International Journal of Engineering Research and Science & Technology

IJERST

ISSN : 2319-5991
Vol. 4, No. 4
November 2015

www.ijerst.com

Email: editorijerst@gmail.com or editor@ijerst.com

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 4, No. 4, November 2015

Research Paper

OPTIMAL DIGITAL CONTROL APPROACH FOR MPPT IN PV SYSTEM

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This paper demonstrates the implementation of P&O MPPT controller. Solar power being the primary source of energy is of main focus in field of energy conversion. The techniques to generate maximum power from simple PV-module are the major challenge. Power electronics have helped to obtain the goal to a greater extent. In this paper attempt have been made to study and analyze different MPPT techniques used in different scenarios to make it simple to choose a particular methodology for particular situation. A new Digital Control Technique Based MPPT is proposed to Track and Maximum Power. MPPT is a method to obtain the maximum power from a module in any weather condition. As solar energy is varying in nature, the MPPT is the main focus of energy conservation. Simulation was conducted to test the effectiveness of the proposed algorithm. Results obtained from simulation proved the effectiveness of the proposed controller making it suitable for hardware implementation.

Keywords: P&O algorithm, MPPT controller, Power electronics, PV system, Solar energy

INTRODUCTION

The world energy scenario is changing abruptly. The huge power demand the world face is becoming a challenge to human day by day. Technology improvements have helped to face this situation better, but it also have created other more challenges regarding the quality of power and efficiency. The conventional energy sources that we relied upon are in stage of being replaced by the renewable energy sources that are widely available.

Recent researches focus mainly on the solar energy that almost all the part of this world receives abundantly with variation in its potential. Many studies have made it possible to convert these energies in to more efficient electrical energy. The intervention of power electronics in almost of all the fields have made more sophistication in industries with loads that require the most efficient and accurate amount of supply. The terminology Maximum power point tracking came in to existence with all these conditions. MPPT is a method to obtain the maximum power

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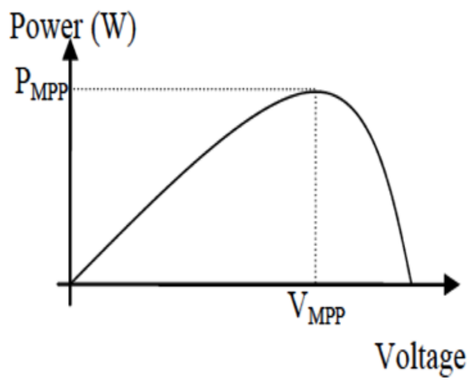
from a module in any weather condition. As solar energy is varying in nature, the MPPT is the main focus of energy conservation. By the V-I characteristics of solar energy, there is only one point in its curve where the maximum power is achieved. Tracking that particular point with accuracy has developed many algorithms in this field. Just as the energy that is variable, the techniques used to track the MPP vary under different circumstances. All algorithms will not suit every module in general. PHOTOVOLTAIC (PV) panels are used to convert solar energy into electric power. The output characteristics of a solar PV panel are dependent on operating conditions such as irradiance level and surrounding temperature. Maximum power points (MPPs) exist on the PV panel characteristic curves where the output power from the solar panel is maximum. Maximum power point tracking (MPPT) algorithms and techniques such as perturb and observe (P&O) algorithm, incremental conductance (InCond) algorithm, ripple correlation control (RCC) algorithm , fractional voltage/current MPPT method and neural network (NN)-based MPPT control have been developed to extract the maximum power from the PV panel. The P&O method, which locates the MPP using the slope of the *P–V* characteristics curve, is widely used due to its simplicity and ease of implementation.

PROPOSED ALGORITHM

The proposed load-current adaptive step-size and perturbation frequency (LCASF) MPPT algorithm adaptively generates large perturbations with longer perturbation periods during transients to achieve fast and stable dynamic response and generates small perturbations with shorter perturbation periods that results in high efficiency and lower oscillations during steady-state operation. The trade-off between fast dynamic response and high efficiency steady-state operation with lower oscillations around the MPP for the load-current-based MPPT method is addressed in this research by developing and using an adaptive-step-size and perturbation-frequency MPPT algorithm. The proposed LCASF MPPT algorithm utilizes an adaptive-perturbation frequency scheme with higher perturbation frequency when the perturbation is smaller, and vice versa.

