Design of MPPT using Perturb & Observe Method Improving Output of PV System

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ABSTRACT

In this paper we used PV array of given rating. The output of PV array is connected to Current Source Inverter.CSI consist of Insulated Gate Bipolar Transistor (IGBT) for conversion. The whole system is simulating under two categories. One is simulating with Inductor (L_{dc}) of high value and second is Low Value of Inductor (L_{dc}) with Double Tuned Resonant Filter. The proposed system is simulating in MATLAB/SIMULINK 2.22.23 (2016a) software. This software is well known simulation software for the analysis of electrical and electronics circuits. Also we can simulate for Mechanical Systems which is very useful for others.

Keywords: Double Tuned Resonant Filter, Current Source Inverter (CSI), Total Harmonic Distortion (THD)

1. INTRODUCTION

1.1 MAXIMUM POWER POINT TRACKING

The solar panel has a characteristic named p-v characteristic where a global maximum is present. This means that for a different operating point of the solar panel, a different output power is obtained. To achieve the maximum power the solar panel must be operate at the voltage where the global maximum of the p-v characteristic is present. Therefore, only for one specific operating point, the maximum power output is choosing from the solar panel. This point in the p-v characteristic is called the Maximum Power Point (MPP). This MPP changes when the irradiation and temperature changes or when the solar panel is partially shaded in rainy or cloudy season.

1.1. 1 MPPT METHODS

I. Perturb & Observe method

II. Incremental Conductance method

III. Fractional Open-Circuit Voltage method

IV. Fractional Short-Circuit Current method

V. Fuzzy Logic Control method

VI. Neural Network method

1.2 PERTURB & OBSERVE METHOD

In P&O method, the MPPT algorithm is based on the calculation of the PV output power and the power change by sampling both the PV current and voltage. The tracker operates by periodically incrementing or decrementing the solar array voltage. If a given perturbation leads to an increase (decrease) in the output power of the PV, then the subsequent perturbation is generated in the same (opposite) direction. So, the duty cycle of the dc chopper is changed and the process is repeated until the maximum power point has been reached. Actually, the system oscillates about the MPP. Reducing the perturbation step size can minimize the oscillation. However, small step size slows down the MPPT. To solve this problem, a variable perturbation size that gets smaller towards the MPP. However, the P&O method can fail under rapidly changing atmospheric conditions. Several research activities have been carried out to improve the traditional Hill-climbing and P&O methods. Reference proposes a three-point weight comparison P&O method that compares the actual power point to the two preceding points before a decision is made about the perturbation sign. Reference proposes a two stage algorithm that offers faster tracking in the first stage and finer tracking in the second stage.

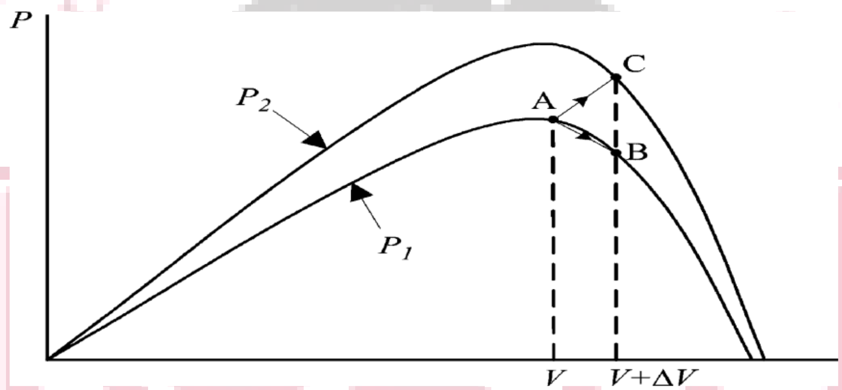


Fig. 1 Changes in Maximum Power Point

The Figure shows that there is a rapidly changing condition in Maximum Power Point. Starting from an operating point A, if atmospheric conditions stay approximately constant, a perturbation in the PV voltage V will bring the operating point to B and hence the perturbation will be reversed due to a decrease in power. However, if the irradiance increases and shifts the power curve from P1 to P2 within one sampling period, the operating point will be move from A to C and new curve achieved. This represents an increase in power and the perturbation is kept the same. Consequently, the operating point diverges from A to C in above figure and will keep diverging if the irradiance steadily increases.

