IPEC Journal of Science & Technology, Vol. 02 (01), June 2023
ISSN: 2583-3286(Online)

Optimization of grid connected PV array system

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Abstract: **Renewable energy resources are becoming more and more desirable in today's times due to increase in greenhouse effect, global warming and environmental awareness. This paper proposes a grid connected PV system that harnesses solar energy by converting sunlight into direct current electricity by using semiconductors, which will be implemented by a complete distributed energy resources system. This model will contain a PV module and it will be controlled and optimized by using maximum power point tracking algorithm. Improved incremental conductance MPPT formula is used in this paper. Detailed mathematical and engineering analysis for the simulated results will be followed with the help of MATLAB software.**

Keywords - **Maximum power point tracking system, incremental conductance algorithm, Perturb and Observe Algorithm, Isolation Transformer, Photovoltaic, DC-DC Boost converter.**

I. Introduction

Nowadays, grid connected photovoltaic (PV) systems are very popular in industrialized countries and can even be considered as the most promising PV application. The integration of these systems into urban buildings offers a large potential for cost reduction and can further increase the overall value of urban architecture. As this is renewable energy resource, it is freely available. And it is 0 emission resource or environment friendly. As we connected PV array to grid. we have to connect by the MPPT controller in order to secure the maximum power output is obtained. There are various types of MPPT (maximum power point tracking) controller based on their techniques used to increase the efficiency of PV array. But they are not able to increase the efficiency at a satisfactory level. In this project we introducing the MPPT controller which is controlled by improved incremental conductance with integral control technique it gives the better efficiency among all conventional technique of MPPT controller.

Photovoltaic (PV) power generation is the most common form of solar energy generation. The output power of a single PV cell, which is the basic unit of PV power generation, is relatively low. PV array output current and voltage are affected by meteorological conditions (irradiance, power also changes continuously. Therefore, how to adjust the load characteristics so that the system can output the maximum power in real time, namely, to achieve the maximum power point tracking (MPPT), is particularly important in PV systems.

PPT methods mainly include traditional methods and intelligent control algorithms [1]. Traditional MPPT methods include hill climbing perturbation and observation, and incremental conductance methods, while intelligent control algorithms include fuzzy-logic [2], artificial neural networks

By this study aims to design the efficient method to control PV panel oscillation. As this is renewable energy resource, it is freely available. And it is zero emission resource or environment friendly. As we connected PV array to grid we have to connect by the MPPT controller in order to secure the maximum power output is obtained. In the proposed Although the effectiveness of intelligent control algorithms has been verified by experiments in many cases, the algorithms still have the disadvantages of high complexity and slow convergence speed, so have been less applied in real projects. The incremental conductance method is currently the most widely used direct control method[3].

In present scenario this is era of developing the renewable energy resources to generate electricity in solar system, the development direction of the MPPT algorithm is mainly on the continuous optimization of PV system mathematics and control model Because of the direct control of converter duty cycle, there is no need to adjust other parameters. This simplifies the MPPT control structure and has good control performance when the external environment is stable. However, the algorithm needs to constantly apply disturbance to the duty cycle to determine the maximum power point (MPP), and thus when the external environment changes, the working point may deviate from the correct tracking trajectory, resulting in misjudgement.

Date of Submission: 9 May 2023
Date of Acceptance: 20 June 2023
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ISSN: 2583-3286(Online)

This would affect the response speed and tracking accuracy of the system, and result in power loss. To maintain a fast response speed and high steady state accuracy of the PV system under changing environmental conditions, this paper proposes an improved incremental conductance method[4]. The MPPT control system is different from the module building method adopted at present, and combined with an optimized control algorithm, it can achieve a more accurate, faster and more stable tracking effect.
In this paper we experimentally proved that incremental conductance technique is superior than perturb and observe technique and it is optimised efficiently by MPPT controller.

II. BLOCK DIAGRAM

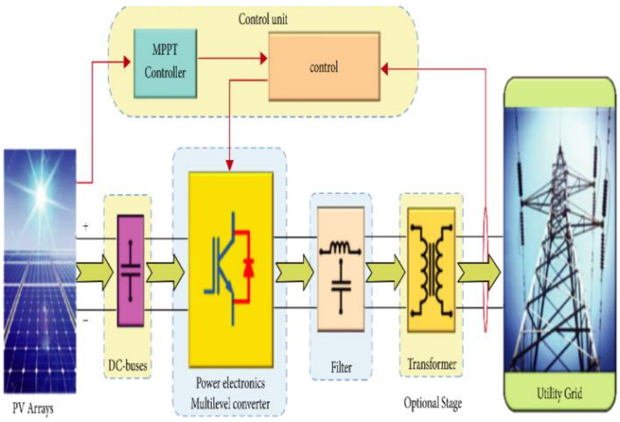

Figure .1

In this block diagram PV array is connected to DC buses to flow the current I and voltage V This I&V is then passes through the MPPT controller which is work on the incremental conductance technique after that it passes through DC-DC boost converter, then it is fed into 3 level inverter to convert the DC-AC and filter that V&I by passing through voltage source control and after that it is connected to utility grid through the transformers and feeders.

