK	BOOST	CUK
Energy storage in single inductor.	Energy storage in single inductor.	Energy storage in capacitor and two inductors.
Current is continuous at output.	Current is continuous at input	Current is continuous at both input and output.
Source current waveforms is not smooth	Source current waveforms is approximately smooth	Source current waveforms is smooth
More stresses on the input side.	No such type of stresses.	No such type of stresses.
More efficiency	Less efficiency compared to buck.	Less efficiency compared to buck but more than buck-boost and boost.
Less voltage ripples at output.	More voltage ripples at output.	Less voltage ripples at output.

4. MAXIMUM POWER POINTTRACKING (MPPT) ALGORITHMS:

Maximum power point trackers (MPPTs) plays a main role in photovoltaic (PV) power systems because they maximize the power output from a PV system for a given set of conditions, and therefore maximize the array efficiency. Thus, an MPPT can minimize the overall system cost. There are many MPPT methods available the most widely-used techniques are Perturb and Observe method and incremental conductance method described in the following sections. They also vary in complexity, sensor requirement, speed of convergence, cost, range of operation, popularity, ability to detect multiple local maxima and their applications. MPPT is algorithm that includes an electronic system to operate the Photovoltaic (PV) modules in a manner which allows the modules to produce all the power they are capable of drawing maximum power from PV module. MPPT is not a mechanical tracking system; it is fully electronic system that varies the electrical operating point of the modules so that the modules are able to deliver maximum available power [7].

4.1 Perturb and Observe Algorithm:

The Perturb and Observe algorithm operate by periodically perturbing (i.e. incrementing or decrementing) the array terminal voltage or current and comparing the PV output power with that of the previous perturbation cycle. If the PV array operating voltage changes and power increases, the control system moves the PV array operating point in that direction; otherwise the operating point is moved in the opposite direction. In the next perturbation cycle the algorithm continues in the same way. When the steady state is reached the algorithm oscillates around the peak point. In order to keep the power variation small the perturbation size is kept very small. Operating point of the module to that particular voltage level It is observed that there some power loss due to this perturbation also the fails to track the power under fast varying atmospheric conditions. But still this algorithm is very popular and simple [9].It is the most popular and widely accepted MPPT algorithm. In P&O, a perturbation in voltage results when the load point is far away from the MPP point due to changing environmental conditions. This perturbation results in changes of the power in the solar module. The perturbation extends itself in the same orientation as long as the power increases. When the maximum power is reached at the next instance of time, the power decreases progressively and the direction is reversed. The algorithm oscillates at the steady state around the maximum point. To keep the variation in power small, the size of the perturbation is kept made small. In this technique the operating point oscillates about the MPP point but does not coincides to MPP point and this problem is more pronounced under non uniform conditions. The basic principle of operation is that at MPP, the gradient of *P-V* curve vanishes. From the gradient, it is possible to obtain a corresponding location of this load point. The change in power with respect to the change in voltage is defined as the gradient. The relations are given below.

$$\frac{dP}{dV} = 0 at MPP \quad (8)$$

$$\frac{dP}{dV} > 0 \text{ at the left of } MPP \quad (9)$$

$$\frac{dP}{dV} < 0 \text{ at the right of } MPP \quad (10)$$

P&O is an iterative method. It senses the panel operating voltage periodically and compares the PV output power with that of the previous power; the resulting change in power (ΔPV) is measured. If ΔPV is positive, the perturbation of the operating voltage should be in the same direction of the increment. However, if it is negative, the system operating point obtained moves away from the MPPT and the operating voltage should be in the opposite direction of the increment, perturbation should be reversed to move back towards the MPP.

Flowchart of P&O algorithm:

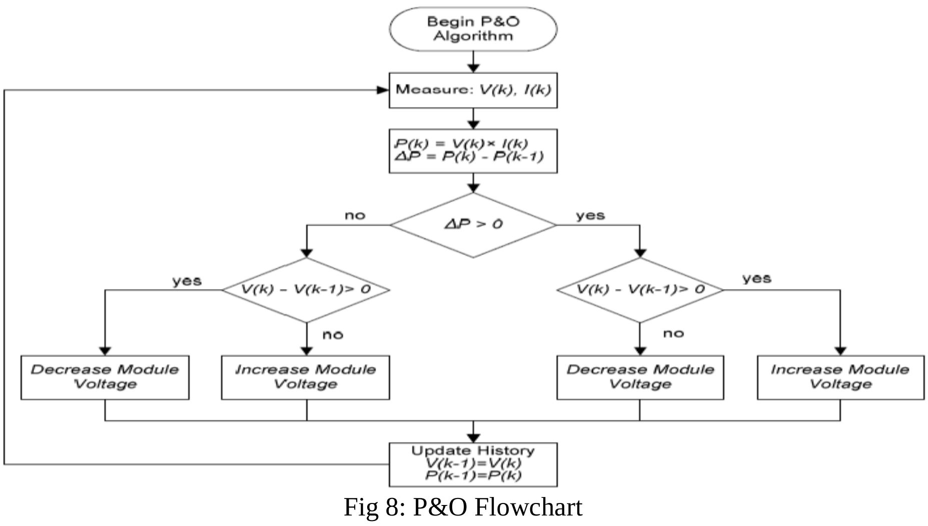

Fig 8: P&O Flowchart

4.2 INCREMENTAL CONDUCTANCE ALGORITHM:

The disadvantage of perturb and observe method to track the peak power under fast varying atmospheric condition is overcome by IC method. The IC can determine that the MPPT has reached the MPP and stop perturbing the operating point. If this condition is not met, the direction in which the MPPT operating point must be perturbed can be calculated using the relationship between dI/dV and –I/V this relationship is derived from the fact that dP/dV is negative when the MPPT is to the right of the MPP and positive when it is to the left of the MPP. This algorithm has advantages over P&O in that it can determine when the MPPT has reached the MPP, where P&O oscillates around the MPP. Also, incremental conductance can track rapidly increasing and decreasing irradiance conditions with higher accuracy than perturb and observe .One disadvantage of this algorithm is the increased complexity when compared to P&O .PV module voltage and current are first recorded by the algorithm. The gradient values *dI* and *dV* are calculated using the previous values of current and voltage. In incremental conductance technique the array terminal voltage is always adjusted according to the MPP voltage, it is based on the incremental conductance and instantaneous conductance of the PV module. Where I and V are PV module output current and voltage respectively The left hand side of equations represents incremental conductance of PV module and the right hand side represents the instantaneous conductance. When the ratio of change in output conductance is equal to the negative output conductance, the PV module will operate at the maximum power point. This method exploits the assumption of the ratio of change in output conductance is equal to the negative output instantaneous conductance [8].We have,

$$P = V I \quad (11)$$

Applying the chain rule for the derivative of products of (11) yields (12) and (13).