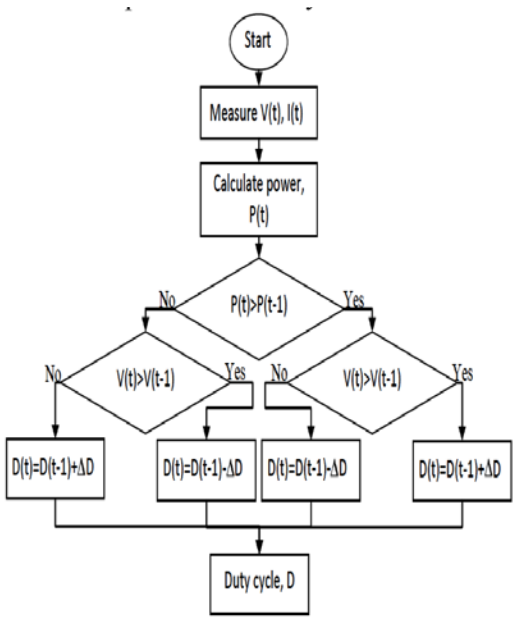
Common approach of implementing P&O algorithm would be through periodically sampling. With P&O, the PV voltage is sampled along the P-V curve characteristic towards the optimum point. Power is calculated corresponding to voltage change, the difference in power range, P will determine the tracking direction along the P-V curve (Figure 1). Oscillation normally occurs at maximum power point but can be reduced with smaller step size.

Figure 1: P-V Curve Characteristic



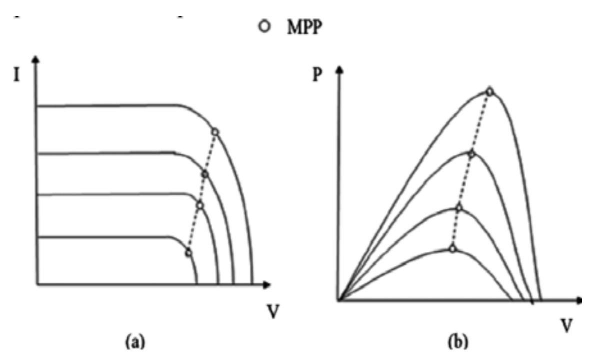
The process flowchart of P&O algorithm. Any increase in PV power and PV voltage will be added to the perturbation duty cycle step size, ΔD or vice-versa. Duty ratio, D of the controller is used to control the parameter directly.

Figure 2: P&O Flowchart



Many algorithms are formulated for PV system. The main aim is to find the point in the V-I characteristics of the solar panel, at which the product of Voltage and current is maximum. It is found that there is only one point in the curve at particular temperature and irradiation condition.

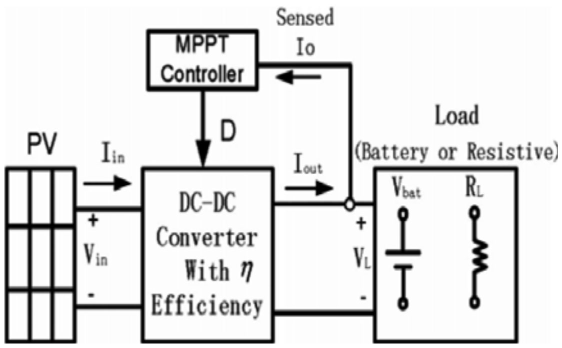
Figure 3(a): V-I Characteristics (b) P–V Characteristics of PV Panel at Different Environmental Conditions