III. PV ARRAY CHARACTERISTIC

Considering economy and maintainability, centralized inverter topologies are generally used in PV power generation systems. Centralized inverters are connected to a large number of PV modules, usually using S-P configuration.
The output current of this configuration can be expressed as :

$$I = N_{PP}[I_{PV} - I_O(I_P - 2)] - \left(\frac{V + IR_S\Gamma}{R_P\Gamma}\right)$$

Where

$$I_P = exp\left(\frac{V + IR_S\Gamma}{V_T N_{SS}}\right) + exp\left(\frac{V + IR_S\Gamma}{(P-1)V_T N_{SS}}\right)$$

I and V are the solar cell output current and voltage, respectively[7]. IPV is the photocurrent, IO is the reverse saturation current, and VT is the thermal voltage of PV arrays. RS and RP are the equivalent series and parallel resistances, respectively. The output characteristics of PV cells are closely related to the solar irradiance. When solar irradiance changes, the PV array has strong nonlinear volt-ampere characteristics. It is neither a constant voltage nor a constant current, and cannot provide constant power for load. The output current is approximately constant in most of the working voltage range, though near the open circuit voltage, the current decline rate is very large. Figure 2 shows the simulation results under different solar irradiance at the PV array temperature of T = 25 °C. It can be seen from the figure that the output characteristics of the photovoltaic array vary greatly under the influence of solar irradiance. When the solar irradiance increases, the output power increase[6].

