Design and Analysis of PV System with P&O Method MPPT Technique and PID Controller

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Abstract (Size 10 & bold &Italic)— The aim of the proposed research work is to analyze the performance of PV system with MPPT Algorithm using (P&O method) & without MPPT system. The proposed system consists of the PV system using MPPT techniques, Boost converter and PID controller. The performance parameters considered are the output voltage from PV with and without MPPT, Output voltage of Boost Converter, Voltage and current of the load after application of PID controller. Also the Power from PV is also analyzed.

Keywords — *MPPT; PV system; PID Controller; Boost Converter.*

I. Introduction (Size 10 & Bold)

The objective for implementing MPPT is to maximally utilize the Solar Photo voltaic panels. This is done by making the PV module operate following the instructions set developed in the form algorithm to track the point of maximum power point. MPPT system is a power electronic device based converter system controlled through control algorithm to track the point of maximum power [1]. This technique is different from the mechanical tracking system. MPPT electronic tracking and mechanical position tracking system can be utilized in conjunction to achieve the goal. Maximum power point tracking circuits, utilize different types of control methods or logic to search for the optimal power point and allow converter circuit to extract maximum power available from a cell at any particular duration [2].

PV system has the drawbacks of, (i) low energy conversion efficiency and (ii) high initial cost. The energy efficiency can be improved by making PV system operate always at the point of its maximum power on the Power Voltage curve [3]. For different set of operating conditions PV system offers different I-V characteristics and for any of such sets, PV cells have a single operating point where the values of the current and voltage of the cell result in a maximum power output. These values of PV cell voltage and current is related to a particular value of load resistance [4]. There are various topologies are used for integration of power from different energy sources [5]. A PV cell, acts as source of constant current, for major portion of its useful current voltage curve. In the region of maximum power point of I-V curve, there is an inverse exponential relationship between current and voltage. The power delivered by the PV system has the maximum value where the derivative (slope) dI⁄dV of the I-V curve is equal and opposite to the I/V ratio. The value can be mathematically obtained by havingdP⁄(dV=0). The knee of the current voltage curve corresponds to the point of maximum power [6].

When a load is directly connected to the solar panel terminals without any signal conditioner in between, the operating point of the panel does not attain the peak power point [7]. This is because; the impedance perceived by the PV panel, derives the operating point of the solar panel. Thus by varying the impedance seen by the panel, the operating point can be shifted towards peak power point. PV panels output is DC and a proper DC-DC converter is employed to transform the impedance of source to the load [8]. By varying the duty cycle of the DC-DC converter results in an impedance change as seen by the panel. At a particular impedance (or duty ratio) the operating point will be at the peak point of power transfer. The current voltage curve of PV panel varies with changes in environmental situation. Therefore, fixing of the duty cycle is not feasible with such dynamically changing operating conditions. MPPT algorithm takes samples of PV array voltage data and current data as received by the voltage and current sensors at frequent intervals. Based on such algorithm, the dc converter duty cycle is adjusted as required. Algorithm is deployed in microcontroller which then sends the controlled output to the converter [9].

A. MPPT Technique

Locating the Maximum Power Point is a challenging issue, and for this purpose several techniques are developed. The developed techniques are at variance in terms of complexity, effectiveness range, sensor requirement, cost, convergence speed, correctness in tracking with change in irradiation and change of temperature and hardware implementation. Among the several MPPT techniques, the Perturb and Observe is the most usually employed algorithms [10] [11].

B. Perturb and Observe Method

In perturb and observe method the voltage and current associated with the Photo Voltaic array are measured with the help of sensors and sent to the controller. The controller algorithm receives the samples of voltage and current data and evaluates the panel power at every instant. The array voltage is increased in small increments through the dc converter by controlling the duty cycle. The array power, so evaluated, is compared with power obtained in the previous sampling event. If the result from the comparator indicates the increase in power; then the voltage is further adjusted in the same direction. This process is repeated till the power reaches its maximum value. This method of increment of voltage many a times leads to oscillations of output power which is considerable undesirable. It is also known as the ‘hill climbing’ method, because it depends on the rise of the power-voltage curve below the peak power point, and the fall above that peak point. In the P&O method the cost of implementation is less [12]