As the solar energy is a promising form of energy to meet our power demand, technology improvement is required to keep the power generated from PV panels to be maximum at all weather conditions. Many algorithms are being developed to find the maximum point of power obtained from a cell, module and hence a panel. Many algorithms are being developed for MPPT. From the basic study, the main algorithm used in almost all applications is the Perturb and observe method. For a digitally controlled DC grid system this algorithm could show an efficiency of 99.5%. By comparing the perturb parameter used OF P&O method as voltage or direct duty ratio for standalone PV pumping application, the D.D.R perturb method was found to perform better. In area where more than one energy source is used, the P&O algorithm finds its enhanced way to track the MPP for boost converter along with time based power monitor, giving an efficiency of 83%. The efficiency of P&O, wanted a modified algorithm to achieve recovered results for different circuits. The perturbation made in this algorithm is fixed which cannot be utilized for converters other than conventional boost converter. But varying the method or parameter of perturbation it was able to use in different cases. With adaptive frequency perturbation, the system with single sensor PV module achieved more efficiency when compared to other algorithms like Inc. Conductance, Ripple Co-relation Control (RCC) Fractional V or I method and Neural Network with fixed perturbation and requiring multiplication factor. For frequency modulated resonant LLC micro-converter the centre point perturbation methods is more valid. Later on for further applications the P&O method was integrated with other algorithms to find a better MPP. The analog MPPT method established to be accurate than the conventional. Analog MPPT method combined with the existing was found to give an efficiency of 97.3% with slope detection algorithm and P&O. For DSP based stand alone system with dual MPPT configuration, the P&O integrated with Fuzzy Logic achieved a greater Convergence speed and reduced Steady state oscillation. Comparison between P&O and fuzzy logic along with PID was made in particular area of Algeria. The study found that P&O method achieved its stability in 9s and fuzzy logic for 5s.with PID the voltage regulation was achieved to maximum efficiency. For energy harvesting small rating of solar modules the power dissipated through the switches effect the efficiency. The fractional open circuit method with P&O helped to reduce the power utilized by the tracking system and to improve the system effectiveness. Above all the partial shading conditions on PV panel have reduced the competence in MPP tracking. The fuzzy logic integrated with PID was analyzed on varying irradiance and temperature conditions. The

PID controller performed well during partial shading conditions.

Figure 4: Block Diagram of a PV Solar Power System with Load Current MPPT Control



The below figure 4 shows a PV solar system block diagram with the proposed LCASF MPPT controller. The power conversion process from the PV panel to the load (battery load or resistive load) interfaced through a dc-dc converter with efficiency equal to η. The dc-dc converter regulates the voltage and current of the solar panel and thus it regulates the output power. The MPPT controller keeps adjusting the duty cycle of the power converter to reach the MPP of the solar panel.

SIMULATION RESULTS

The power converter topology used is a synchronous dc–dc buck converter, operating in continuous conduction mode with 100-kHz switching frequency and PWM control. PV panel ratings and power converter parameters are identical with the parameters in the system response time analysis in the last section and results as shown in Figures.

Figure 5(a),(b),(c) PV Panel Voltage, Current, and Load Current Waveforms Under Input Transient Response of Controller with Battery Load for LCASF Algorithm

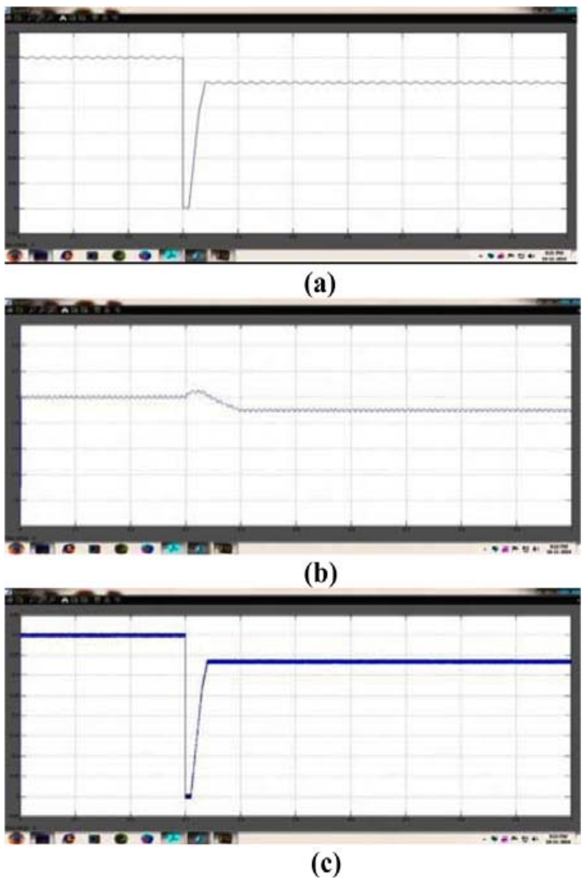
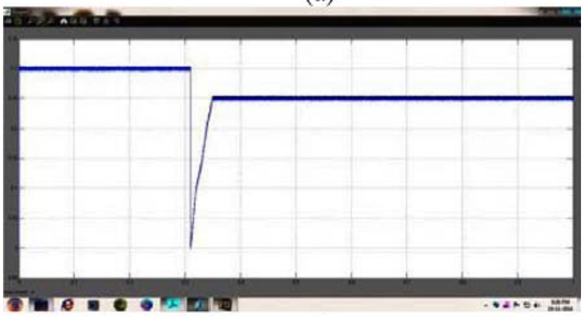
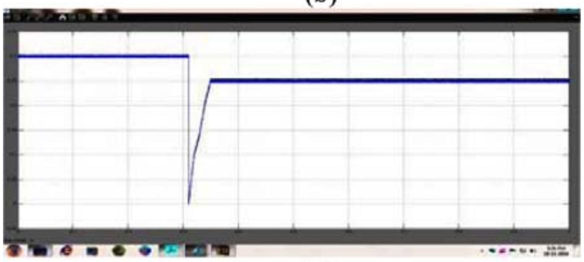