$$\frac{dP}{dV} = \frac{d(VI)}{dV} \quad (12)$$

$$\text{At MPP} \frac{dP}{dV} = 0 \quad (13)$$

Equations (12) and (13) can be simplified and written in terms of array voltage V and array current I as given by (14).

$$\frac{dI}{dV} = \frac{-I}{V} \quad (14)$$

The MPPT regulates the PWM control signal of the dc – dc converter until the condition of (15) is satisfied

$$\left(\frac{dI}{dV}\right) + \left(\frac{I}{V}\right) = 0 \quad (15)$$

$At\ MPPT \frac{dI}{dV} = \frac{-I}{V}$

$Left\ of\ MPPT \frac{dI}{dV} > \frac{-I}{V}$

$Right\ of\ MPPT \frac{dI}{dV} < \frac{-I}{V}$

Flowchart of IC algorithm:

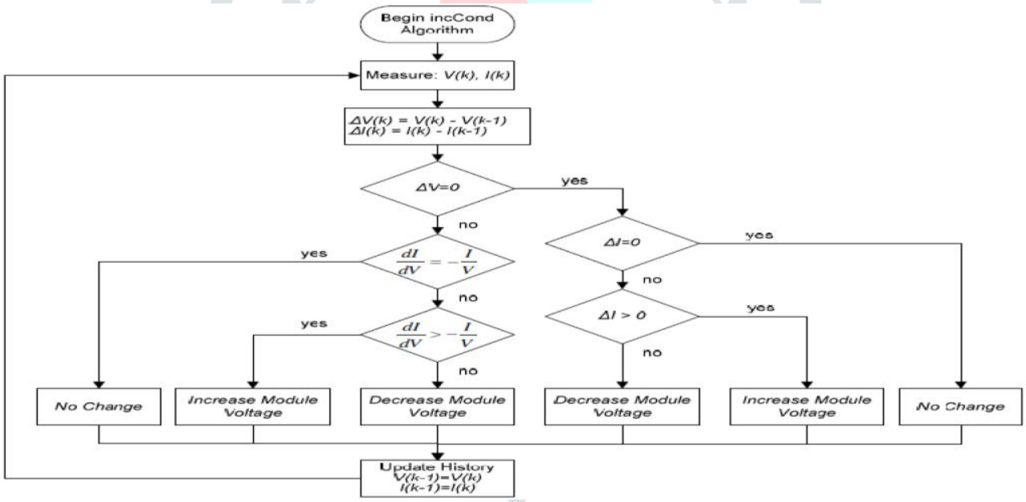

Fig 9: I.C Flowchart

Table 3: Comparison of MPPT Algorithms

PERTURB AND OBSERVE	INCREMENTAL CONDUCTANCE
Simple	Complexity
Sense voltage and current	Sense voltage and current
This MPPT fails where there are abrupt changes in weather conditions.	This MPPT method offers good performance under rapidly changing atmospheric conditions.
When MPP is reached the output power oscillates around the maximum, result in power loss in the PV system and when the array terminal voltage is perturbed every MPPT cycle.	When the MPP has been reached and thus when perturbation can be stopped.
Low efficiency	High efficiency
Process is slow	Fast and accurate
Tracking speed is slow and poor.	High tracking speed
It requires simple circuit	The main disadvantage is it requires complex control circuits
Low cost and easy implementation.	High cost and hard implementation

OVER ALL BLOCK DIAGRAM OF SYSTEM:

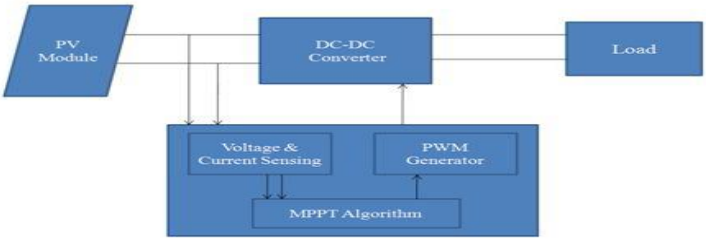

Fig 10: Block Diagram

Simulation Diagrams:

PV system with P&O along with the BUCK converter:

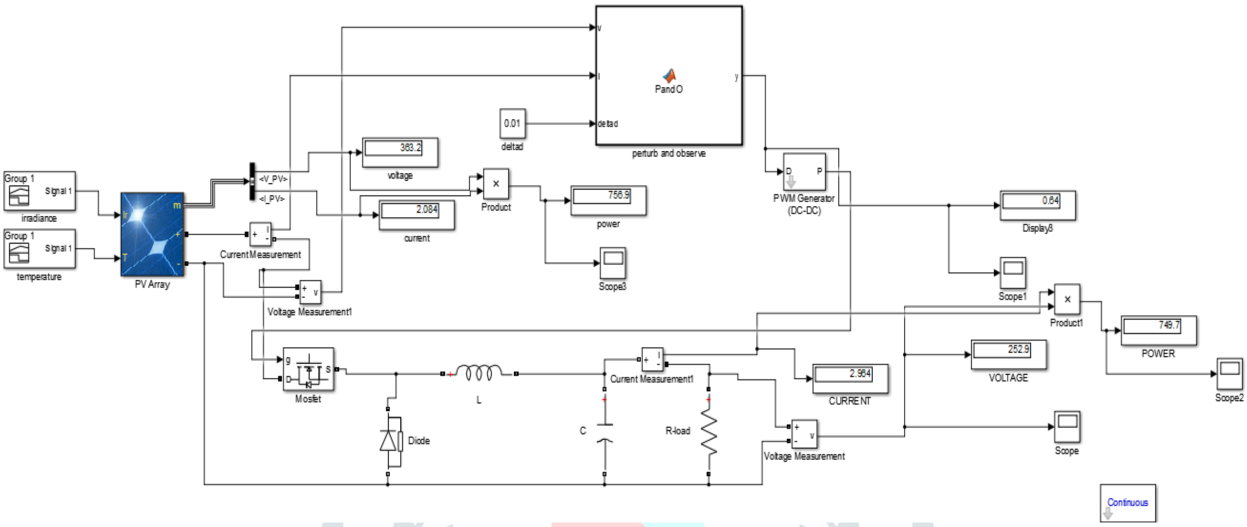

Fig. 11: PV module with P&O algorithm with BUCK converter

It has been implemented in the Matlab/ simulink. The figure above shows the simulation of MPPT of solar photovoltaic system with Buck DC-DC Converter using P &O Algorithm for a resistive load R=85.32 Ω. The Buck Converter reduces the input voltage to a lower value of output voltage according to the duty cycle applied to its gate input of the MOSFET in the Buck converter so that whenever there is a change in the irradiance or temperature; the duty cycle of the converter can be adjusted in order to get maximum power at the load side. The simulation has been performed for a progressive change of solar irradiance from 600 to1200 W/m^2 for different values of temperature such that changes from 25°c to 40°c.

PV system with P&O along with the BOOST converter:

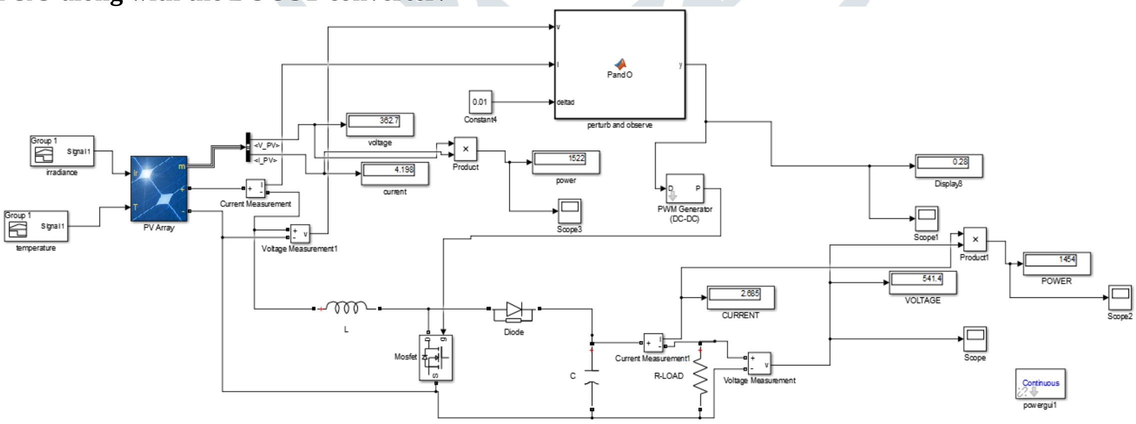

Fig. 12: PV module with P&O algorithm with BOOST converter

It has been implemented in the Matlab/simulink. The figure above shows the simulation of MPPT of solar photovoltaic system with Boost DC-DC Converter using P&O Algorithm for a resistive load R=201.6Ω. The Boost Converter increases the input voltage to a greater value of output voltage according to the duty cycle applied to its gate input of the MOSFET in the Boost converter so that whenever there is a change in the irradiance or temperature; the duty cycle of the converter can be adjusted in order to get maximum power at the load side. The simulation has been performed for a progressive change of solar irradiance from 600 to 1200 W/m^2 for different values of temperature varying from 25°c to 40°c.

PV system with P&O along with the CUK converter:

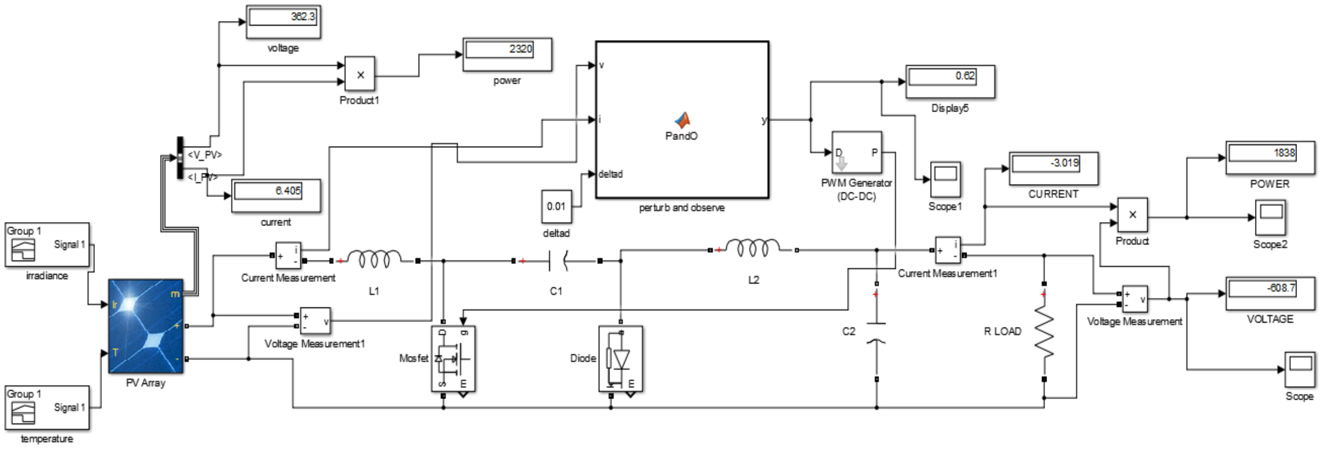

Fig. 13: PV module with P&O algorithm with CUK converter

It has been implemented in the Matlab/ simulink. The figure above shows the simulation of MPPT of solar photovoltaic system with CUK DC-DC Converter using P&O Algorithm for a resistive load R=201.6Ω. The CUK Converter increases or decreases the input voltage to a greater value or lower value of output voltage based on the load according to the duty cycle applied to its gate input of the MOSFET in the CUK converter so that whenever there is a change in the irradiance or temperature; the duty cycle of the converter can be adjusted in order to get maximum power at the load side. The simulation has been performed for a progressive change of solar irradiance from 600 to 1200W/m^2 for different values of temperature such that changes from 25° c to 40°c.

