ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE)
Vol. 2, Issue 4, April 2016

Distributed Maximum Power Point Tracking Based PV Module Inverter for Energy Harvesting

Saravana Kumar.S[1], Esakki Muthu Pandi.A[2]

PG Scholar, Department of EEE, Vandayar Engineering College, Thanjavur, India [1]
Assistant Professor, Department of EEE, Vandayar Engineering College, Thanjavur, India [2]

***Abstract*—This paper investigates the merits of distributed maximum power point tracking (DMPPT) in solar photovoltaic applications. The proposed topology of the system is a typical inverter module in combination with a boost converter that provides considerable increase in harvested energy during partial shading conditions. The modulation technique adopted for the PV inverter module is a hybrid technique that incorporates fundamental frequency pulse width modulation (FPWM) and multilevel sinusoidal pulse width modulation (MSPWM). By adopting the hybrid modulation technique, we can reduce the level of total harmonic distribution (THD) present in the output of the inverter module. The feasibility of the proposed system is analyzed using MATLAB SIMULINK.**

***Index Terms*— Harmonics, DMPPT, hybrid modulation, THD, FPWM, MSPWM.**

I. Introduction

Maximum power point tracking (MPPT) is a technique that charge controllers use for wind turbines and photovoltaic (PV) solar systems to maximize power output. The PV generators exhibit nonlinear *I–V* and *P–V* characteristics. The maximum power produced varies with both irradiance and temperature. Since the conversion efficiency of PV arrays is very low, it requires maximum power point tracking (MPPT) control techniques.

The maximum power point tracking (MPPT) is the automatic control algorithm to adjust the power interfaces and achieve the greatest possible power harvest, during moment to moment variations of light level, shading, temperature, and photovoltaic module characteristics. The purpose of the MPPT is to adjust the solar operating voltage close to the MPP under changing atmospheric conditions. It has become an essential component to evaluate the design performance of PV power systems.

II. Photo Voltaic Cell

A photovoltaic cell or photoelectric cell is a semiconductor device that converts light to electrical energy by photovoltaic effect. If the energy of photon of light is greater than the band gap, then the electron is emitted and the flow of electrons creates current. However, a photovoltaic cell is different from a photodiode. In a photodiode light falls on n-channel of the semiconductor junction and gets converted into current or voltage signal but a photovoltaic cell is always forward biased.

The single-phase two-stage configuration is preferable for residential PV applications. The control structure of a two-stage single-phase PV system with the proposed control concept is which indicates that the hybrid control strategy is implemented in the control of the boost stage depending on the instantaneous available power of the PV panels, the actual output power of the PV panels can be expressed as where Po (t) is the output power of the PV panels (i.e., input power of the power conversion stage), PPV(t) is the available maximum power of the PV panels, and Limit is selected by taking into account the tradeoffs among the thermal performance (life time) of power devices, the PV inverter utilization factor, and the annual energy yield.

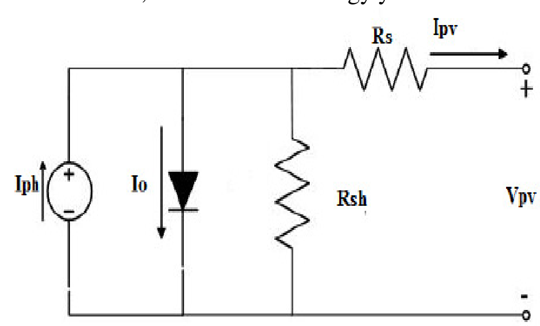

Fig.1. Photovoltaic cell schematic diagram.