Figure 6: (a),(b),(c) PV Panel Voltage, Current, And Load Current Waveforms Under Input Transient Response of Controller With Battery Load for LCA Algorithm

(a)

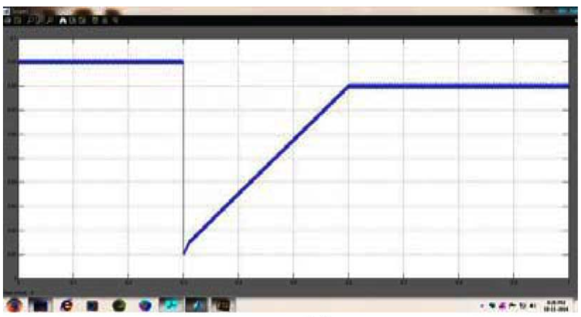


(b)



(c)

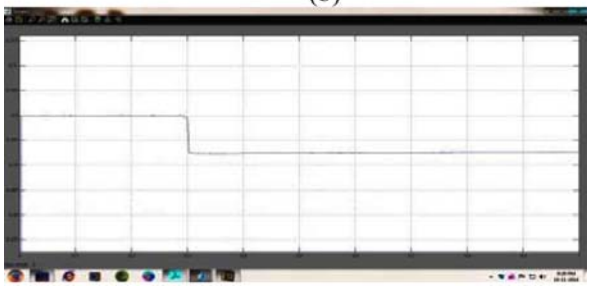
Figure 7: (a),(b),(c) PV Panel Voltage, Current, and Load Current Waveforms Under Input Transient Response of Controller With Battery Load For 1% Fxs Algorithm



(a)

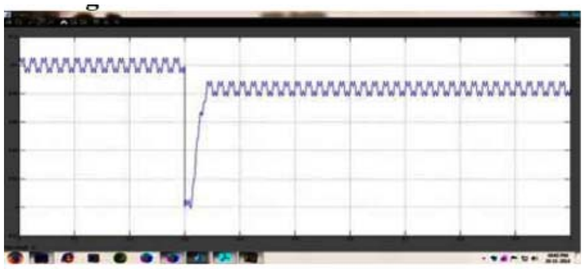
Figure 7 (Cont.)

(b)

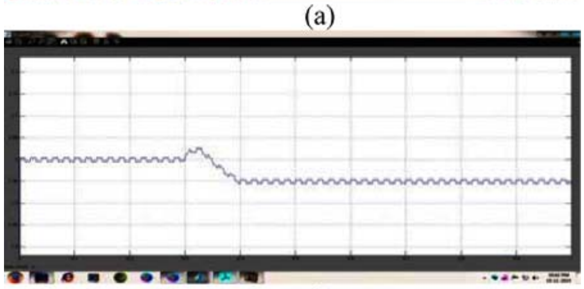


(c)

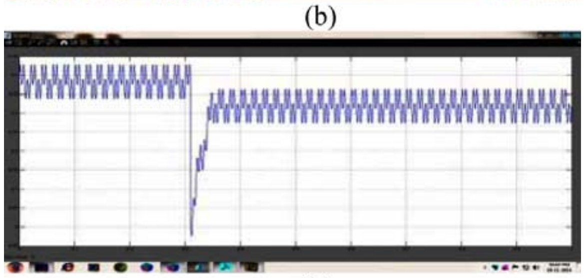
Figure 8: (a),(b),(c) PV Panel Voltage, Current, and Load Current Waveforms Under Input Transient Response of Controller with Battery Load For 5% Fxs Algorithm.



