Comparative Study of Perturb & Observe (P&O) and Incremental Conductance (IC) MPPT Technique of PV System

Kanchan Jha[1] and Prof. Ratna Dahiya[2]

[1]National institute of Technology Kurukshetra,Haryana ,kjha2303@gmail.com
[2]National institute of Technology Kurukshetra, ratna_dahiya@yahoo.com

Abstract. The International Solar Alliance aims to efficiently exploit Solar Energy in sunshine countries (Suryaputra) between the Tropics. Similar pledges, like Sustainable Development Goal-7 (Affordable and Clean Energy), to increase the contribution from other non-conventional sources are in place to meet the objectives set out in UNFCCC. However, availability of renewable energy is an intermittent process and thus require both efficiency and effectiveness in the processes used to harness them.

The present paper aims to bring out a comparative study of the two MPPT methods globally used to maximize the solar energy trapped: The two techniques are (P&O) and (IC). PV module consisting of DC-DC Boost Converter, MPPT Controller, and Inverter etc has been used to analyze the methods. Two level voltage source inverter has been incorporated to enhance the simulation and eliminate the harmonics. All simulations have been performed in MATLAB Simulink platform.

Keywords: *Solar PV module, DC-DC Boost Converter, PWM Technique, MPPT Techniques, Three phase VSI Inverter*

Introduction

With the world becoming more sensitive to impacts of climate change, the share of renewable energy in total energy demand has been increasing. However, much needs to be done to efficiently harness the Solar Energy, as it is intermittent and varies with the movement of the Earth and other climatic factors[4]-[5]. This paper is presenting an equivalent circuit of solar PV cell which is applied to develop 200W PV module which is shown in section 2. Several MPPT technique have been proposed in literature to find MPP of solar PV module [2]. MPPT, Maximum Power Point Tracking, is a method to effectively track the point at which the maximum energy can be trapped. Two methods- The (P&O) and the (IC) methods are most commonly used for this purpose [3][9]. MPPT uses DC-DC boost converter so that it can match Solar PV source and the load by controlling the duty cycle [1]. This paper further presents three level inverter to supply AC load. LC filter is used in this paper to reduce harmonics and to get desired output voltage waveform [7][8].

1 SOLAR POWER GENERATION

In this paper we have designed Solar panels to convert solar energy into electrical energy. We have designed it as a combination of series and parallel connections of photo voltaic modules of solar. Solar PV module is designed by solar cell which are manufactured by semiconductor devices [5]. A typical solar cell is a representation of a current source connected in parallel path with a diode and two resistors [4].

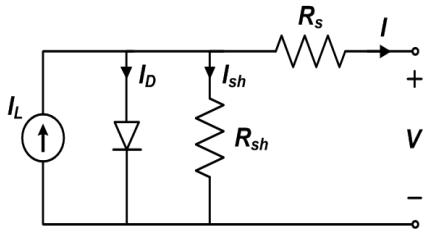

Figure 1.1: Equivalent circuit of an ideal solar cell

Parameter	Specification
Maximum Power (P_{mpp})	200.1430W
Maximum Voltage (V_{mpp})	26.3V
Maximum Current (I_{mpp})	7.61A
Short Circuit Current (I_{SC})	8.21A
Open Circuit Voltage (V_{OC})	32.9V

Table 1.2: Specification of Solar module

The modeling equation of the solar cell is described

$$I_{pv} = N_p I_{ph} - N_p I_{sh}\left[exp\left\{q\frac{(V_{pv}+I_{pv}R_{sh})}{N_s AKT_c}\right\} - 1\right] - \frac{(V_{pv}+I_{pv}R_s)}{R_{sh}} \quad [1]$$

Where Ish = diode saturation current

I_{sh} depends on temperature and expression for temperature dependency is

$$I_{sh} = I_{rs}\left[\frac{T_c}{T_{ref}}\right]^3 [\exp\{\frac{qE_g\left(\frac{1}{T_{ref}}-\frac{1}{T_c}\right)}{AK}\}] \quad [2]$$

Where I_{rs} is the reverse diode current given By

$$I_{rs} = \frac{I_{sc}}{[\exp\{\frac{qV_{OC}}{N_S AKT_C}\}-1]} \quad [3]$$

$$I_{pv} = \left[I_{sc} + K_i\left(T_c - T_{ref}\right)\right]\left[\frac{G}{1000}\right] \quad [4]$$

Where

I_{pv} = Output Power of PV Module.