A. *Need for Renewable Energy*

Renewable energy is the energy which comes from natural resources such as sunlight, wind, rain, tides and geothermal heat. These resources are renewable and can be naturally replenished. Therefore, for all practical purposes, these resources can be considered to be inexhaustible, unlike dwindling conventional fossil fuels. The global energy crunch has provided a renewed impetus to the growth and development of clean and renewable Energy sources. Clean Development Mechanisms (CDMs) are being adopted by organizations all across the globe. Apart from the rapidly decreasing reserves of fossil fuels in the world, another major

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

IJARMATE
International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE)
Vol. 2, Issue 4, April 2016

factor working against fossil fuels is the pollution associated with their combustion. Contrastingly, renewable energy sources are known to be much cleaner and produce energy without the harmful effects of pollution unlike their conventional counterparts and they exist over wide geographical areas and also resulting in significant energy security and mitigation of climate change. This paper presents a method to estimate the inverter lifetime so that we can predict a failure prior to it actually happening. The key contribution of this study is to link the physics of the power devices to a large scale system simulation within a reasonable framework of time. By configuring this technique to a real system, it can be used as a converter design tool or online lifetime estimation tool. In this paper, the presented method is applied to the grid side inverter to show its validity. Two different damage accumulation methods are used and the estimation results are compared. The neutral-point voltage is balanced by adding a time-offset to the turn-on time of the switches. If an inaccurate time-offset is added, the neutral-point deviation still remains. An accurate time-offset is obtained through the proposed time-offset estimation scheme. This method is implemented without additional hardware, complex calculations, or analysis.

III. ALIGNED SWITCHING HYBRID MODULATION

Hybrid Modulation technique includes both fundamental frequency pulse width modulation (FPWM) and multilevel sinusoidal pulse width modulation (MSPWM). This technique is adopted in order to obtain the reduced switching loss feature along with acceptable harmonic realization. Aligned switching strategy is incorporated with this hybrid modulation to run over unequal switching losses. Aligned switching is the switching that takes place in a systematic pattern so as to have uniform power loss dissipation among the components with in a cell [9]. The block diagram representation of the aligned switching strategy is shown in Fig. 2.

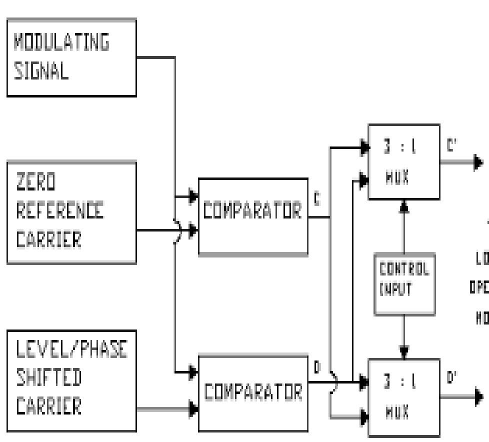

Fig.2. Scheme of Aligned switching strategy

IV. DIFFERENT DMPPT TECHNIQUES

There are different techniques used to track the maximum power point. Few of the most popular techniques are:

1) Genetic algorithm
2) Incremental Conductance method
3) Fractional short circuit current
4) Fractional open circuit voltage
5) Neural networks
6) Fuzzy logic
7) Perturb and observe method.

A. *Perturb and observe method*

Perturb & Observe (P&O) is the simplest method. In this we use only one sensor, that is the voltage sensor, to sense the PV array voltage and so the cost of implementation is less and hence easy to implement. The time complexity of this algorithm is very less but on reaching very close to the MPP it doesn't stop at the MPP and keeps on perturbing on both the directions.

When this happens the algorithm has reached very close to the MPP and we can set an appropriate error limit or can use a wait function which ends up increasing the time complexity of the algorithm. However, the method does not take account of the rapid change of irradiation level (due to which DMPPT changes) and considers it as a change in MPP due to perturbation and ends up calculating the wrong MPP. To avoid this problem, we can use incremental conductance method.