PV system with I.C along with the BUCK converter:

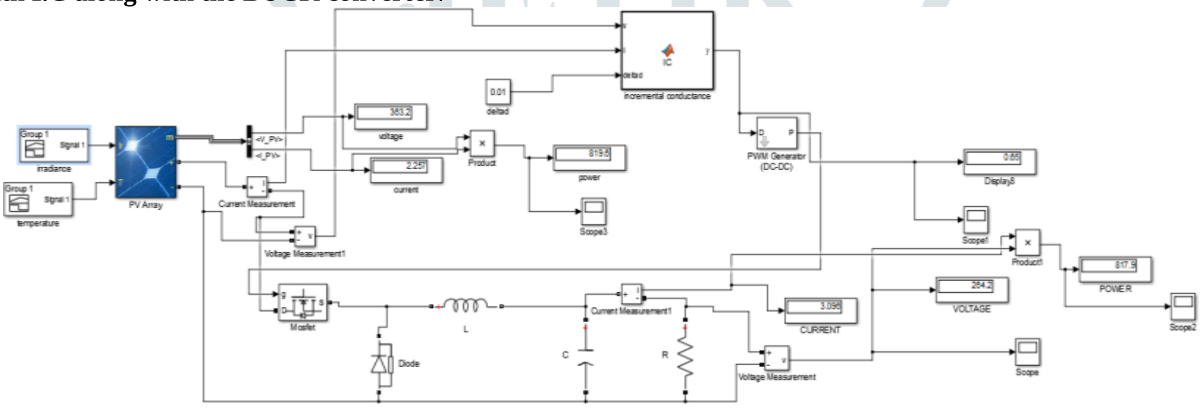

Fig. 14: PV module with I.C. algorithm with BUCK converter

It has been implemented in the Matlab/ simulink. The figure above shows the simulation of MPPT of solar photovoltaic system with BUCK DC-DC Converter using I.C Algorithm for a resistive load R=85.32 Ω. The BUCK Converter decreases the input voltage to a lower value of output voltage according to the duty cycle applied to its gate input of the MOSFET in the BUCK converter so that whenever there is a change in the irradiance or temperature the duty cycle of the converter can be adjusted in order to get maximum power at the load side. The simulation has been performed for a progressive change of solar irradiance from 600 to 1200W/m^2 for different values of temperature such that changes from 25° c to 40° c.

PV system with I.C along with the BOOST converter:

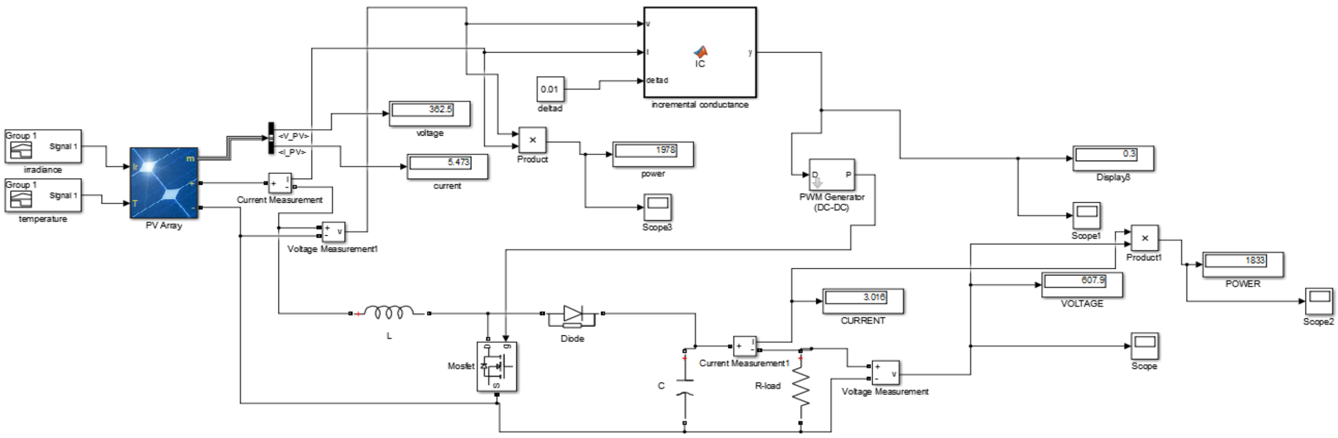

Fig. 15: PV module with I.C. algorithm with BOOST converter

It has been implemented in the Matlab/simulink. The figure above shows the simulation of MPPT of solar photovoltaic system with Boost DC-DC Converter using I.C Algorithm for a resistive load R=201.6 Ω. The Boost Converter increases the input voltage to a greater value of output voltage according to the duty cycle applied to its gate of the MOSFET in the Boost converter so that whenever there is a change in the irradiance or temperature,the duty cycle of the converter can be adjusted in order to get maximum power at the load side.The simulation has been performed for a progressive change of solar irradiance from 600 to 1200 W/m^2 for different values of temperature such that varies from 25° c to 40° c.

