Control of Agrid Connected PV System using Hill-Climbing Techniques

K. Chaitanya N. A. Srinivas Reddy, B. S. S. Santosh

***Abstract:** Renewable energy resources generally consist of solar, wind, tidal energy which have low operating cost and low pollutant emissions has a great concern. Where as in conventional energy with great increase in global warming, fossil fuel shortage and damage to the environment system. Among them, Photovoltaic (PV) systems are used as they are clean, light and easily installable. The power output of the Photovoltaic cell based on irradiance and ambient temperature. This paper proposes a algorithm for drawing peak available power from the Photovoltaic array using the boost converter linked to photovoltaic system is managed by the Incremental Conductance Maximum Power Point Tracking Algorithm(IC-MPPTA).This algorithm is established on the certainty that the slope of the P-V characteristics of the PV array is zero at MPP, negative on the right side of the curve and positive on the left side of the curve. This algorithm is compared by simulating a 100KW PV system connected to grid. These MPPT algorithm is written in MATLAB M-files is utilized in simulation. From results, the proposed method for MPPT is faster and more stable than any other method.*

***Index Terms:** Incremental conductance, Irradiance, Maximum power point tracking, PV array.*

I. INTRODUCTION

The concern over nonconventional energy source is growing day to day. Due to the use of non-conventional energy sources like coal, natural gas, oil, etc., a large amount of greenhouse gases like CO2, NO(x), SO(x) are released into the atmosphere [1]. Due to the emission of these gases into the atmosphere, global warming is threatening the world. One of the other main reasons which tend us towards the renewable energy sources is due to the increase in electricity demand day by day. In order to cop up with the increasing electricity demand we need to search for alternative energy sources which are inexhaustible and not harmful to the atmosphere [2]. In all the nonconventional energy sources, solar energy is best source as it is widely available, ecofriendly, inexhaustible.

Photovoltaic technology is most effective solution to generate power from solar radiations because of decreasing cost of solar panels, improvement in manufacturing technology, the constant increment in efficiency of solar cells [3]. The challenge faced by researchers is low efficiency of PV cells due to non-linear output features with different isolation levels. Theoretical efficiency of PV cells is about 28% but practically it will be only 15% [4] and [5]. So for better use of PV systems we go for the improvement of efficiency by "MPPT" which is one of the economic techniques [6]. Numerous MPPT algorithms are referred in the literature, such as P&O method [7] and [8], intelligent based methods [9]-[11], incremental conductance method[7] and [12]. These methods differ based on hardware implementation, complexity, and speed of convergence.In [13], it gone through MPPTby AI techniques which have the advantages of less computational effort, no requirement of knowledge about internal parameters of the system.In [14], deals with the comparison of P&O method and IC method and concluded that incremental conductance method is yielding better result compared to perturb and observe method.PV system can be either used in stand-alone condition or connected to grid. Grid connected mode is of more interest these days over stand-alone system because stand-alone system has some drawbacks like constant maintenance, large battery capacity and costly.In [15], deals with the review of the MPPT algorithms for stand-alone PV systems. In [16], A direct MPPT algorithm for grid connected PV inverters is studied.

This paper, proposes connecting PV array to grid through boost converter controlled by IC-MPPT technique and this IC-MPPT technique is having more computational speed and stable operation.Paper is structured as below. Section II deals with Grid connected PV system and methodology. Section III deals with results of simulation and finally section IV concludes the paper.

II. GRID CONNECTED SYSTEM

A. Components of PV system

The connection diagram of PV module connected to grid with boost converter is shown below.

Fig.1. Structure of grid connected PV system.

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The main elements of PV conversion are PV modules, Boost converters, Grid. As the system is grid connected no battery backup is needed and hence more complexity and more cost.