2. PULSE WIDTH MODULATION

Pulse Width Modulation is basically defined by the process of modifying the width of pulses in pulse train which is direct proportional to small control signal. In which to achieve wider resulting pulse we increase the value of control voltage.Pulse Width Modulation (PWM) is a method for changing how long a square wave stays “ON”.In this method, sine wave reference signal and triangular carrier signal is used.

2.1 DUTY CYCLE

In general terms, the Duty Cycle is state as the ON time of modulated signal. In other words it is measure of high state in modulated signal. It is generally measured in percentage. Figure shows the ON OFF configuration and duty cycle. Figure 2 shows the T_{ON} and T_{OFF} of cycle. In which T_{ON} time is termed as duty cycle.

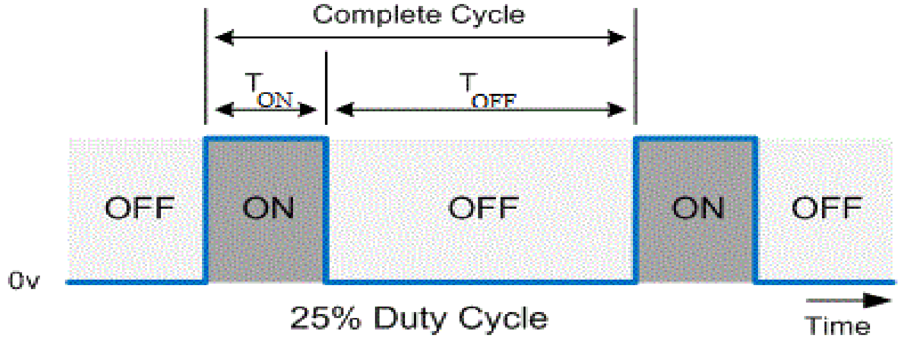


Fig. 2 Duty Cycle

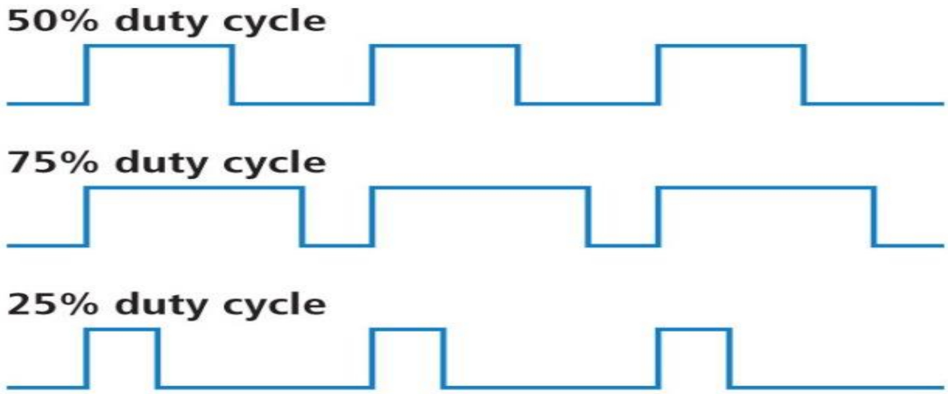


Fig. 3 Different strategy of Duty Cycle

3. TOTAL HARMONIC DISTORTION (THD)

Harmonic distortion is the change in the waveform of the supply voltage from the ideal sinusoidal waveform. It is caused by the interaction of distorting loads with the impedance of the supply network. Its major adverse effects are the heating of induction motors, transformers and capacitors and the many other types of loads. Also it causes overloading of neutrals. Figure 4 Ideal sinusoidal waveform of alternating current supply.