PV system with I.C along with the CUK converter:

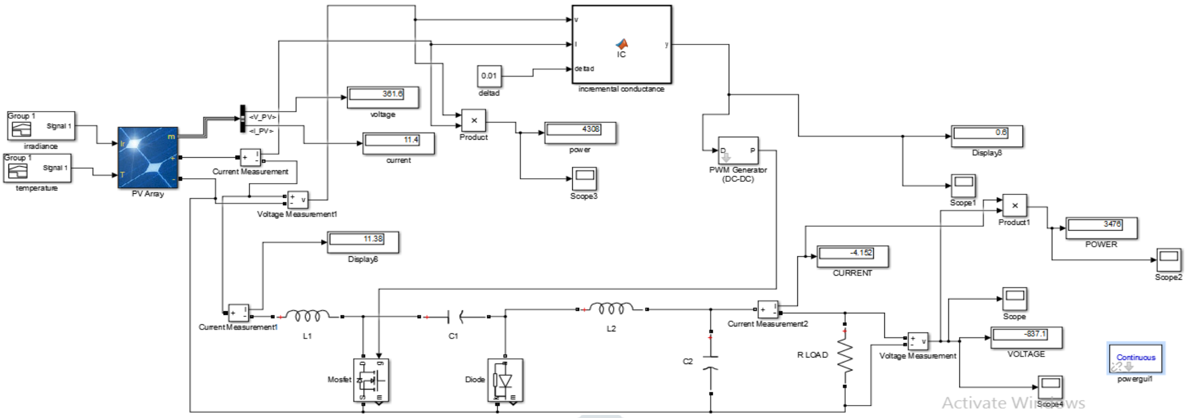

Fig. 16: PV module with I.C. algorithm with CUK converter

It has been implemented in the Matlab/ simulink. The figure above shows the simulation of MPPT of solar photovoltaic system with CUK DC-DC Converter using I.C Algorithm for a resistive load R=201.6 Ω .The CUK Converter increases or decreases the input voltage to a greater value or lower value of output voltage according to the duty cycle applied to its gate input of the MOSFET in the CUK converter so that whenever there is a change in the irradiance or temperature; the duty cycle of the converter can be adjusted in order to get maximum power at the load side.The simulation has been performed for a progressive change of solar irradiance from 600 to 1200W/m^2 for different values of temperature such that varies from 25°c to 40°c.

Table 4: Comparison results of MPPTtechniques with DC-DC converters

	BUCK					BOOST					CUK				
	I_{out}	V_{out}	P_{out}	η	% Ripple voltage	I_{out}	V_{out}	P_{out}	η	% Ripple voltage	I_{out}	V_{out}	P_{out}	η	% Ripple voltage
P&O	2.857	243.8	696.6	98.19	3.28	2.909	586.4	1706	93.73	1.7	-3.011	-607.1	1828	80.59	1.97
I.C	2.987	254.9	761.4	98.90	1.17	2.897	584	1692	92.96	1.71	-3.717	-749.4	2786	83.28	1.33

By comparing of two MPPT techniques with three types of dc-dc converters using PV array as an input source then we get the results in above table. The values of output voltage, current, power, efficiency and percentage of ripple voltage is compared and here R-load is taken. Finally by comparing the incremental conductance with buck converter having high efficiency of 98.90 and less percentage of ripple voltage of 1.17 for the R-load is 85.32Ω. It has best percentage of ripple and high efficiency. In most dc applications, the output ripple represents both a variation around the desired dc level and a possible energy effect at undesired frequencies. In a standard dc supply, it is common to specify the maximum peak to peak ripple, and often the ripple RMS magnitude as well. For example, typical numbers for peak to peak ripple fall in the 50-100 mv range for low dc voltages. A good rule of thumb is that the ripple will be about 1% of the nominal output [9].

RESULTS AND GRAPHS:

Photovoltaic System with P&O Algorithm and Buck Converter: The figures below show the output voltage, current and power for irradiance varying from 600W/m^2 to 1200 W/m^2 and temperature varies from 25°C to 75°C for a PV System working with a Buck Converter using Perturb and Observe Algorithm. The system has been designed for a duty cycle of 0.61.Hence, the input voltage of 363.2V has been reduced to 243.8V under standard conditions i.e. 1000w/m2 irradiance and 30 C temperature. It can be noticed that the current; voltage and power are at their maximum at 1000W/m^2 and 30°C. They decrease as the value of irradiance decreases from 1000W/m^2 to 600W/m^2 and temperature increases from 30°C to 40°C.

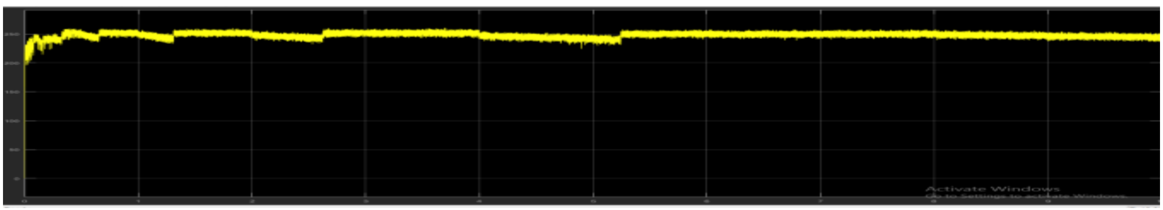

Fig. 17(a)

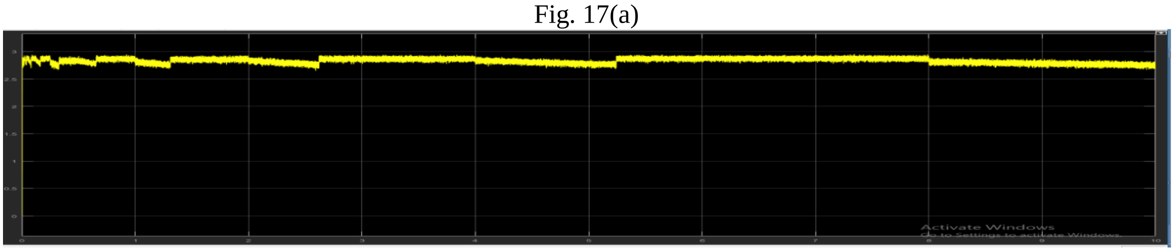

Fig. 17(b)