1.) PV module

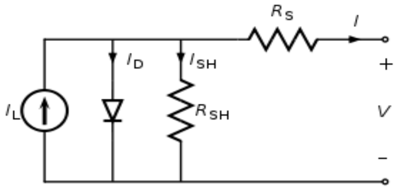

Fig.2. Equivalent circuit of PV cell

Photovoltaic cells are connected in series and parallel in photovoltaic array to obtain required current and voltage values. PV array converts the solar radiations into DC electrical energy. The V-I characteristics are obtained from Kirchhoff's law as below equation (1)

$$i = I_{ph} - I_s\left[\exp\left(\frac{v+iR_s}{Av_t}\right) - 1\right] - \frac{v+iR_s}{R_{sh}} \qquad (1)$$

Where

v is output voltage.

i is the output current.

A is quality factor of diode.

$V_t = KT/q$ is thermal voltage .

Fig.2 represents the equivalent circuit of a PV cell. Fig.3 represents current vs voltage and power vs voltage characteristics at different irradiance and temperatures.From the characteristics conclusions drawn are increase in solar irradiance will increase short circuit current and with increment in solar cell temperature will decrease the open circuit voltage of PV cell.

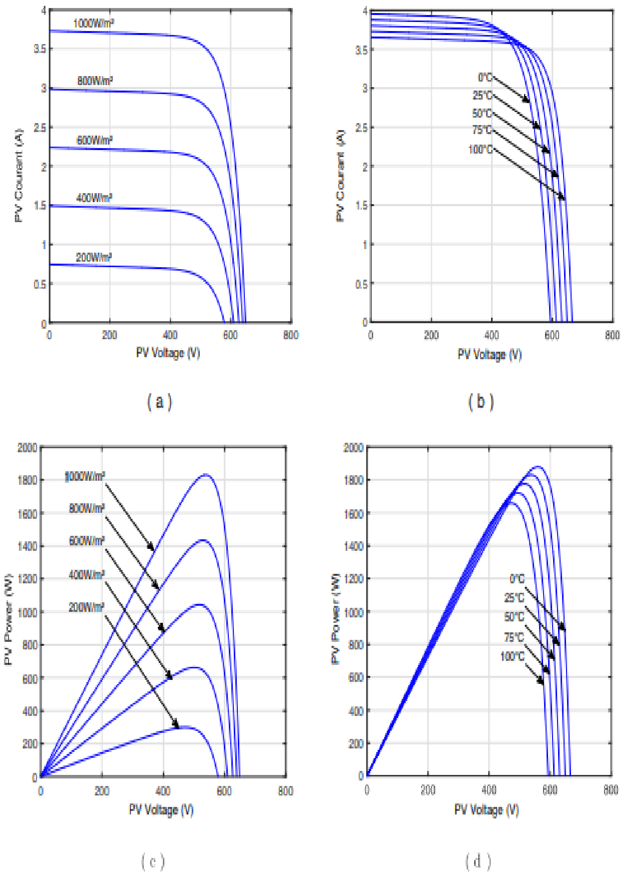

Fig.3. (a) current vs voltage curves at various irradiance.
(b)current vs voltage curve at various temperatures.
(c) power vs voltage curve at various irradiance.
(d) power vs voltage curve at various temperatures

Table.1. Parameters of 100 kW PV module

Parameter	Value
V_{oc}	64.2 V
I_{sc}	5.96 A
V_{mp}	54.7 V
I_{mp}	5.58 A
N_{ser}	5 panels
N_{par}	66 panels
K	1.38*10^-23 J/K
Q	1.6*10^-19 C
T	25 ⁰C
I_r	1000 m^2

2.) Boost Converter

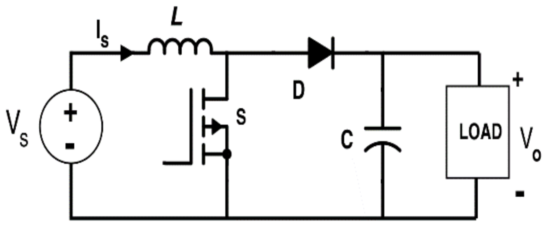

Fig.4. Circuit for Boost converter

Boost converter step ups the voltage from PV module under given conditions. Boost converter acts as a medium between the PV module and the Utility grid. The transmission of energy is done via four important components they are Inductor, Switch (which is can be any type of power electronic switch), a capacitor and a diode at the output terminals. The step up of the voltage by the boost converter depends on the value of duty cycle (k). Duty cycle can be defined as the ratio of switch ON to total ON and OFF period. Hence the output voltage ratio can be given by the equation (1).

$$\frac{V_O}{V_I} = \frac{1}{1-k} \qquad (2)$$

3.) Auxiliary devices

Auxiliary devices used in the system are filter, energy meter etc., Filters are used to reduce the harmonic current and improve the performance of the system. Energy meter is used for the measurement of energy transferred between grid and PV source.