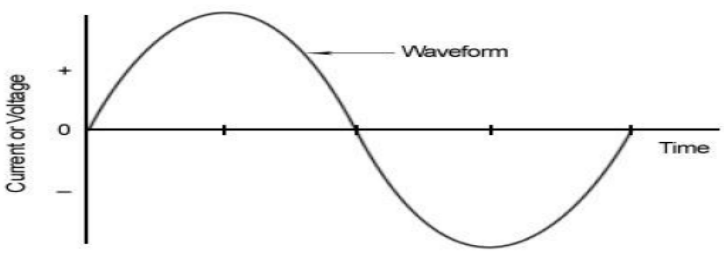


Fig. 4 Ideal Sinusoidal Waveform

3.1 LINEAR LOAD

A "linear" load connected to an electric power system is defined as a load which draws current from the supply which is proportional to the applied voltage (for example, resistive, incandescent lamps etc). An example of a voltage and current waveforms of a linear load is shown in Figure 5. In Linear Load, the voltage and current waveforms are sinusoidal and in phase.

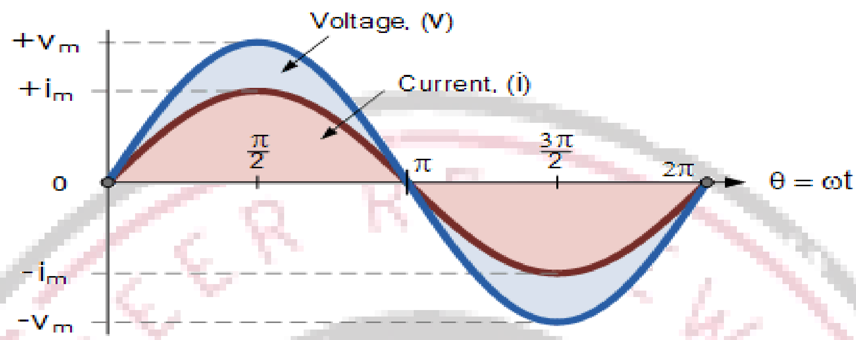


Fig.5 Linear Load

3.2 NON LINEAR LOAD

A load is considered "non-linear" if its impedance changes with the applied voltage. Due to this changing impedance, the current drawn by the non-linear load is also non-linear i.e. non-sinusoidal in nature, even when it is connected to a sinusoidal voltage source (for example computers, variable frequency drives, discharge lighting etc). An example of a voltage and current waveforms of a non-linear load is shown in Figure 6. In Non-Linear loads, the voltage and current waveforms are not sinusoidal and not in phase. These non sinusoidal currents contain harmonic currents that interact with the impedance of the power distribution system to create voltage distortion that can affect both the distribution system equipment and the loads connected to it.

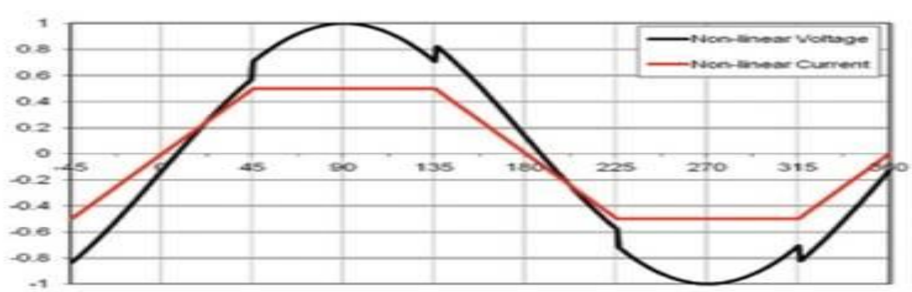


Fig. 6 Non Linear Load

4. CARRIER BASED PULSE WIDTH MODULATION (CPWM)

Due to some limitation of Sinusoidal Pulse Width Modulation, the Modified Carrier Based Pulse Width Modulation is introduced. In Sinusoidal Pulse Width Modulation the pulses nearer the peak of sine wave do not change significantly with the variation of modulation index. Second thing that the carrier signal is applied to whole cycle. Its increases no. of switching devices and also increases switching losses. To overcome above situation Carrier based Pulse Width Modulation is presented. Its provides continuous path for the dc side current. There is one switch either in top or bottom must be ON during every switching period. This can be also achieved in Sinusoidal Pulse

Width Modulation (SPWM). In SPWM, due to overlap time. It allows continuous path for dc side current. Overlap time is occurring when power devices change it states. This overlap time is not sufficient for energizing dc link inductor. This may be result in increasing Total Harmonic Distortion (THD). So the Carrier Based sinusoidal Pulse Width Modulation (CBPWM) is presented. Here two carriers and one reference is used. In this carrier wave is applied during the first and last 60º intervals per half cycle. i.e. 0º to 60º and 120º to 180º.This is similarly done for negative half cycle. The carrier signal and reference signal of Carrier based Pulse width modulation is illustrate in figure 7.