(a)

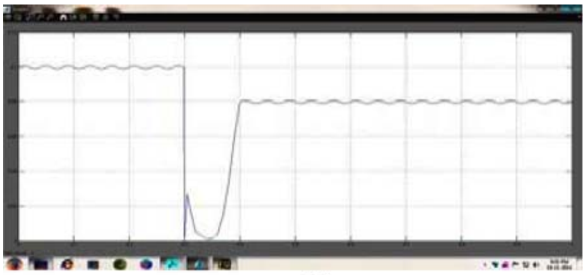


(b)



(c)

Figure 9: (a),(b),(c) PV Panel Voltage, PV Panel Current, and Load Current Waveforms Under Input Transient Response of Controller with Resistive Load for LCASF Algorithm

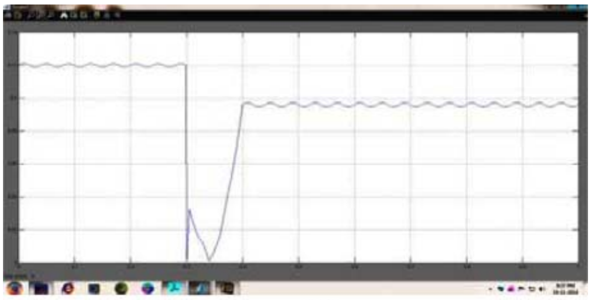


(a)

(b)

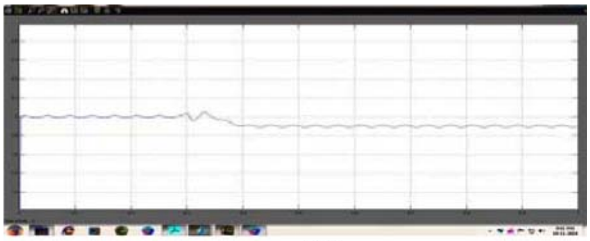
(c)

Figure 10: (a),(b),(c) PV panel voltage, PV panel current, and load current waveforms under input transient response of controller with resistive load for LCA algorithm.

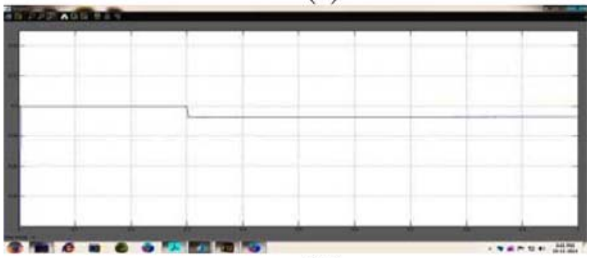


(a)

Figure 10 (Cont.)

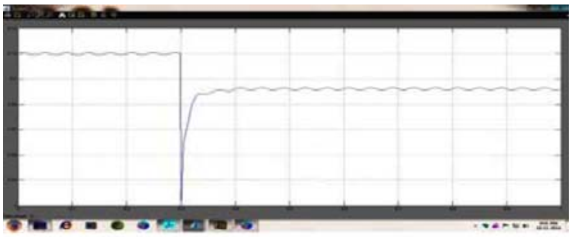


(b)

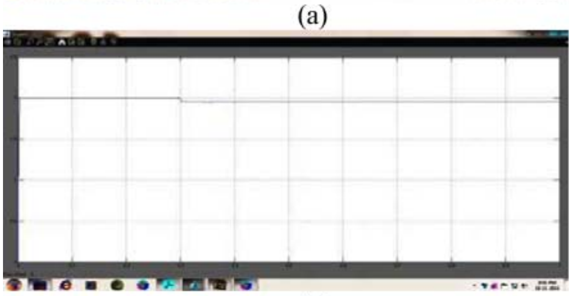


(c)

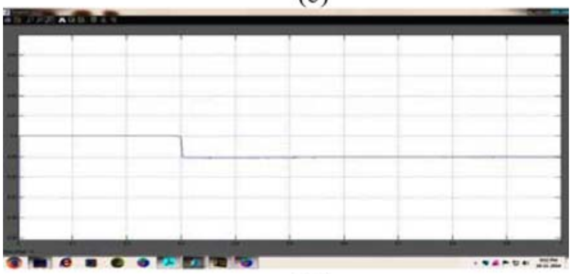
Figure 11: (a),(b),(c) PV Panel Voltage, PV Panel Current, And Load Current Waveforms Under Input Transient Response of Controller With Resistive Load For 1% FXS Algorithm



(a)

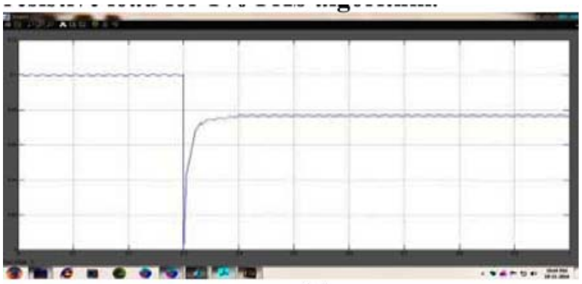


(b)