4.) Electrical Load

Electrical load is the portion of electrical network that absorbs electrical power from the power source.

5.) Grid

Electrical grid is a circuit of synchronized power consumers and power providers who are linked by transmission and distribution lines and controlled and operated by two or more control centers. Connecting the PV module to the grid is not an easy task as large capacity PV modules are going to induce more harmonics in current and voltage waveform. So the effect of PV modules on electrical utility grid cannot be neglected.

B. Methodology

The system mainly composed of PV module, grid, connected through boost converter controlled by IC algorithm to trace the maximum power point of the PV module.

1.) MPPT controller

MPPT is algorithm which is included in the charge controllers for withdrawing peak available power from PV array. Max power differs with ambient temperature, PV cell temperature and solar radiation. Principle of MPPT is to obtain peak power from solar array by operating at optimal temperature. There are many MPPT control algorithms here this paper we use IC control technique. IC-MPPTA is based on fact that slope of the power and voltage characteristics of PV array is zero at MPP, on left side it is positive and on right side it is negative in Fig (5). While considering the slope of the Power-current characteristics they are zero at MPP, on left side it is negative and on right side it is positive.

$dI/dV = -IV$ At MPP (3)

$dI/dV > -IV$ Left side of Max point (4)

$dI/dV < -IV$ Right side of Max Point (5)

By comparison of increase in voltage (current) and increase in power between two successive trails, the variation in MPP voltage can be calculated. The flowchart for the incremental conductance scheme is shown in Fig (6).

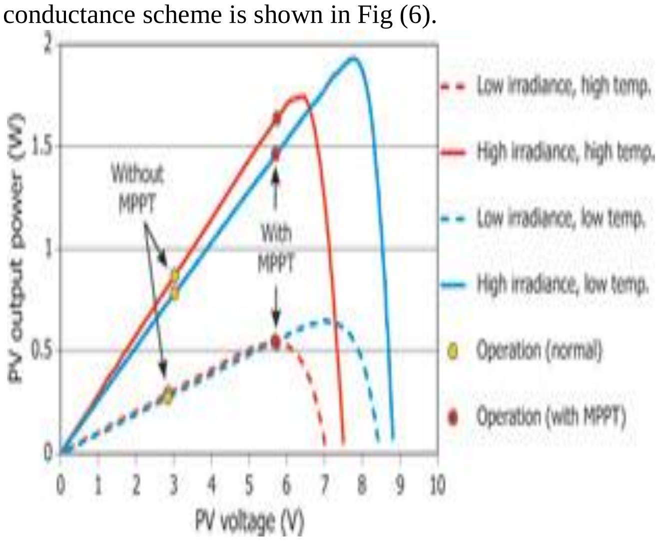

Fig (5).PV characteristics of PV module.