N_p = PV cells arranged in parallel, Ns = PV cells arranged in series.

I_{ph} = Photo current , I_{sh} Diode saturation Current, q = Charge of electron, R_s = Series Resistance (Ω) R_{sh} = Shunt Resistance (Ω) T_c = Actual Cell Temperature(^{0}C) , K = Boltzmann Constant (1.381 e^{-23}J/Watt), G = Irradiance of Sun ($\frac{\omega}{m^2}$) , A =1.3, Ideality Factor (Depends on PV Cell) .

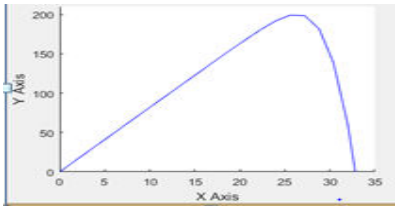

Figure 1.2 : P(Y)-V(X) axis curve of solar cell

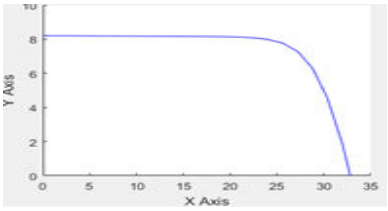

Figure 1.3 :I(Y)-V(X) axis curve of solar cell

2 Maximum Power Point Tracking (MPPT) Algorithm

This paper presents two MPPT techniques. These techniques are used to extract maximum power from PV module under mentioned conditions.

A. Perturb & Observe Technique(P&O)

Two conditions are required in P&O type MPPT technique. First condition is it can operate at high sampling rate. The output values of voltage waveform and current waveform should be able to make the pattern of the output power waveform if any changes occur in the reference signal. This signals used for the power converter of the maximum power point tracking. Second condition is the response time of the converter must be rapid while maintaining the switching losses (frequency) as minimum as possible. The boost converter (DC/DC) switch is turned on when the actual current matches the reference current [1]. Hence, the reference current can be perturbed (increased/decreased) in every switching cycle [2].

B . *Incremental Conductance Method*

The P&O method is tracking peak power but it is not accurate and the response is slow with more oscillations. To overcome this problem we have further used incremental conductance MPPT technique. This method can determine that the Maximum power point tracking is reaching to the MPP and subsequently stop perturbing the point of operation [9]. This condition is mandatory if it is not met then the perturbation direction is determined by the relation between dI/dV and –I/V. Mathematically we can derived this equation with the fact that dP/dV is negative when the Maximum power point technique is to

the right of the MPP and it will be positive when present the left of the Maximum power point [3]. DC-DC Boost converter in used for step up the voltage according to demand and VSI is used to convert DC to AC to supply AC load cascaded with LC filter.
where

$$L = \frac{\sqrt{2}Rl}{w0} \ , \ C = \frac{1}{\sqrt{2}\, w0\, Rl}$$, L and C are the value of LC filter

3 SIMULATION RESULT: COMPARISON & DISCUSSION

The P&O and IC MPPT algorithms are simulated and we have analyzed the results by keeping the conditions identical. We have seen that when atmospheric conditions are stable, the Perturb & observe MPPT oscillates close to Maximum power point, but Incremental conductance finds the Maximum power point accurately and its response is more fast. We have calculated these values corresponding to irradiance of 1000w/m^2 and an ambient temperature of 25 degree Celsius.