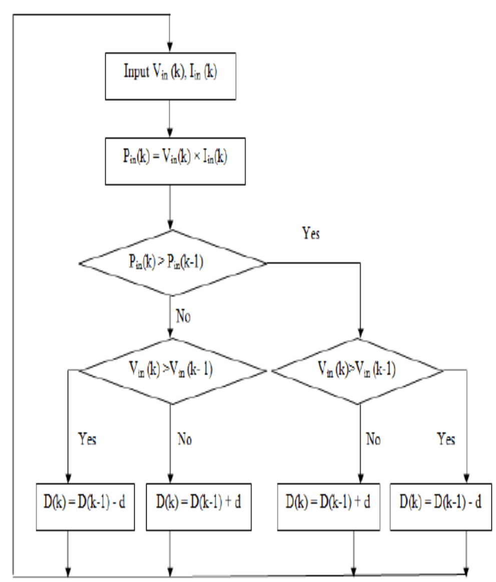

Fig.3. Flow chart for P & O system

B. *Incremental Conductance*

Incremental conductance method uses two voltage and current sensors to sense the output voltage and current of the PV array. At MPP the slope of the PV curve is 0; this can be represented as shown below,

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE)
Vol. 2, Issue 4, April 2016

$$(dP/dV)MPP = d\,(VI)/dV$$
$$0 = I + V dI/dVMPP$$
$$dI/dVMPP = -\,I/V$$

The left hand side is the instantaneous conductance of the solar panel. When this instantaneous conductance equals the conductance of the solar then MPP is reached. Here we are sensing both the voltage and current simultaneously. Hence the error due to change in irradiance is eliminated. However, the complexity and the cost of implementation increase. As we go down the list of algorithms the complexity and the cost of implementation goes on increasing which may be suitable for a highly complicated system. This is the reason that Perturb and Observe and incremental Conductance method are the most widely used algorithms.

C. Fractional Open Circuit Voltage

The near linear relationship between VMPP and VOC of the PV array, under varying irradiance and temperature levels, has given rise to the fractional VOC method.

$$VMPP = k1\ Voc$$

Where k1 is a constant of proportionality. Since k1 is dependent on the characteristics of the PV array being used, it usually has to be computed beforehand by empirically determining VMPP and Voc for the specific PV array at different irradiance and temperature levels. The factor k1 has been reported to be between 0.71 and 0.78. Once k1 is known, VMPP can be computed with Voc measured periodically by momentarily shutting down the power converter. However, this incurs some disadvantages, including temporary loss of power.

D. Fractional Short Circuit Current

Fractional results from the fact that, under varying atmospheric conditions, IMPP is approximately linearly related to the ISC of the PV array.

$$IMPP = K2\ Isc$$

Where K2 is proportionality constant. Just like in the fractional Voc technique, K2 has to be determined according to the PV array in use. The constant K2 is generally found to be between 0.78 and 0.92. Measuring Isc during operation is problematic. An additional switch usually has to be added to the power converter to periodically short the PV array so that Isc can be measured using a current sensor. Microcontrollers have made using fuzzy logic control popular for DMPPT over last decade. Fuzzy logic controllers have the advantages of working with imprecise inputs, not needing an accurate mathematical model, and handling nonlinearity.

E. Neural Network

Another technique of implementing DMPPT which are also well adapted for microcontrollers is neural networks. Neural networks commonly have three layers: input, hidden, and output layers. The number nodes in each layer vary and are user dependent.

The input variables can be PV array parameters like VOC and ISC, atmospheric data like irradiance and temperature, or any combination of these. The output is usually one or several reference signals like a duty cycle signal used to drive the power converter to operate at or close to the MPP.

V. Simulation Results

The performance of the proposed inverter is analyzed on the basis of percentage of Total Harmonic Distortion. The analysis is done using SIMULINK/MATLAB for the proposed unipolar multi carrier scheme. The simulink model of the DMPPT technique is shown in the Fig. 3. Here the type of MSPWM adopted is the Hybrid Phase Opposition and Disposition technique (HPOD).

In this technique the carrier waves are 180 degrees out of phase and hence the name. A hybrid DMPPT–CPG control concept has been proposed for grid connected PV inverters by considering the long-term mission profiles and the system level power management requirements, allowing the optimal selection of the power control limit depending on specific mission profiles.

