SIMULATION OF PERTURB AND OBSERVE BASED MAXIMUM POWER POINT TRACKING ALGORITHMS FOR PHOTOVOLTAIC SYSTEM

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Abstract

The human activities contribute to the global warming of the planet. As a result, every country strives to reduce carbon emissions. The world is facing not only the depletion of fossil fuels, but also its rising prices which causes the worldwide economic instability. Numbers of efforts are being undertaken by the Governments around the world to explore alternative energy sources and to achieve pollution reduction. Solar electric or photovoltaic technology is one of the biggest renewable energy resources to generate electrical power and the fastest growing power generation in the world. The main aim of this work is to analyze the interface of photovoltaic system to the load, the power electronics and the method to track the maximum power point (MPP) of the solar panel. The first chapter consists of an overview of the PV market and cost. It describes the application of the PV system, the energy storage and the different standard requirement when having grid-connected PV system. Then main emphasis is to be placed on the photovoltaic system, the modeling and simulation photovoltaic array, the MPP control and the DC/DC converter will be analyzed and evaluated. The step of modeling with MATLAB and Simulink of the photovoltaic system is shown respectively and simulation results are provided. iii The Simulink model of the PV could be used in the future for extended study with different DC/DC converter topology. Optimization of MPPT algorithm can be implemented with the existing Photovoltaic and DC/DC converter.
***Keywords**: Photovoltaic Array (PVA), MPPT, Ćuk Converter.*

1. Introduction

Among the renewable energy resources, the energy through the solar photovoltaic effect can be considered the most necessary and prerequisite sustainable resource because of the ubiquity, large quantity, and sustainability of solar energy. The output characteristics of PV module depends on the solar irradiance, cell temperature and output voltage of PV module. Since PV module has nonlinear characteristics, it is necessary to model it and simulate for Maximum Power Point Tracking (MPPT) of PV system applications. A PV module generates small power, so the task of a MPPT in a PV energy conversion system is to continuously tune the system so that it draws maximum power from the solar array regardless of weather or load conditions (Chermitti et al, 2012). Previously buck, boost and buck-boost converters are used to transfer the power generated by PVA to load (Ankur Bhattacharjee, 2012; Kalirasu and Dash, 2010). In literature it is reported that direct control of Ćuk converter minimizes power loss and avoids the discontinuous conduction. The limitation of PI controller is observed by some of the (Safari and Mekhilef, 2011). The PI controller increase complexity of system. In this work direct control of duty cycle using MPPT technique is explored.

2. Basic block diagram of MPPT system

The voltage and current generated by PVA are inputs of the MPPT system and the task of the MPPT algorithm is to calculate the reference voltage. The MPPT systems contain two control loops to achieve maximum power. The inner loop contains the MPPT algorithm block and comparator to generate the switching pulses. The external control loop contains the PI controller, which controls the input voltage of the converter. The PI controller works towards minimizing the error between Vref (generated by MPPT block) and the output voltage of DC-DC converter by vary the duty cycle. The MPPT block is used to generate an error signal, which is non zero at most of the operating points except at MPP. Simplicity of operation, ease of design, inexpensive maintenance, and low cost made PI controllers very popular in most linear systems. However, the MPPT technique of standalone PV system is a nonlinear control problem due to the nonlinearity nature of PV module and un-predictable environmental conditions. Hence, PI controller performance is inferior with PVA system (Safari and Mekhilef, 2011).

As discussed earlier, MPPT is nothing but a process of making source impedance equal to the load impedance and this task can be achieved in real time by DC-DC converter. A DC-DC converter acts as an interface between the load and the module as shown in figure 1. By changing the duty cycle, the load impedance as seen by the source varies and matches at the point of the peak power with the source so as to transfer the maximum power (Patel & Agarwal 2008; Surya Kumari & Sai Babu 2011; Faranda & Leva 2008). Consider a step down converter with output voltage Vo, Input voltage Vi and duty cycle D, it can be written as:

$Vo = D * Vi$. (1)

With Ro as output impedance and Ri as input impedance, the impedance transfer equation becomes

$Ro = D^2 * Ri$, (2) and $Ri = R_0/D^2$. (3)

Thus, the output resistances Ro remains constant and by changing the duty cycle, the input resistance Ri seen by the source, changes. Hence, the resistance corresponding to the peak power point is obtained by changing the duty cycle

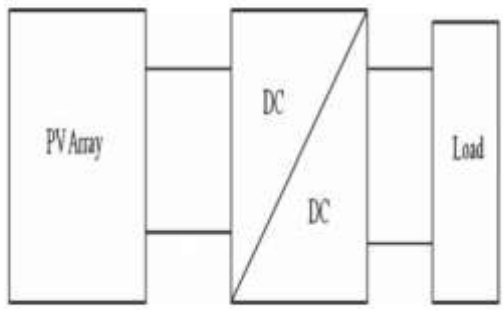

Figure 1. Basic block diagram of MPPT system.