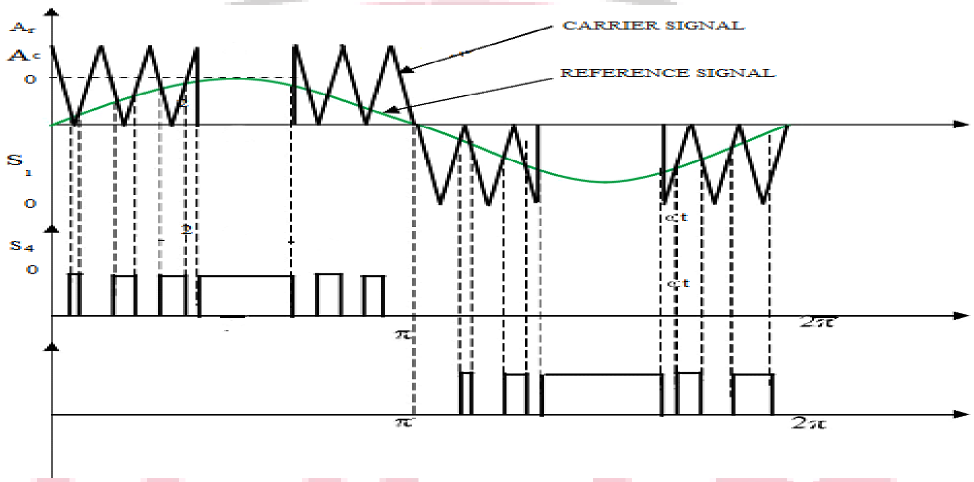
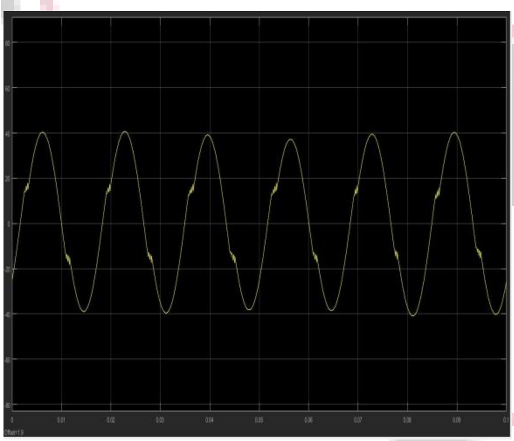