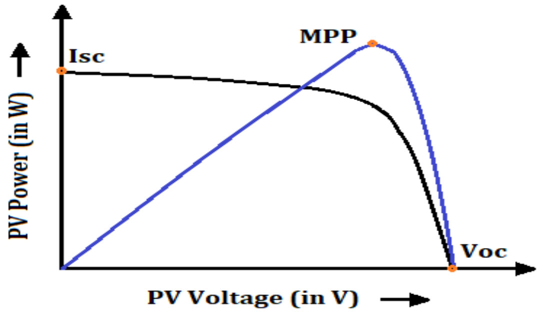

Fig. 1 PV Power-Voltage Characteristics

The algorithm involves perturbation of duty ratio of the converter driving pulse. Perturbation of the power converter duty ratio leads to the modification of the DC-link voltage between the power converter and the PV array. The polarity of the sign indicates the increment or decrement in the power level, the sign pertaining to last perturbation and last increment value of power is the decisive factor that gives impetus for the next perturbation. From figure 3.9, it is evident that power increases with increase in the power however on the right side of MPP, decreasing the voltage decreases the power [13].

II. Simulation of PV system Using Perturb and Observe method

The simulation of PV system with MPPT (P&O method) is presented in figure 2. The system consists of the PV system, Boost converter, PID controller & MPPT control. The detailed simulation parameters are given in table1.

TABLE I
SIMULATION PARAMETERS PV SYSTEM WITH MPPT

DC Source	
Solar Photo Voltaic Panel:	
PV output Voltage, V_{PV}	80V
Irradiation	1000W/m^2;
Temperature	25ºC
Parallel Strings	4
Series modules per String	2
Module	1Soltech 1STH-350-W
Maximum Power (W)	500W
Open Circuit Voltage, V_{OC} (V)	51.5
Short Circuit Current, I_{SC} (A)	9.4
Voltage at Max Power Point, V_{mp} (V)	43
Current at MaxPower Point, I_{mp} (I)	8.13
TempCoefficient of V_{OC} (% per ºC)	-0.36
Temp Coefficient of I_{SC} (% per ºC)	0.09
Cells per module, N_{cell}	80
Light generated Current, I_L (A)	9.4447
Diode Saturation Current, I_o (A)	3.23e-10
Diode Ideality Factor	1.045
Shunt Resistance, R_{sh} (Ω)	47.96
Series Resistance, R_{se}(Ω)	0.22828
PID controller	
Kp	0.00001
K_D	0.000015
Ki	0.000015
DC-DC Converter	
Vout	200V(dc)
Duty Ratio, δ	0.62
Carrier Frequency SPWM, f_c	10kHz
Line inductor, L	15uH
DC Link Capacitor, C	22uF

The results were obtained from the simulation and presented in the results section. The parameters evaluated are PV voltage and Current with and without MPPT, output power of the system, output voltage from the boost converter and the output voltage and current. Also the THD of the load Voltage is presented to investigate the harmonic distortion in the load voltage.

Figure 3 shows the functional block of MPPT controller. The output voltage from the PV along with the reference voltage is given to the P& O block. The MPPT controller is developed based on the fact that the perturbation in the power is kept in direction identical with increment in the power. While, if there is decrease in power, then the direction of following perturbation is reversed.

Figure 4 presents functional block of PID controller. The PID controller manipulates the process variable through feedback. The error values are continuously calculated as the difference between the desired set points and the measured process variables and applies a correction based on Proportional (KP), Derivative (KD) and Integral (KI) terms. It automatically applies accurate and responsive corrections to a control function. Figure 4 shows the application of PID for the PV system [14] - [16].

III. Results & Discussion

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A. Simulation Result of PV system With MPPT

The simulation of PV system is performed in MATLAB using P&O method for the MPPT and the output voltage is observed to be 70V as shown in figure 5.

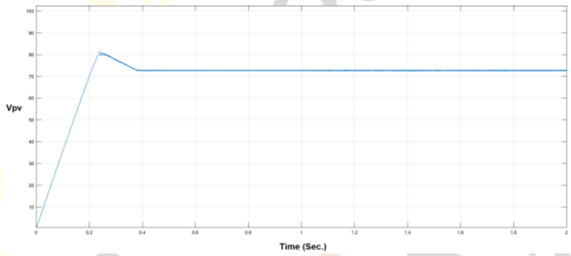

Fig 5: Output voltage of PV system Using MPPT

Figure 6 shows the output voltage, Current and Power from the PV system with MPPT and it is observed from the figure that the Vpv is nearly 72 V, Current is 7A and maximum power is of 500W.