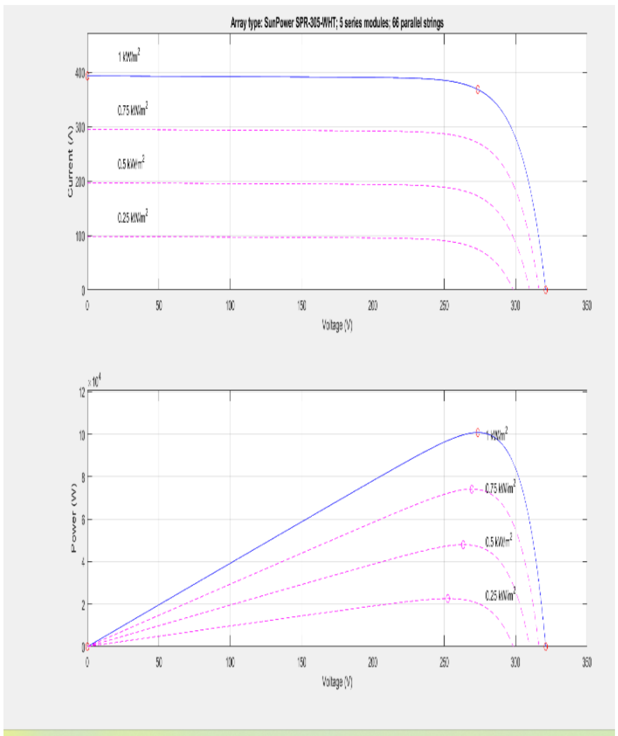

Figure .2 PV array characteristics

IV. INCREMENTAL CONDUCTANCE METHOD OF MPPT CONTROLLER (PROPOSED METHOD)

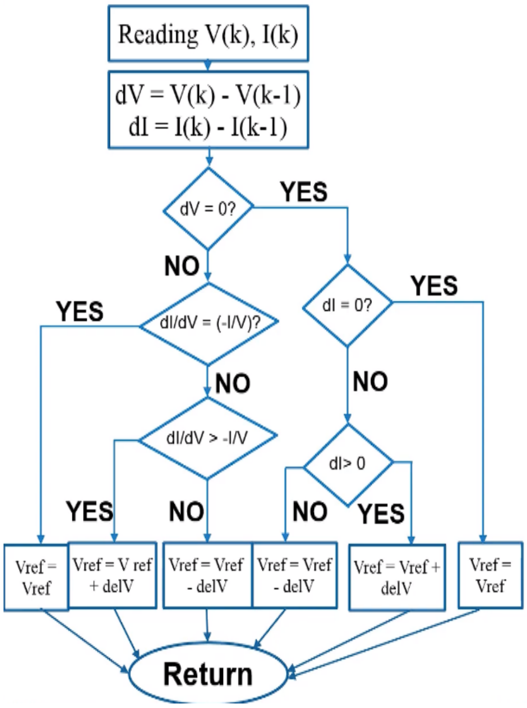

Figure.3 Flowchart of incremental conductance method

The proposed algorithm is shown in the flow chart in Fig. . When the irradiance changes, the current and voltage will be affected accordingly. This algorithm thus uses the instantaneous changes of current and voltage of PV modules. While the traditional incremental conductance algorithm makes a judgment on the position of the system operating point, the improved incremental conductance algorithm makes a judgment based on the directions of power, voltage and current[6]. Considering the system at the left side of the MPP, for the system running in the positive direction (dv > 0) the duty cycle will continue to move in the disturbance direction of the previous step, while for the system running in the negative direction (dv < 0) the duty cycle will continue to move in the opposite direction of the disturbance of the previous step. Similarly, when the system is at the right side of the MPP, for the positive system running direction (dv > 0) the duty cycle will continue to move in the opposite direction of the disturbance of the previous step, whereas for the negative system operating direction (dv < 0), the duty cycle will continue to move in the direction of the disturbance of the previous step. Therefore, the algorithm can accurately and correctly judge the disturbance direction of the next step of the working point, thus solving the system misjudgement phenomenon in the traditional method[8].
The incremental conductance algorithm detects the slope of the P–V curve, and the MPP is tracked by searching the peak of the P–V curve. This algorithm uses the instantaneous conductance I/V and the incremental conductance dI/dV for MPPT. Depending on the relationship between the two values, as expressed in (4)–(6), the location of the operating point of the PV module in the P–V curve can be determined, i.e., (4) indicates the PV module operates at the MPP, whereas (5) and (6) indicate the PV module operates at the left and right side of the MPP in the P–V curve, respectively.

$$di/ dv = -I/V$$

$$di/dv > -I/V$$

$$di/dv < -I/V$$

The above equations are obtained from the concept where the slope of the P–V curve at MPP is equal to zero, i.e.:

By rewriting (7), the following equation is obtained:

$I + V\, di/dv = 0$

In the conventional incremental conductance algorithm, is used to detect the MPP, and the voltage and current of the PV module are measured by the MPPT controller. If it is satisfied, the duty cycle of the converter needs to be decreased, and vice versa if is satisfied, whereas no change on the duty cycle if is satisfied [9].
Proposed incremental conductance algorithm
The incremental conductance algorithm depends on the slope of the P–V curve, which is affected by the solar irradiation level and load resistance. As the algorithm uses the current and voltage of the PV module in the calculation, the effect of solar irradiation and load changes on the current and voltage of the PV module must be considered in the algorithm.

Table 1 Changes in PV voltage and current during changes in solar irradiation and load resistance

		dV	dI
Solar	Increase	Increase	
Irradiation	Decrease	Decrease	
Load	Increase	Increase	Decrease
Resistance	Decrease	Decrease	Increase

Changes in PV panel.

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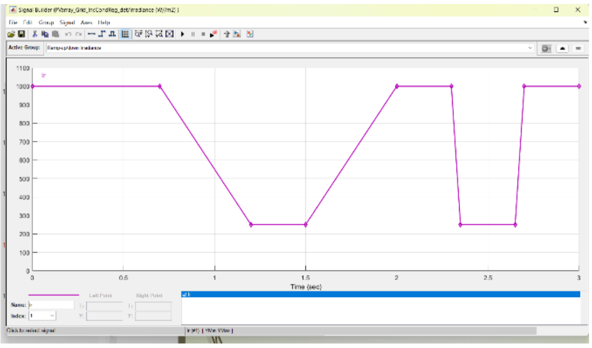

Figure.4 Irradiance of PV panel

There are many different words and meanings such as solar radiation (electromagnetic), solar irradiance (for power), solar irradiation (for energy), as well as solar insolation to describe the amount of sunlight that is available at any particular location.