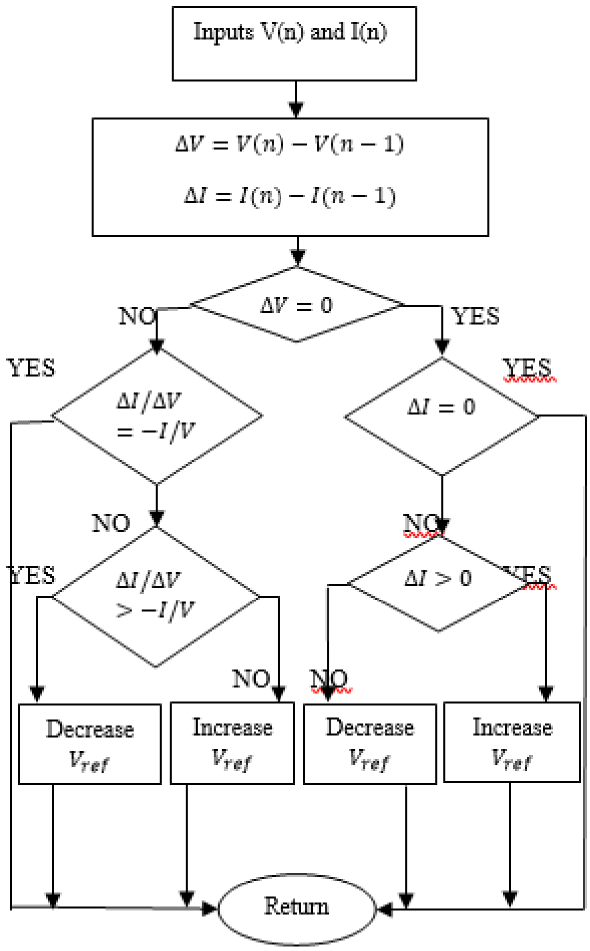

Fig (6). Flow chart of incremental conductance.

2.) Control circuit

The main aim of the control circuit is to produce Pulse width modulation signal for the inverter. Fig (7) shows the control circuit.

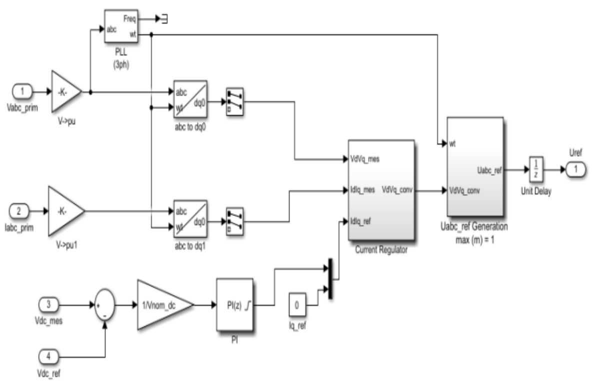

Fig (7). Control circuit

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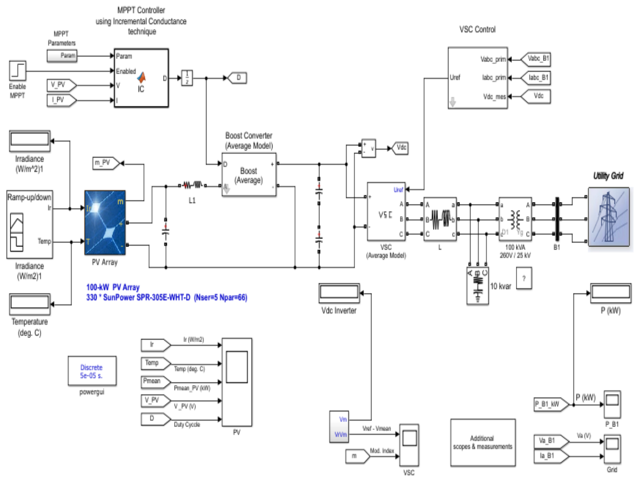

Fig.8.Matlab model of grid connected PV system.