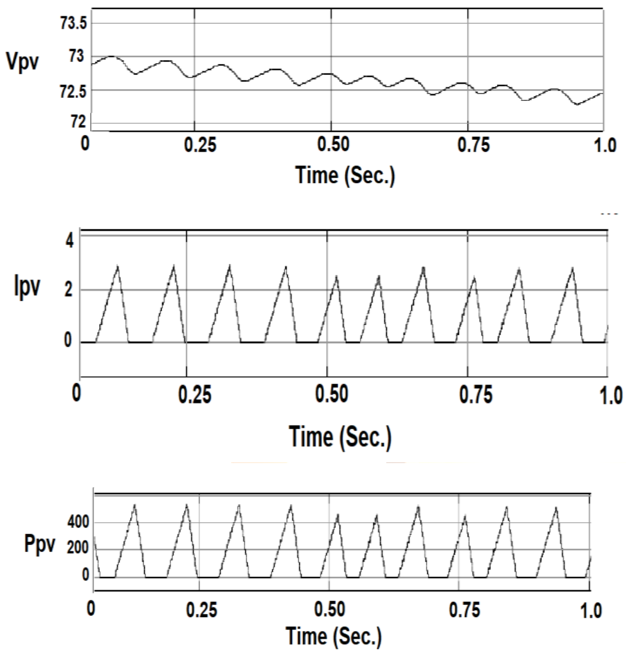

Fig 6: Simulation Vo, I & P of the PV System

B. Simulation Result of DC-DC Converter

In order to maintain a constant voltage across the load, a DC-DC boost converter is employed to increase the voltage across the inverter. The duty cycle of the converter is 0.62 and the output voltage is observed as 200V as presented in figure 7.

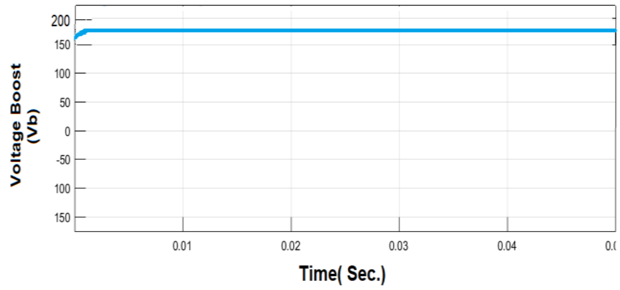

Fig 7: Output Voltage from the Boost Converter

C. Power from PV using MPPT

The mean power output of the system after application of MPPT controller and PID controller are presented in figure 8 and figure 9. From the figure it is clear that the active power is nearly 90 W while the reactive power is negligible 0.8W. Figure 8 shows the active power and figure 9 shows the reactive power.

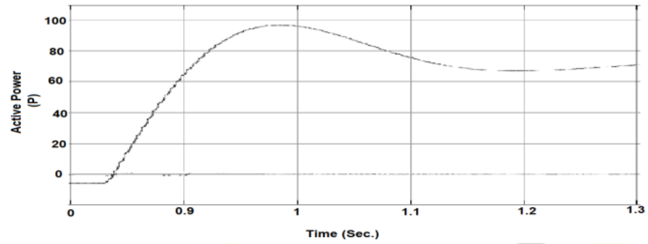

Fig 8: Active Power from the PV System

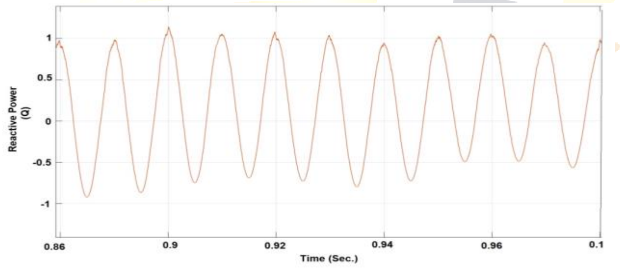

Fig 9: Reactive Power from the PV System

D. Load Voltage and Current

The load voltage is purely sinusoidal as from the simulation it is clear that the output from the boost converter is fed to the inverter passing through filter unit also the output voltage from the converter is well synchronise through the PID controller to maintain constant voltage across the load. Figure 10 and Figure 11 presents the output voltage and current across the load respectively. The peak to peak value of load voltage is 150 V. The harmonic investigation through FFT analysis of the load voltage is presented in figure 12 and it is found to be 0%.