3. MPPT CONTROL ALGHORITHM

Perturb and Observe (P&O):

In this algorithm a slight perturbation is introduce system [7]. This perturbation causes the power of the solar module changes. If the power increases due to the perturbation then the perturbation is continued in that direction [7]. After the peak power is reached the power at the next instant decreases and hence after that the perturbation reverses. 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. A PI controller then acts moving the 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 Figure 2, which shows an family of PV array power curves as a function of voltage (P–V curves), at different irradiance (G) levels, for uniform irradiance and constant temperature. As previously described, these curves have global maxima at the MPP. Assume the PV array to be operating at point A in Figure 2, which is far from the MPP. In the P&O algorithm, the operating voltage of the PV array is perturbed by a small increment, and the resulting change in power, Delta P, is measured. If Delta P is positive, then the perturbation of the operating voltage moved the PV array's operating point closer to the MPP. Thus, further voltage perturbations in the same direction (that is, with the same algebraic sign) should move the operating point toward the MPP. If Delta P is negative, the system operating point has moved away from the MPP, and the algebraic sign of the perturbation should be reversed to move back toward the MPP.

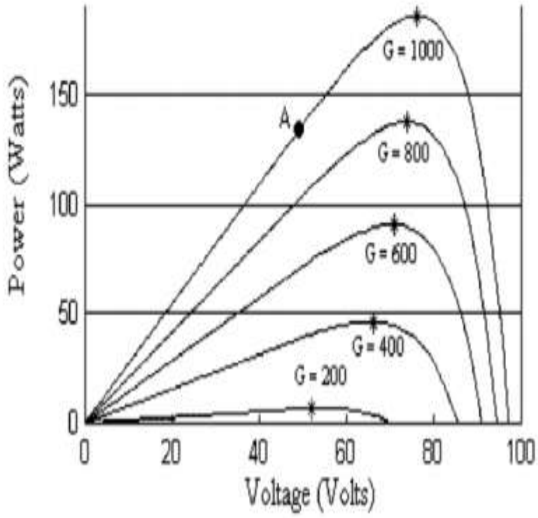

Fig 2: Photovoltaic array power–voltage relationship

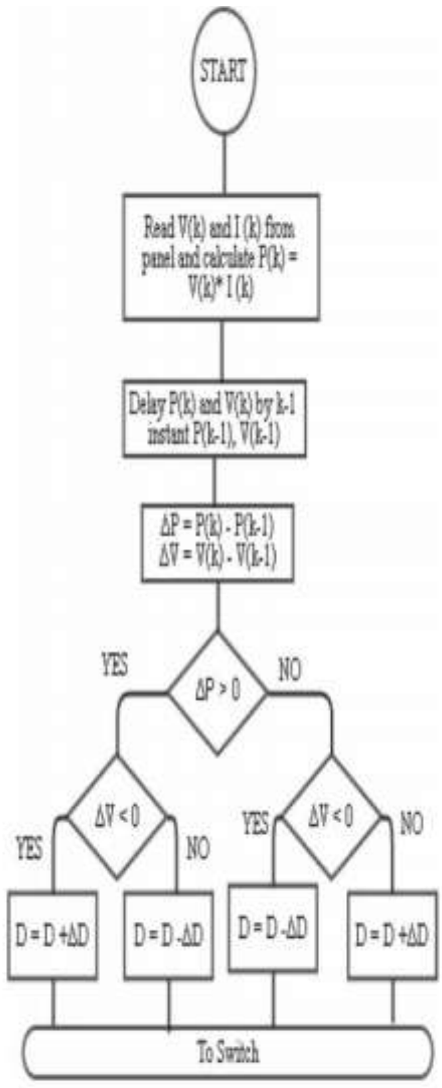

Fig 3: Flow chart Of P& O MPPT algorithm

The advantages of this algorithm, as stated before, are simplicity and ease of implementation. However, P&O has limitations that reduce its MPPT efficiency. One such limitation is that as the amount of sunlight decreases, the P–V curve flattens out, as seen in Figure 3. This makes it difficult for the MPPT to discern the location of the MPP, owing to the small change in power with respect to the perturbation of the voltage. The drawback of P&O is that it cannot determine when it has actually reached the MPP. Instead, it oscillates around the MPP, changing the sign of the perturbation after each P measurement.