V. SIMULATION RESULTS AND ANALYSIS AND COMPARISON WITH ANOTHER P&O METHOD

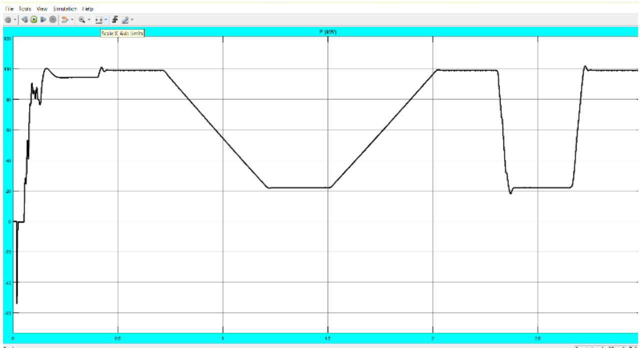

Figure .5 Graph of power of proposed technique

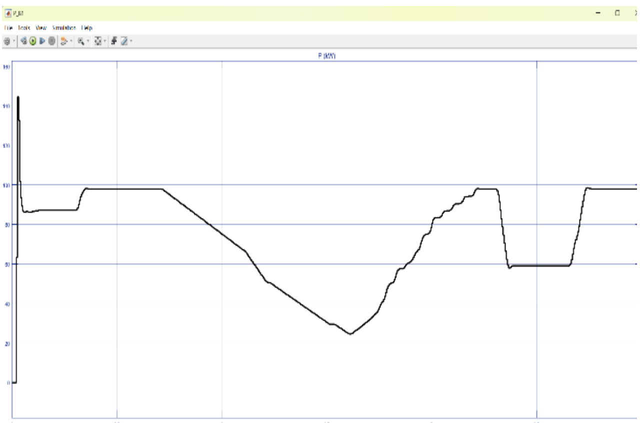

Figure .6 Graph attained for same irradiance by P&O MPPT controller

In fig.6 incremental conductance technique of MPPT controller, power versus time graph is attained according to the irradiance of sunlight which is varying continuously. if we attained the 100.7KW power in DC form we got 99.04KW at utility grid side after changing the DC into AC by inverter.

In fig.5 P&O technique of MPPT controller, power versus time graph is attained according to the irradiance of sunlight which is varying continuously but in this technique the variation of power is more as compared to the irradiance it is unable to follow the variation or changing irradiance in this we attained 101.6KW power in DC and we got 97.99KW power at utility grid side after changing the DC into AC. From here we clearly saw that incremental conductance technique is superior than P&O technique.

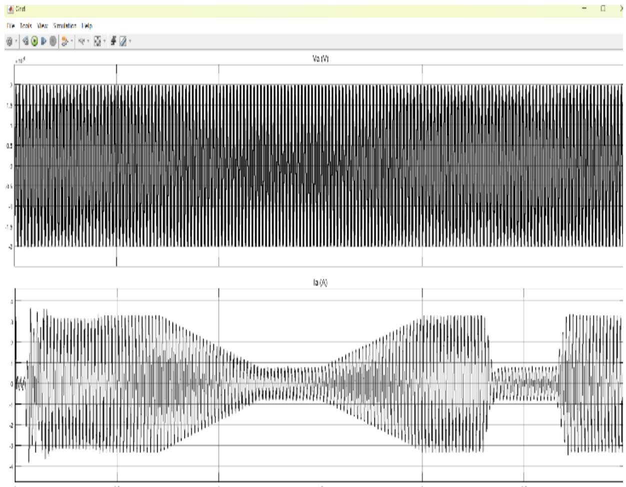

Figure .7 Voltage and current waveform attained by incremental conductance technique

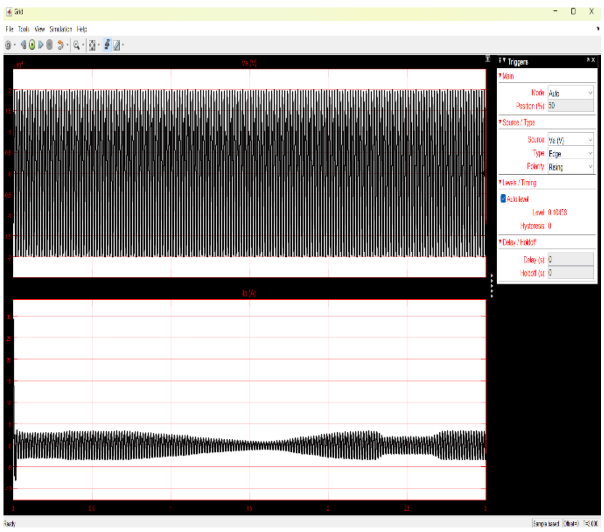

Figure. 8 Voltage and current waveform attained by Perturb and Observe method

ISSN: 2583-3286(Online)

VI. CONCLUSION

In this paper, an incremental conductance algorithm is proposed to track the MPP for a PV module under a fast-changing solar irradiation level. The confusion faced by the conventional algorithm is discussed and modifications are proposed to mitigate the inaccurate response. Compared with the current research status, the control system structure of the proposed algorithm is simpler and more stable, and can accurately respond and track MPP no additional hardware components are needed in implementation. It can thus be easily implemented using a low-cost microcontroller, increasing the likelihood of the method being adopted in real PV power generation systems.

VII. ABBREVIATIONS

PV: Photovoltaic; MPP: Maximum power point; MPPT: Maximum power point tracking; STC: Standard test conditions; P-V: Power-voltage; P-D: Power-duty cycle ,AC-alternating current, DC: direct current, INC :incremental conductance technique, P&O: perturb and observe

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