III. RESULTS

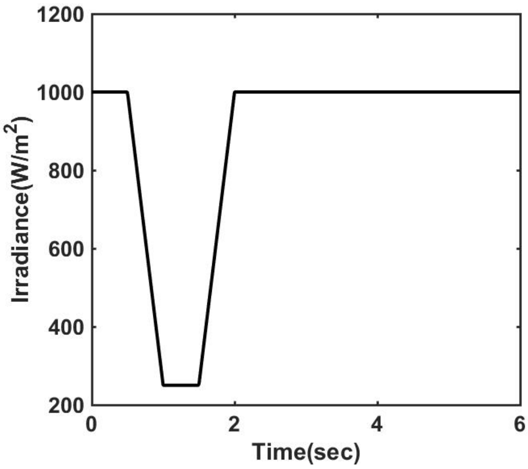

Fig.9. Irradiance in W/m^2 vs Time in seconds plot

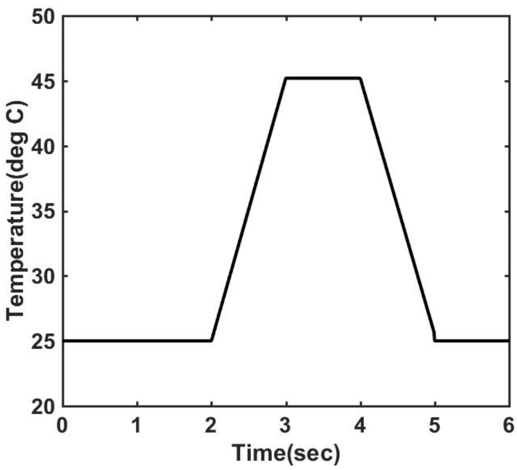

Fig.10.Temperature in deg C vs Time in seconds plot

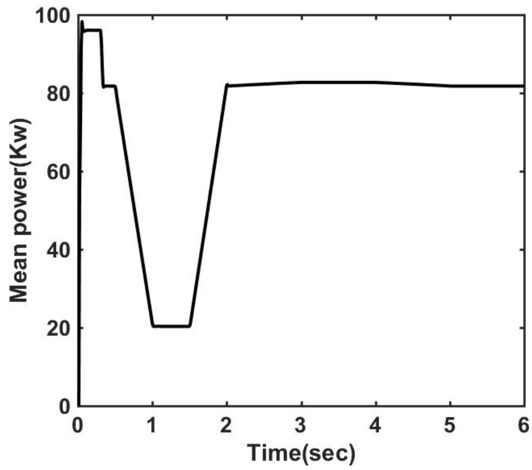

Fig.11.Mean power in Kw vs Time in seconds plot

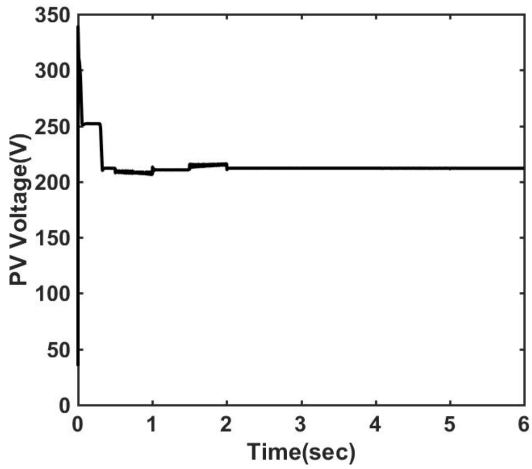

Fig.12.PV Voltage in Volts vs Time in seconds plot

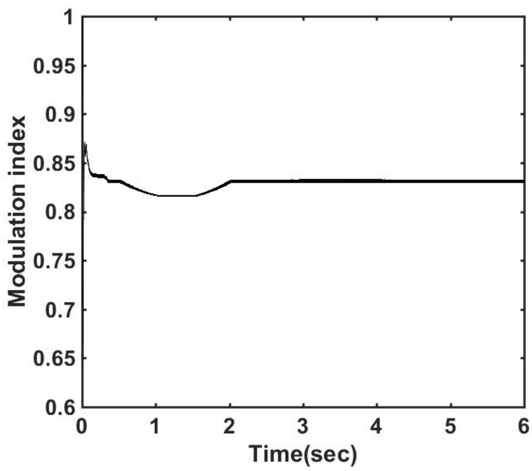

Fig.13.Modulation index vs Time in seconds plot

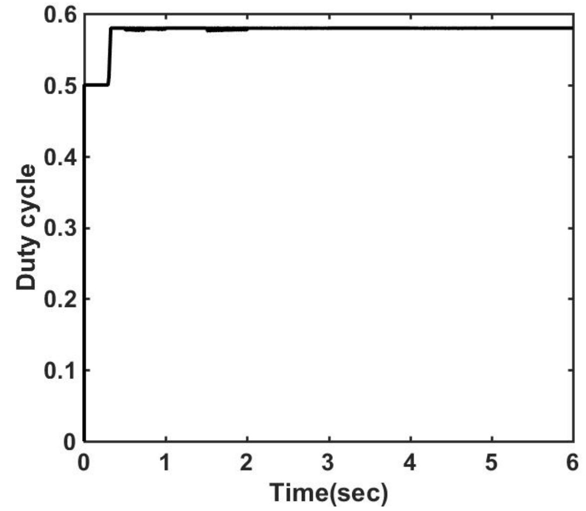

Fig.14.Duty cycle vs Time in second plot

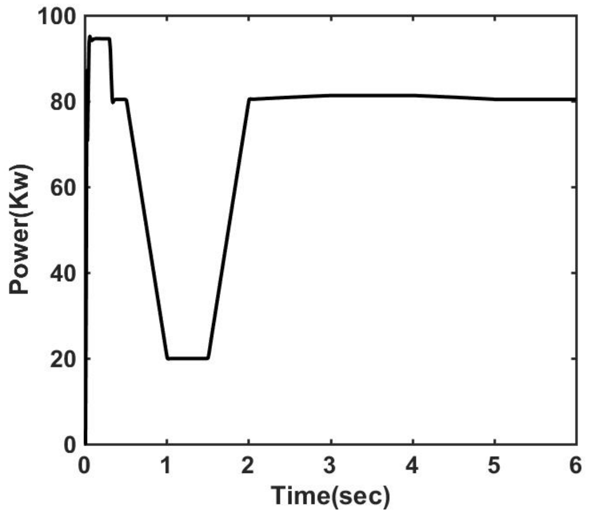

Fig.15.Power in Kw vs Time in seconds plot