4. MODEL STRUCTURE AND SIMULATION

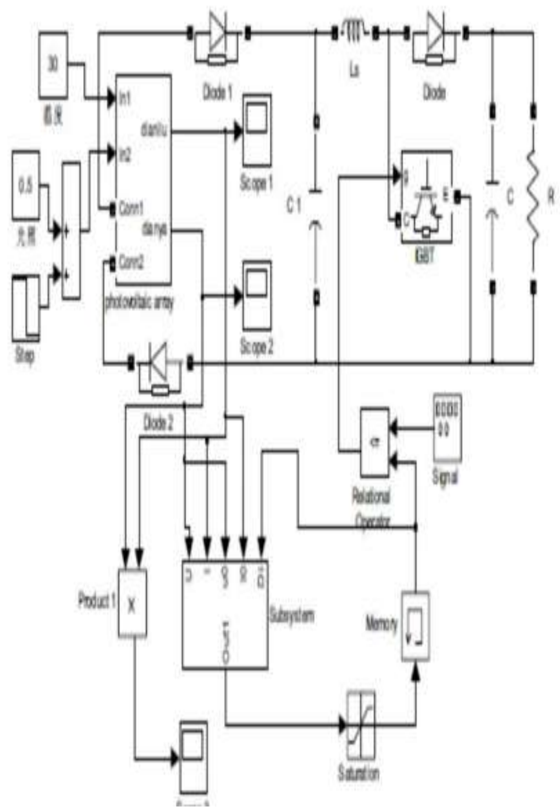

Fig 4 simulation of MPPT

In the process of simulation environment temperature is settled at the level of 300 and the light 1kw/m2. To facilitate the observation of trace results light intensity changes from the original 1kw/m2 to 0.6kW/m2 after 0.4 seconds. Taking simulating accuracy and speed into consideration, we chose ode23tb. Simulation time take 0.1s. The pv system is designed using subsystem in Matlab and the o/p of the pv cell is connected to diode and is connected to the filter capacitor and resistor and is given to the boost converter and the ripples form the boost converter can be eliminated using the capacitor filter and the Load of resistive load is connected which acts as a dc load, the o/p terminals of the PV system are connected to the MPPT algorithm either the P&O or Incremental conductance Method. And the o/p signal of MPPT is Compared with The carrier wave this in terms can be known as PWM (Pulse Width Modulation), and the gating signals generated from the PWM are given to the IGBT Gating signals.