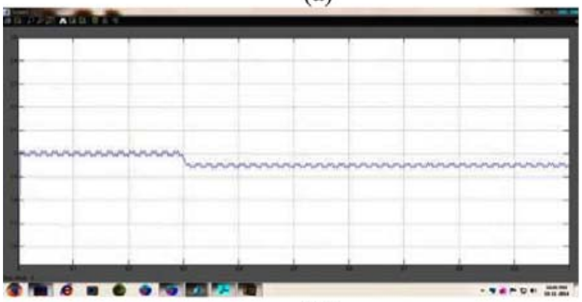


(c)

Figure 12: (a),(b),(c) PV Panel Voltage, PV Panel Current, And Load Current Waveforms Under Input Transient Response of Controller With Resistive Load For 5% Fxs Algorithm



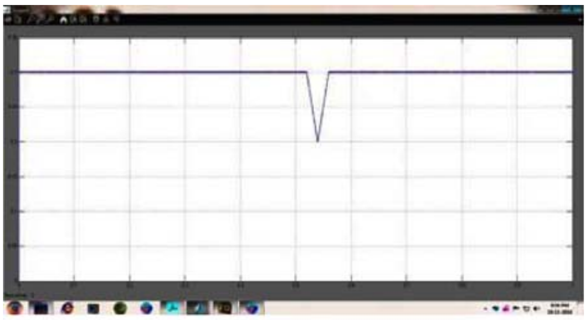
(a)



(b)

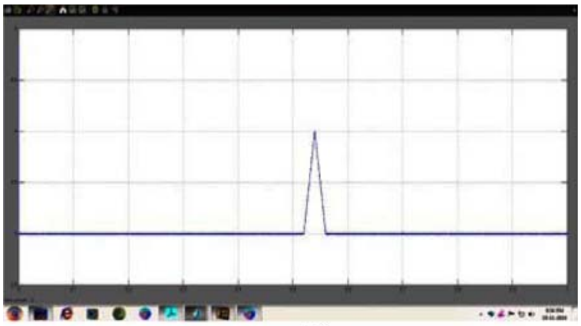
(c)

Figure 13: (a),(b),(c),(d) PV Panel Voltage, Current, Load Current, And Voltage Waveforms Under Load Voltage Transient With LCASF Controller

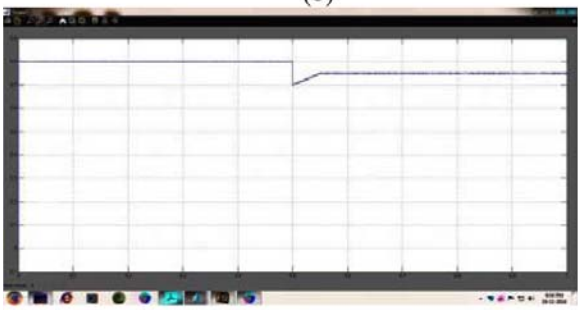


(a)

Figure 13 (Cont.)



(b)



(c)

(d)

CONCLUSION

The simulation and graphical analysis of grid connected photovoltaic system at varying irradiation level by using power based perturb and observe maximum power point tracking algorithm (conventional method with fixed step size) have been done in the form of voltage, current and power as shown in Figures respectively. This algorithm tracks both the voltage and current of the PV array so that PV array operates at maximum output power (Pmpp). The Increased power demand paved the way to invent new technologies to improve the power obtained from renewable energy sources. From various studies the hill climbing algorithms such as perturb and observe and incremental conductance is seen to be better than all other MPPT algorithms. The efficiency is high in perturb and observe and Incremental conductance methods Though soft computing techniques like fuzzy and neural networks are developing. Individual MPPT for each PV module differ in varying circuit topologies. For stand alone and grid connected systems with conventional converters perturb and observe method finds its better performance. For improvised or resonant inverters, modified P&O methods need to be included. Improved PSO is been utilized mainly in partial shaded conditions and to reduce oscillations. An varying irradiation by using current based adaptive step size and perturbation frequency maximum power point tracking algorithm graphical analysis have been done on the basis of power current and duty cycle as shown in graphs. The output power, voltage and the load current waveforms are shown in figures respectively.

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ISSN 2319-5991