Fig. 7 Carrier Based Pulse Width Modulation

5. RESULTS

5.1 WITHOUT USE OF DOUBLE TUNED RESONANT FILTER



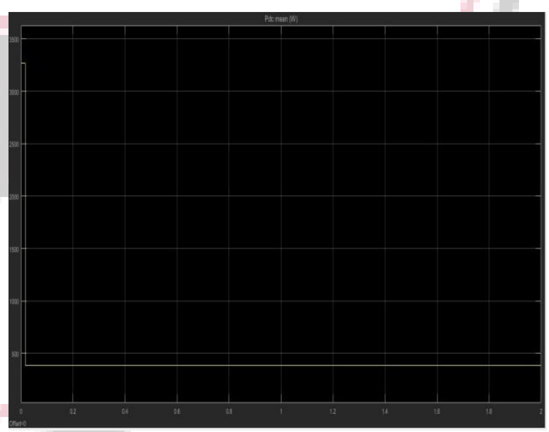


Fig. 8 CSI Output Current

Fig. 9 PV Power

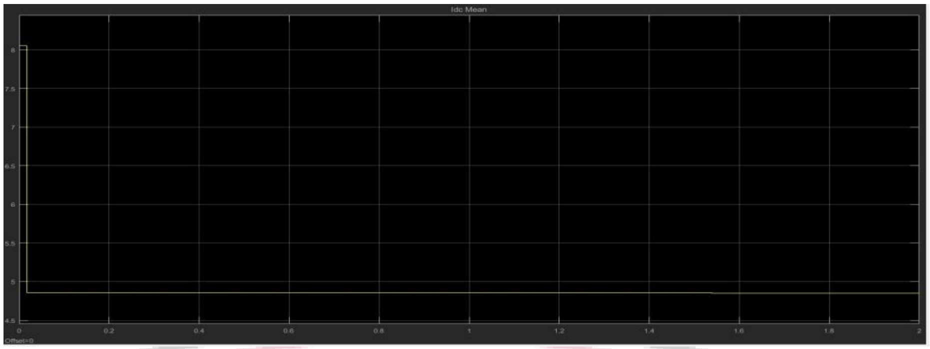


Fig. 10 PV Current

5.2 WITH USE OF DOUBLE TUNED RESONANT FILTER

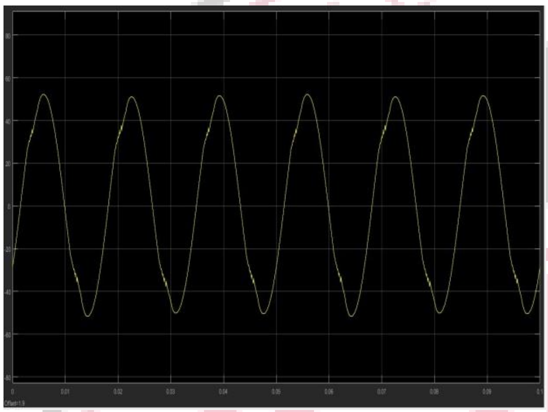


Fig. 11 CSI Output Current

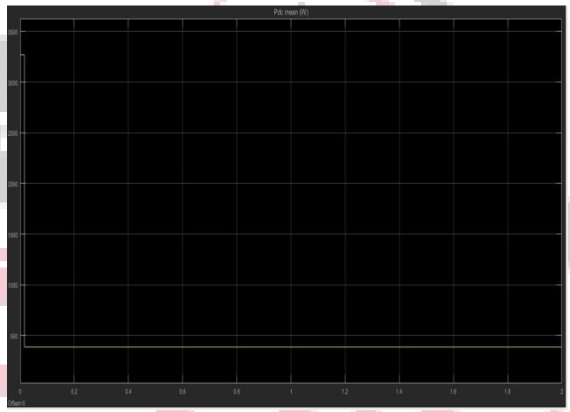


Fig. 12 PV Power

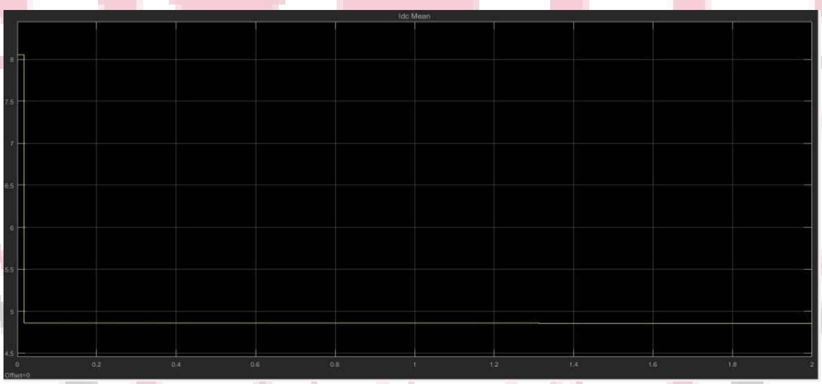


Fig. 13 PV Current

REFERENCES

1. W. Tsai-Fu, C. Chih-Hao, L. Li-Chiun, and K. Chia-Ling, "Power loss comparison of single- and two-stage grid-connected photovoltaic systems," IEEE Transaction on Energy Conversion, vol. 26, no. 2, pp. 707–715, Jun.2011.