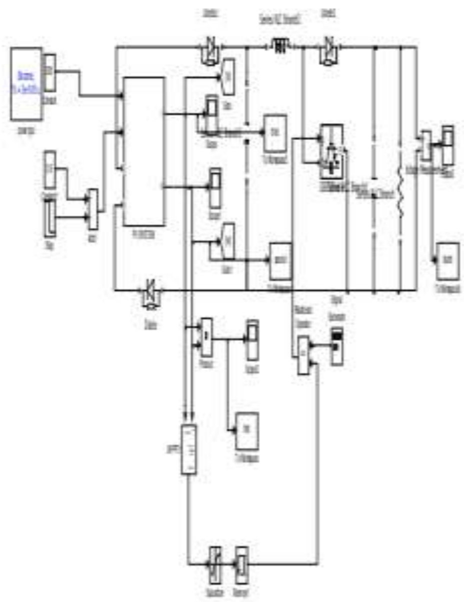

Fig.5 P& O simulation Circuit

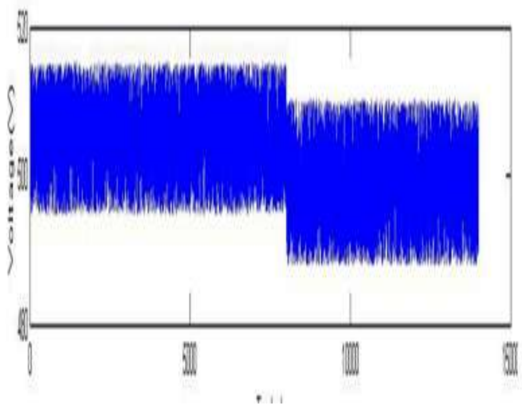

Fig 6: Photo voltaic output Voltage

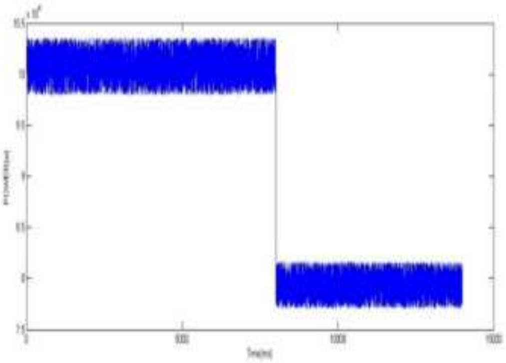

Fig 7: Photo Voltaic output Current

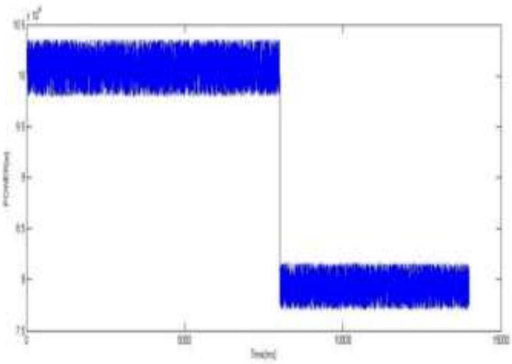

Fig 8: PV o/p power

CONCLUSION

In this paper, the study of the photovoltaic system with maximum power point controller has been developed. From the theory of the photovoltaic, a mathematic model of the PV has been presented.Then, the photovoltaic system with DC-DC boost converter, maximum power point controller and resistive load have been designed. Finally, the system has been simulated with Simulink MATLAB. First, the simulations of the PV panels showed that the simulated models were accurate to determine the characteristics voltage current because the current voltage characteristics are the same as the characteristics given from the data sheet. In addition, when the irradiance or temperature varies, the PV models output voltage current change. Then, the simulation showed that Perturb and observe algorithm can track the maximum power point of the PV, it always runs at maximum power no matter what the operation condition is. The results showed that the Perturb and observe algorithm delivered an efficiency close to 100% in steady state. The simulations of the PV with maximum power point, boost converter and resistive load were performed by varying the load, the irradiance and the temperature. Finally, the PV performance and the maximum power point was analyzed, and the three phase full bridge DC-AC inverter was simulated on a resistive load. The results showed that the DC voltage generated by the PV array could produce an AC current sinusoidal at the output of the inverter. The amplitude of the current depends on the PV power.

References

1. Katan RE, Agelidis VG, Nayar CV. Performance analysis of a solar water pumping system. Proceedings of the 1996 IEEE International Conference on Power Electronics, Drives, and Energy Systems for Industrial Growth (PEDES), 1996; 81–87.

2. Taha MS, Suresh K. Maximum power point tracking inverter for photovoltaic source pumping applications. Proceedings of the 1996 IEEE International Conference on Power Electronics, *Drives, and Energy Systems for Industrial Growth (PEDES), 1996; 883–886.*

3. Kourtoulis E, Kalaitzakis K, Voulgaris NC. Development of a microcontroller-based, photovoltaic maximum power point tracking control system. IEEE Transactions on Power Electronics 2001; 16(1): 46–54.

4. Won C-Y, Kim D-H, Kim S-C, Kim W-S, Kim H-S. A new maximum power point tracker of photovoltaic arrays using fuzzy controller. Proceedings of the 24th IEEE Power Electronics Specialists Conference (PESC), 1994; 396–403.

5. Hua C, Shen C. Comparative study of peak power tracking techniques for solar storage systems. IEEE Applied Power Electronics Conference and Exposition—APEC, Proceedings of the 1998 13th Annual Applied Power Electronics Conference and Exposition 1998; 2: 697–685. 6. Hussein KH, Zhao G. Maximum photovoltaic power tracking: an algorithm for rapidly changing atmospheric conditions. IEE Proceedings of Generation, Transmission, Distribution 1995; 142(1): 59–64.

[7] Vikrant.A.Chaudhari, "Automatic Peak Power Traker for Solar PV Modules Using dSpacer Software.," in Maulana Azad National Institute Of Technologyvol. Degree of Master of Technology In Energy. Bhopal: Deemed University, 2005, pp. 98.

[8] T. P. Nguyen, "Solar Panel Maximum Power Point Tracker," in Department of Computer Science & Electrical Engineering: University of Queensland, 2001, pp. 64.

[9] B. S, Thansoe, N. A, R. G, K. A.S., and L. C. J., "The Study and Evaluation of Maximum Power Point Tracking Systems," International Conference on Energy and Environment 2006 (ICEE 2006), pp. 17-22, 2006.

10. Andersen M, Alvsten B. 200W low cost module integrated utility interface for modular photovoltaic energy systems. IECON: Proceedings of the 1995 IEEE 21st International Conference on Industrial Electronics, Control and Instrumentation 1995; 1(1): 572–577.