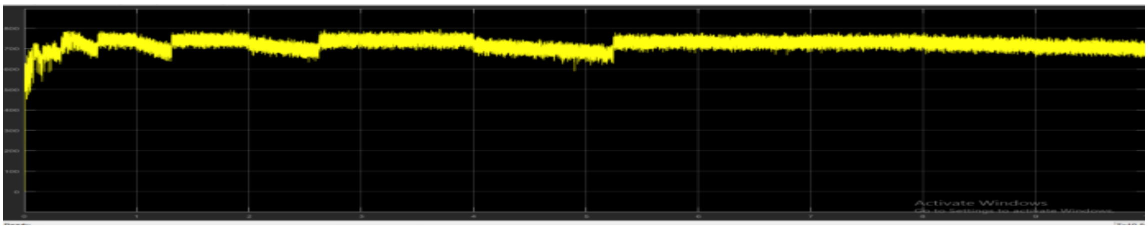

Fig.17(c)

Fig.17(a), (b), (c):Voltage, Current, Power Waveforms with respect to time

Photovoltaic System with P&O Algorithm and Boost Converter:

Fig. 18(a)

Fig.18(b)

Fig. 18(c)

Fig 18(a), (b), (c): Voltage, Current, Power Waveforms with respect to time

The figures above show the output voltage, current and power for irradiance varying from 600 W/m^2 to 1200W/m^{2}and temperature varying from 25°C to 40°C for a PV System working with a Boost Converter using Perturb and Observe Algorithm. The system has been designed for a duty cycle of 0.3. Hence, the input voltage of 362.6 V has been increased to 586.4 V under standard conditions i.e. 1000w/m2 irradiance and 30°C temperature. It can be noticed that the current; voltage and power are at their maximum at 1000W/m^2 and 30°C. They decrease as the value of irradiance decreases from 1000W/m2 to 600W/m^2 and temperature increases from 30°C to 40°C.

Photovoltaic System with P&O Algorithm and CUK Converter:

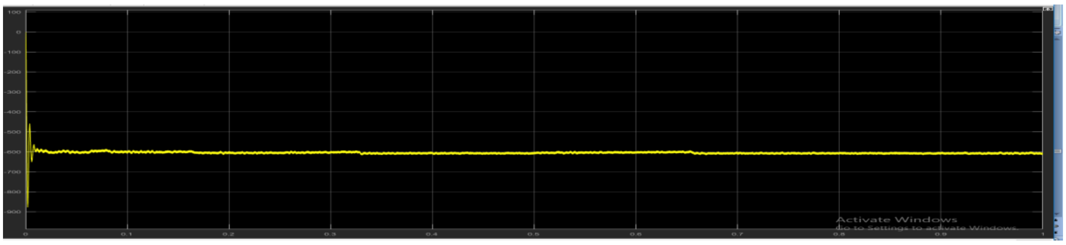

Fig. 19(a)

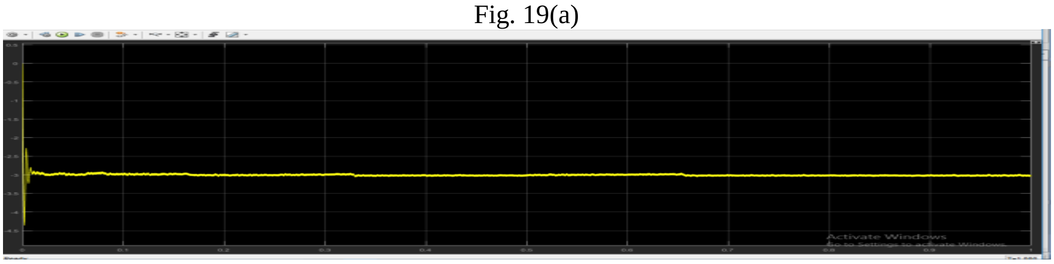

Fig. 19(b)

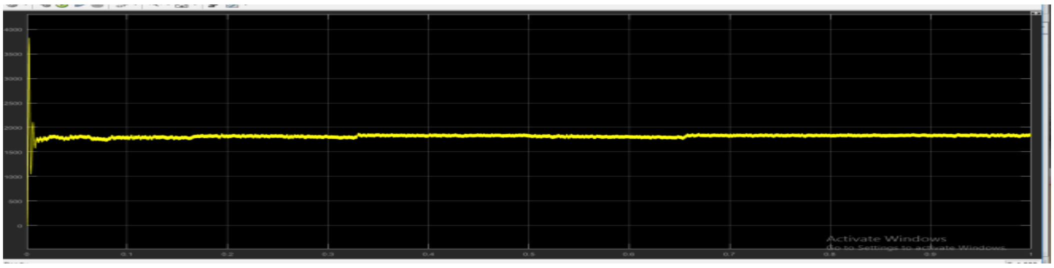

Fig.19(c)

Fig 19(a), (b), (c):Voltage, Current, Power Waveforms with respect to time

The figures above show the output voltage, current and power for irradiance varying from 600W/m^2 to 1200W/m^{2}and temperature varying from 25°C to 40°C for a PV System working with a CUK Converter using Perturb and Observe Algorithm. The system has been designed for a duty cycle of 0.61. Hence, the input voltage of 362.3V has been increased or decreased to -607.1V under standard conditions i.e. 1000w/m^2 irradiance and 30°C temperature. It can be noticed that the current, voltage and power are at their maximum at 1000W/m^2 and 30°C. They decrease as the value of irradiance decreases from 1000W/m^2 to 600W/m^2 and temperature increases from 30°C to 40°C.

Photovoltaic System with I.C Algorithm and Buck Converter:

The figures below show the output voltage, current and power for irradiance varying from 600W/m^2 to 1200W/m^{2}and temperature varying from 25°C to 40°C for a PV System working with a Buck Converter using Incremental Conductance Algorithm. The system has been designed for a duty cycle of 0.65. Hence, the input voltage of 363.2V has been reduced to 254.9 V under standard conditions i.e. 1000 w/m2 irradiance and 30 ° C temperatures. It can be noticed that the current, voltage and power are at their maximum at 1000W/m2 and 30°C. They decrease as the value of irradiance decreases from 1000W/m^2 to 600W/m^2 and temperature increases from 30°C to 40°C.