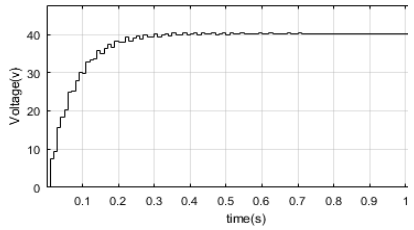

Figure 3.1: Output voltage of P&O MPPT technique

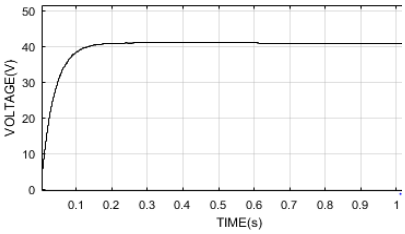

Figure 3.4 : Output voltage of IC MPPT Technique

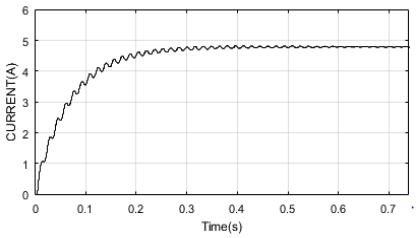

Figure 3.2 : Output Current of P&O MPPT technique

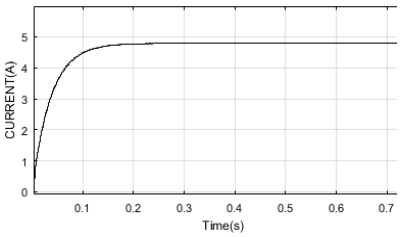

Figure 3.5 :Output current of IC MPPT technique

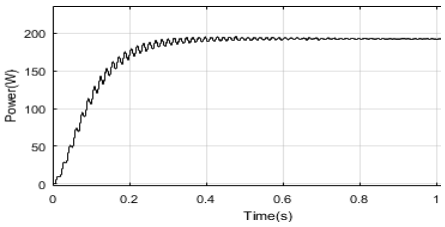

Figure 3.3 : Output Power of P&O MPPT technique

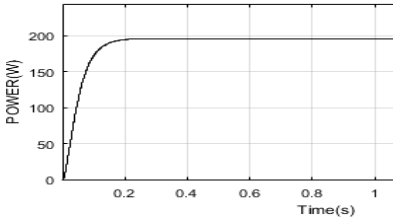

Figure3.6 :Output Power of IC MPPT techniqu

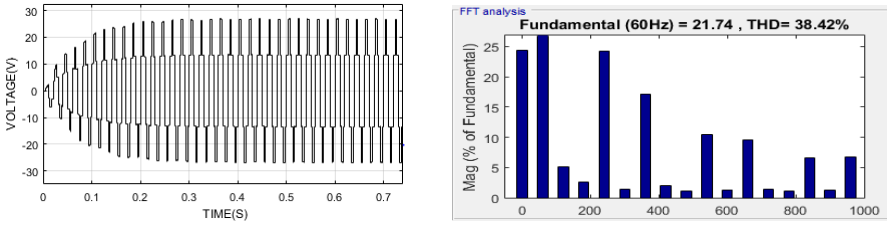

Figure 3.7:output volatege and THD of inverter in P&O MPPT Technique

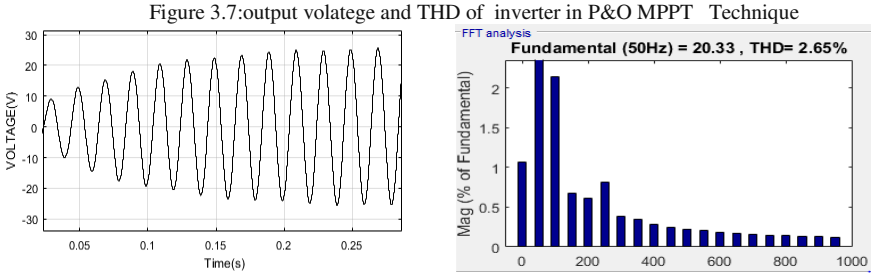

Figure 3.8 : Output volatege and THD of inverter with LC filter in P&O MPPT Technique

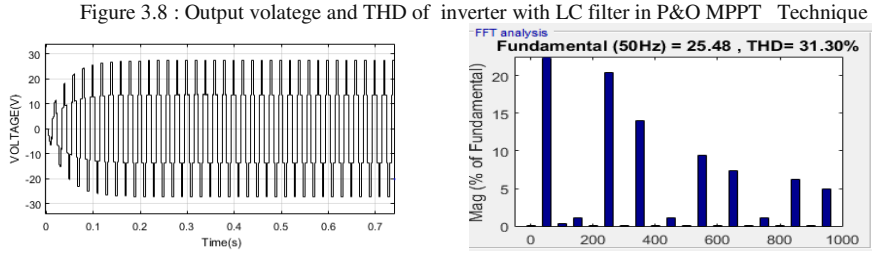

Figure 3.9: output volatege and THD of inverter in Incremental conductance MPPT Technique