2. S. B. Kjaer, J. K. Pedersen, and F. Blaabjerg, "A review of single-phase grid-connected inverters for photovoltaic modules," IEEE Trans. Ind. Appl., vol. 41, no. 5, pp. 1292–1306, Sep.–Oct. 2005.

3. G. Petrone, G. Spagnuolo, and M. Vitelli, "A multivariable perturb and observe maximum power point tracking technique applied to a single-stage photovoltaic inverter," IEEE Trans. Ind. Electron., vol. 58, no. 1, pp. 76–84, Jan. 2011.

4. E. Villanueva, P. Correa, J. Rodriguez, and M. Pacas, "Control of a single phase cascaded H-bridge multilevel inverter for grid-connected

photovoltaic systems," IEEE Trans. Ind. Electron., vol. 56, no. 11, pp. 4399–4406, Nov. 2009.

5. C. Cecati, F. Ciancetta, and P. Siano, "A multilevel inverter for photovoltaic systems with fuzzy logic control," IEEE Trans. Ind. Electron., vol. 57,no. 12, pp. 4115–4125, Dec. 2010.

6. S. Busquets-Monge, J. Rocabert, P. Rodriguez, S. Alepuz, and J. Bordonau, "Multilevel diode-clamped converter for photovoltaic generators with independent voltage control of each solar array," IEEE Trans. Ind. Electron., vol. 55, no. 7, pp. 2713–2723, Jul. 2008.

7. N. A. Rahim, K. Chaniago, and J. Selvaraj, "Single-phase seven-level grid connected inverter for photovoltaic system," IEEE Trans. Ind. Electron., vol. 58, no. 6, pp. 2435–2443, Jun. 2011.

8. B. Sahan, S. V. Ara´ujo, C. N¨oding, and P. Zacharias, "Comparative evaluation of three-phase current source inverters for grid interfacing of distributed and renewable energy systems," IEEE Trans. Power Electron., vol. 26, no. 8, pp. 2304–2318, Aug. 2011.

9. B. Sahan, A.N. Vergara, N. Henze,A. Engler and P. Zacharias, "A single stage PV module integrated power converter based on a low power current source inverter", IEEE Transaction on Industrial electronics, vol.55 no.7,pp 2602-2609,Jul-2008.

10. P. P. Dash and M.Kazerani, "Dynamic modeling and performance analysis of a grid-connected current-source inverter-based photovoltaic system, "IEEE Trans. Sustainable Energy, vol. 2, no. 4, pp. 443–450, Oct. 2011.

11. S. Jain and V. Agarwal, "A single-stage grid connected inverter topology for solar PV systems with maximum power point tracking," IEEE Trans. Power Electron., vol. 22, no. 5, pp. 1928–1940, Sep. 2007.

12. A. Darwish, A. K. Abdelsalam, A. M. Massoud, and S. Ahmed, "Single phase grid connected curent source inverter: Mitigation of oscillating power effect on the grid current," in Proc. IET Conf. Renewable Power Generation, Sep. 2011, pp. 1–7.

13. R. T. H. Li, H. S.-H. Chung, and T. K. M. Chan, "An active modulation technique for single-phase grid-connected CSI," IEEE Trans. Power Electron., vol. 22, no. 4, pp. 1373–1382, Jul. 2007.

14. Katsuya Hirachi and Yasuharu Tomokuni, "A novel control strategy on single-phase PWM current source inverter incorporating pulse area modulation," Proceedings of Power Conversion Conf., vol. 1, pp. 289–294, Aug. 1997.

15. S. Nonaka, "A suitable single-phase PWM current source inverter for utility connected residential PV system," Sol. Energy Mater. Sol. Cells, vol. 35, pp. 437–444, Sep. 1994.

16. T. Esram, and Patrick L. C., "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques", IEEE Trans. On Energy Conv., Vol. 22, No. 2, JUNE 2007 Pp 439-449

17.Chapter 6 Pulse Width Modulated Inverters and Chapter 8 Resonance Pulse Inverters and Chapter 4 Power transistor in Power Electronics Circuits, Devices and Applications By Muhammad H. Rashid Third Edition, PEARSON ©2014 Dorling Kindersley Pvt. Ltd.