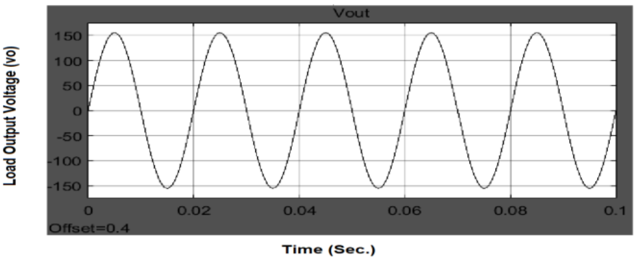

Fig 10: Load voltage

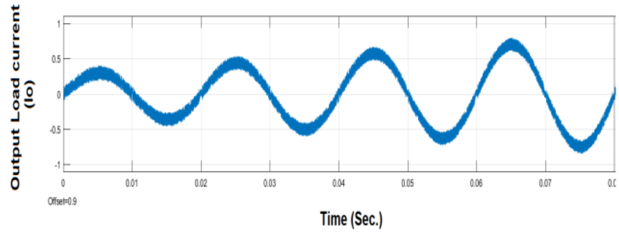

Fig 11: Load Current

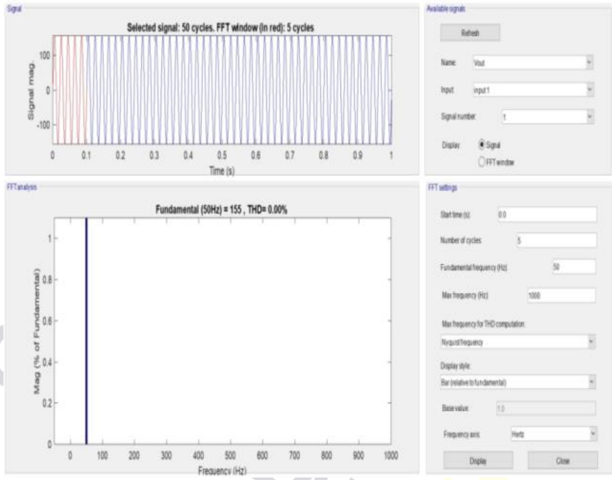

Fig 12 FFT Analysis of Load Voltage

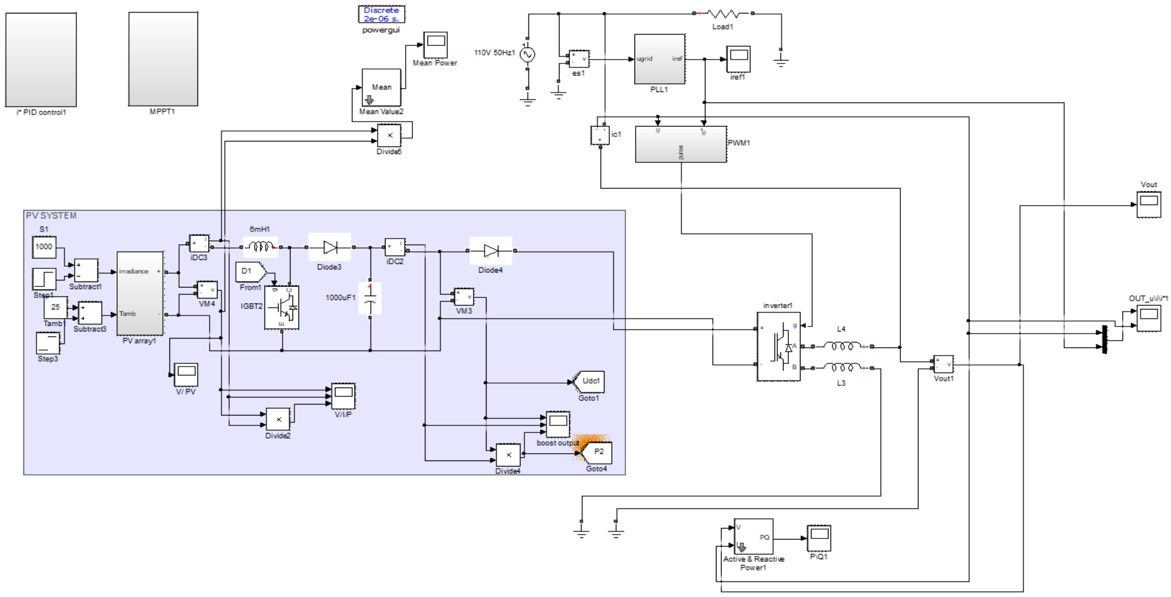

Fig 2: Simulation of PV system using MPPT (P&O Method)

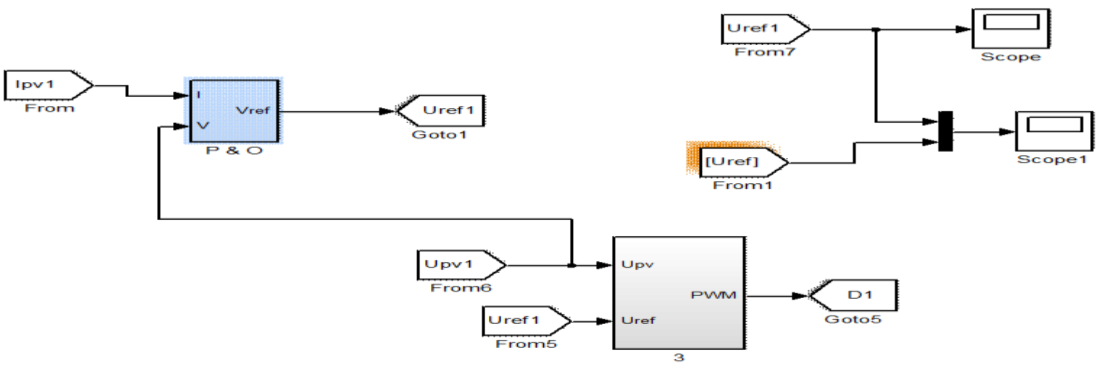

Fig 3: Functional Block of MPPT (Perturb and Observe Method)

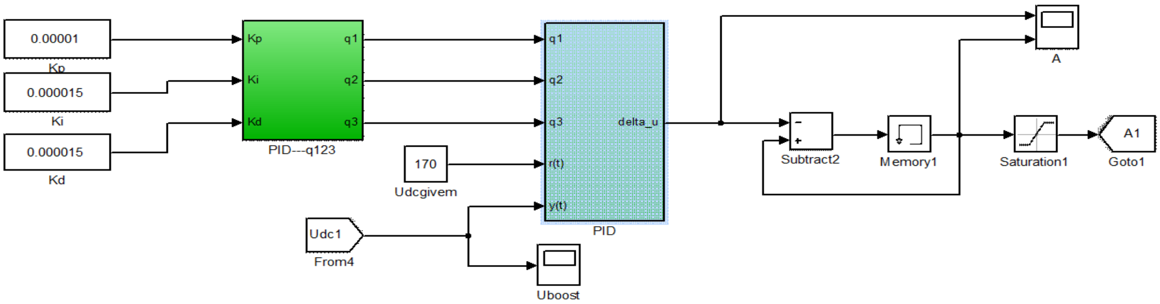

Fig 4: Functional PID block

IV. Conclusions

MATLAB-SIMULINK is used to implement the P&O MPPT method for simulation. The proposed work's MPPT approach can simultaneously enhance the PV system's dynamic and steady state performance. Through simulation, it was discovered that the system, in spite of fluctuations, successfully tracked the maximum power point. The device can instantly track the maximum power point when the external environment abruptly changes. The boost converters have been successful in tracking the MPP, particularly in reducing the oscillations brought on by the application of the P&O approach. Also the PID is implemented to control the output voltage & maintain is constant across the load. The performance parameters voltage of PV system, Current of PV system, Power and Load voltage and current validates that the proposed system is effective for the stand alone PV system connect to load.

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