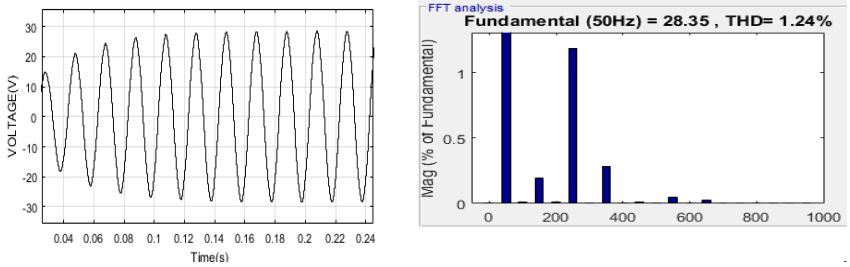

Figure 3.10: Output volatege and THD of inverter wuth LC filter in Incremental conductance MPPT Technique

4 CONCLUSION

The IC method is more advantageous over perturb and observe because it is able to determine the MPP with less harmonics around this value. It can also perform MPPT technique under very fast variation in irradiation with more accuracy than the P&O method which is shown in table 4.1. We have eliminated lower order harmonics using VSI inverter cascaded with LC filter. In future some modifications can be explored in Incremental Conductance method so as to make it more robust. The com-

plexity can be checked by using Fuzzy Logic and Artificial Intelligence methods so as to make the technique more intelligible.

S.No	MPPT Technique	THD Without filte(%)	THD with filter(%)	Settling time(s)
1	P&O	38.42	2.65	0.3
2	IC	31.30	1.24	0.15

Table 4.1: Comparative analysis of P&O vs IC MPPT technique

REFERENCES

1. A. Nakajima and S. Masukawa, "Study of Boost type DC-DC Converter for Single Solar Cell," *IECON 2018 - 44th Annual Conference of the IEEE Industrial Electronics Society*, Washington, DC, 2018, pp. 1946-1951
2. G. A. Raiker, "Dynamic Response of Maximum Power Point Tracking using Perturb and Observe Algorithm with Momentum Term," *2017 IEEE 44th Photovoltaic Specialist Conference (PVSC)*, Washington, DC, 2017, pp. 3073-3076.
3. K. Sundareswaran, V. V. Kumar, S. P. Simon and P. S. R. Nayak, "Cascaded simulated annealing/perturb and observe method for MPPT in PV systems," *2016 IEEE International Conference on Power Electronics, Drives and Energy Systems (PEDES)*, Trivandrum, 2016, pp. 1-5.
4. N. Santhosh and B. Prasad, "Efficiency improvement of a solar PV-panel through spectral sharing by combination of different panels," *2016 IEEE Students' Conference on Electrical, Electronics and Computer Science (SCEECS)*, Bhopal, 2016, pp. 1-4.
5. K. Harini and Syama S., "Simulation and analysis of incremental conductance and Perturb and Observe MPPT with DC-DC converter topology for PV array," *2015 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT)*, Coimbatore, 2015, pp. 1-5.
6. M. A. Islam, A. Merabet, R. Beguenane and H. Ibrahim, "Modeling solar photovoltaic cell and simulated performance analysis of a 250W PV module," *2013 IEEE Electrical Power & Energy Conference*, Halifax, NS, 2013, pp. 1-6
7. M. Nauman and A. Hasan, "Efficient Implicit Model-Predictive Control of a Three-Phase Inverter With an Output LC Filter," in *IEEE Transactions on Power Electronics*, vol. 31, no. 9, pp. 6075-6078, Sept. 2016.
8. Y. Liu, Jianchun Peng, Guibin Wang, Huaizhi Wang and K. Y. See, "THD and EMI performance study of foil-wound inductor of LCL filter for high power density converter," *2016 IEEE 8th International Power Electronics and Motion Control Conference (IPEMC-ECCE Asia)*, Hefei, 2016, pp. 3467-3471.
9. M. J. Hossain, B. Tiwari and I. Bhattacharya, "An adaptive step size incremental conductance method for faster maximum power point tracking," *2016 IEEE 43rd Photovoltaic Specialists Conference (PVSC)*, Portland, OR, 2016, pp. 3230-3233.