Fig.20(a)

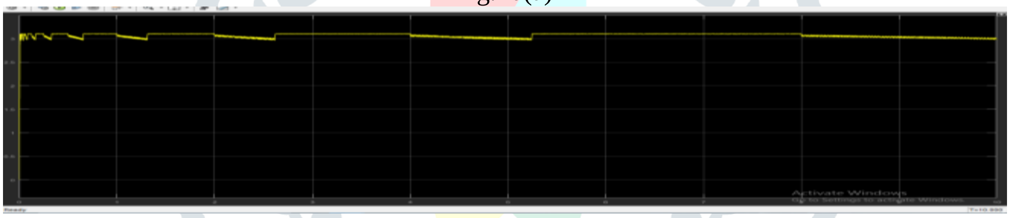

Fig. 20(b)

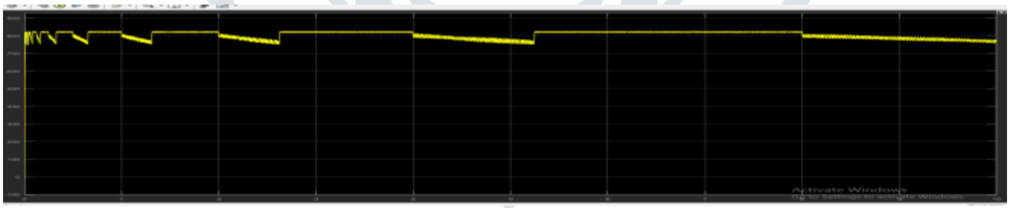

Fig.20(c)

Fig 20(a), (b), (c):Voltage,Current,Power Waveforms with respect to time

Photovoltaic System with I.C Algorithm and Boost Converter:

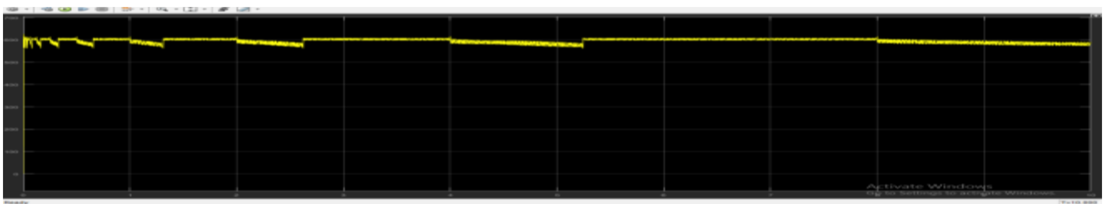

Fig.21(a)

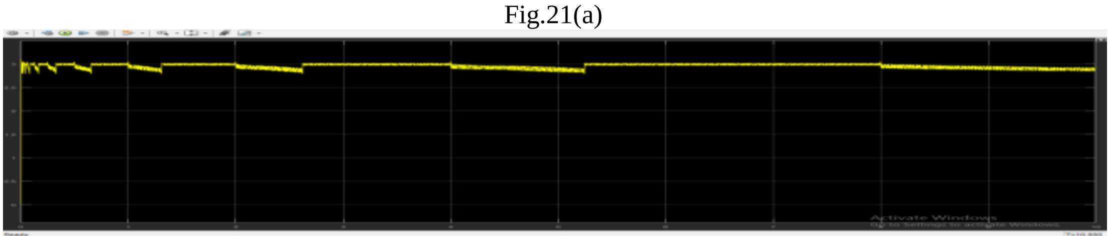

Fig.21(b)

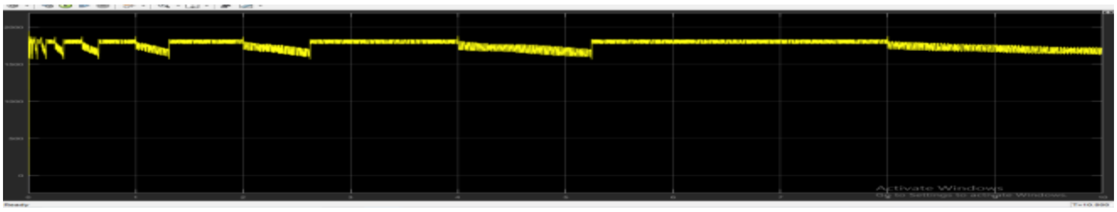

Fig.21(c)

Fig 21(a), (b), (c): Voltage, Current, Power Waveforms with respect to time

The figures above show the output voltage, current and power for irradiance varying from 600W/m^2 to 1200W/m^2 and temperature varying from 25°C to 40°C for a PV System working with a Boost Converter using Incremental conductance Algorithm. The system has been designed for a duty cycle of 0.3. Hence, the input voltage of 362.6V has been increased to 584 V under standard conditions i.e. 1000w/m^2irradiance and 30°C temperature. It can be noticed that the current, voltage and power are at their maximum at 1000W/m^2 and 30°C. They decrease as the value of irradiance decreases from 1000W/m^2 to 600W/m^2 and temperature increases from 30°C to 40°C.