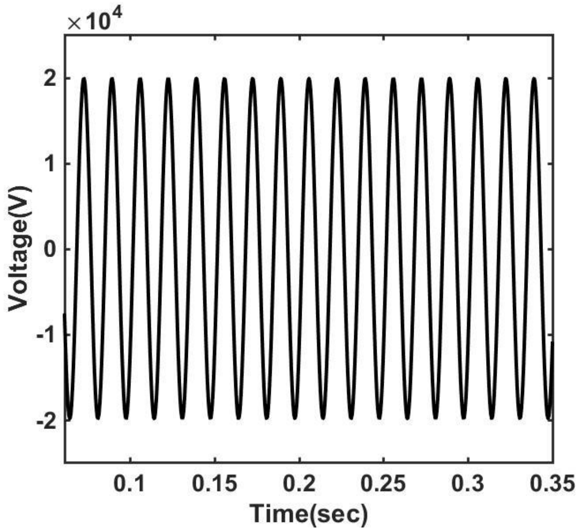

Fig.16. Voltage in voltsvs Time in seconds plot

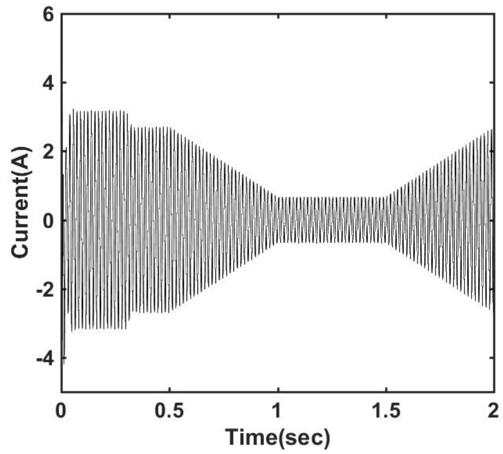

Fig.17. Current in Amperes vs Time in seconds plot

IV. CONCLUSION

The Photovoltaic module connected to grid via boost converter in this paper. This paper proposes a algorithm for drawing peak available power from the PV array using the boost converter connected to the PV system is controlled by the IC-MPPTA.The results above prove that the Incremental conductance method is performing well and can trace rapidly increment and decrementing irradiance state with more precession than P&O method.

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