Photovoltaic System with I.C Algorithm and CUK Converter:

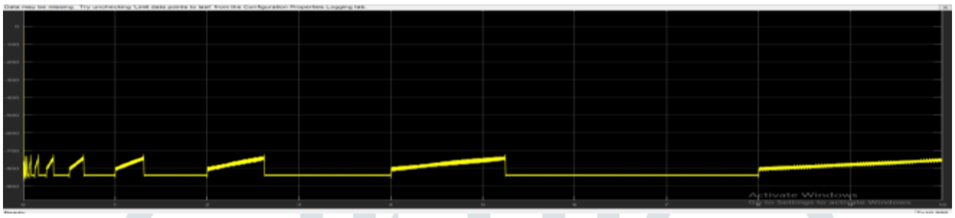

Fig. 22(a)

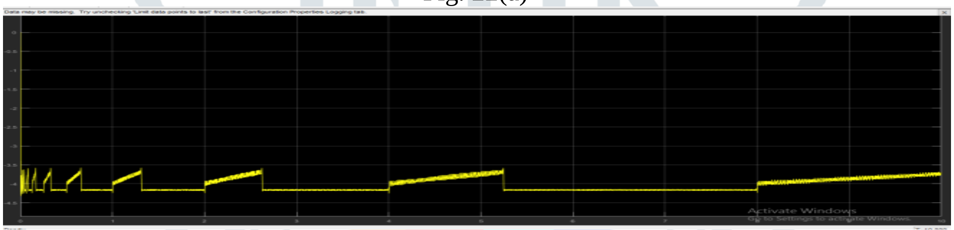

Fig. 22(b)

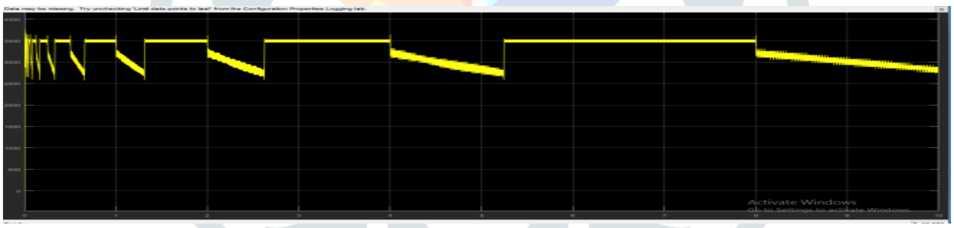

Fig.22(c)

Fig 22(a), (b), (c): Voltage, Current, Power Waveforms with respect to time

The figures above show the output voltage, current and power for irradiance varying from 600 W/m^2 to 1200W/$m^2$and temperature varying from 25°C to 40°C for a PV System working with a Cuk Converter using Incremental conductance Algorithm. The system has been designed for a duty cycle of 0.6. Hence, the input voltage of 361.9V has been increased or decreased to -749.4V under standard conditions i.e. 1000w/m^2 irradiance and 30°C temperature. It can be noticed that the current; voltage and power are at their maximum at 1000W/m^2 and 30°C. They decrease as the value of irradiance decreases from 1000W/m^2 to 600W/m2 and temperature increases from 30°C to 40°C.

CONCLUSION:

When the external environment changes suddenly the system cannot track the maximum power point quickly. With the use of different types of dc to dc converter it is possible to track the maximum power point (MPP) with increase in efficiency of the system, but on the other hand with the excess use of dc to dc converter there can be decrease in overall efficiency of the system. Moreover from the results obtained by varying irradiance and temperature it can be concluded that as the irradiance decreases or increases less amount of solar energy is received by the photovoltaic system and hence the output current; voltage and power reduces or raises. The Incremental Conductance method is more efficient than Perturb and Observe method because panel terminal voltage is changed according to its value relative to the MPP voltage. Perturb and observe method can fail under rapidly changing atmospheric conditions. Incremental conductance method eliminates the problem in Perturb and Observe method. In simulation Buck converter show the best performance the controller work at the best condition.Even though the time response of PO algorithm is faster than that of Incremental Conductance. The power extracted by Inc. Cond MPPT is more regulated than PO algorithm. At different weather conditions, comparison of two MPPT algorithms with four dc-dc converters taking the output values of the current, voltage, power, ripple voltage and their efficiencies. By comparing in efficiency the incremental conductance with buck converter is the best and it has a less percentage of ripple voltage also. According to applications view the P&O is preferred than I.C method because it is having low cost and easy implementation.

REFERENCES:

[1] KshitijaaRanjan, Narendra Kumar2, Modelling and Simulation of Perturb and ObserveAlgorithm on Solar PV System using DifferentConverters in MATLAB/Simulink, 1st IEEE International Conference on Power Electronics.Intelligent Control and Energy Systems (ICPEICES-2016).

[2] James Dunia, Bakari M. M. Mwinyiwiwa, Alex L. Kyaruzi, ĆUK Converter Based Maximum Power Point Tracking for Photovoltaic System Using Incremental Conductance Technique, International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163Volume 1 Issue 11 (November 2014)

[3] A.Attou, A.Massoum and M.Saidi, Photovoltaic Power Control Using MPPT and Boost Converter, BALKAN JOURNAL OF ELECTRICAL & COMPUTER ENGINEERING, 2014, Vol.2, No.1

[4] A.Pradeep Kumar Yadav1, S.Thirumaliah2, G.Haritha, Comparison of MPPT Algorithms for DC-DC Converters Based PV Systems, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 1, Issue 1, July 2012.

[5] harshaldeopare,amruthadeshpande, Modeling and simulation of i.c maximum power point tracking.ICESA 2015.

[6] SamerAlsadi, BasimAlsayid, Maximum Power Point Tracking Simulation for Photovoltaic Systems Using Perturb and Observe Algorithm. International Journal of Engineering and Innovative Technology (IJEIT)Volume 2, Issue 6, December 2012.

[7] 1Umashankar S., 1Punna Srikanth, 2D. Vijay Kumar and 2D.P. Kothari, Comparative Study of Maximum Power Point Tracking Algorithms with DC-DC Converters for Solar PV System.International Journal of Electrical and Computer Engineering.ISSN 0974-2190 Volume 3, Number 1 (2011), pp. 11-20.

[8] Bikram sah, GudeyVenkataEswara Satish Kumar, A Comparative study of different MPPT techniques using different dc-dc converters in a standalone PV system, 2016 IEEE Region 10 Conference (TENCON) — Proceedings of the International Conference 1695.

[9] Taufik, Ali Shaban, Ahmad Nafisi, Output Current Ripple Factor Performance of Half-Wave Rectifier With and Without Freewheeling Diode, 0-7803-6401-5/00/$10.Q00 2 000 IEEE.