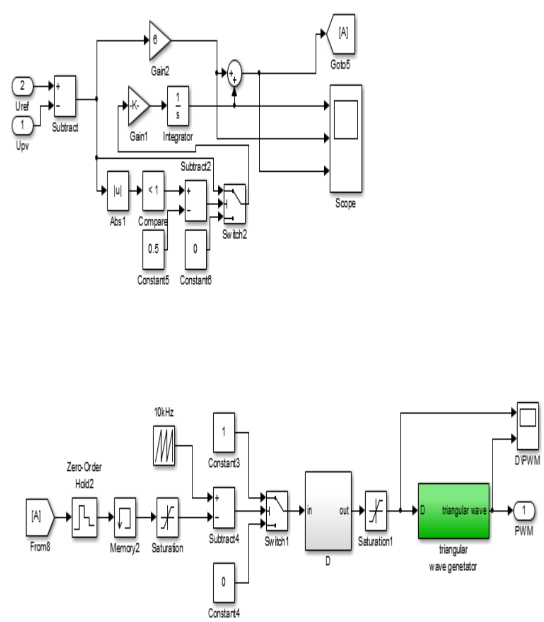

Fig.4. Simulink Model of DMPPT system.

The maximum power point tracking (MPPT) algorithms for grid connected photovoltaic system overall circuit diagram is shown below. Due to the instantaneous changing of solar irradiance and temperature, it is desirable to determine the optimal voltage that ensures maximum energy yield. In order to optimize the photovoltaic energy generation, the MPPT is integrated in the inverter control.

The maximum power generated by the photovoltaic system is sent to the power grid to be consumed by the nearest customers. A constant switching frequency is used for the

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

IJARMATE

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE)
Vol. 2, Issue 4, April 2016

current controlled inverter. The main idea of this method is to superpose an adequate triangular signal having the desired switching frequency to the reference current.

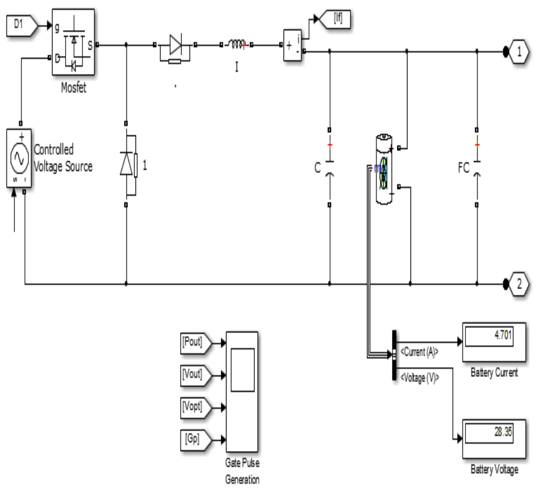

Fig.5. Simulink Diagram of the Proposed System

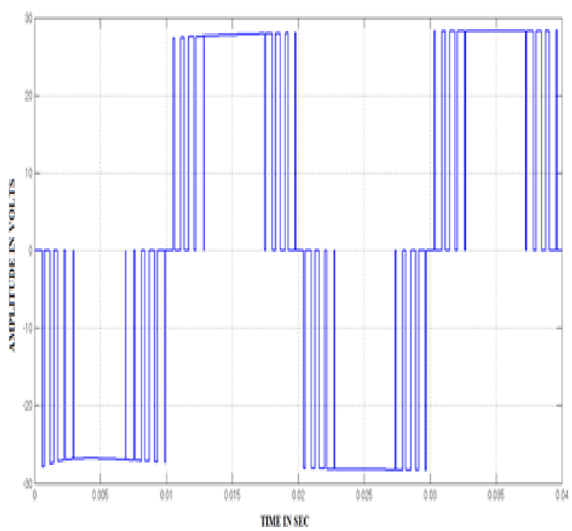

Fig.6. Simulated AC output voltage.

The arrangement of the carrier and modulating signal of the hybrid alternative phase opposition and disposition technique has been shown below in the Fig.6. (a). From this figure we can infer that the carrier waves are 180 degrees out of phase to each other. The triggering pulses generated based on the carrier and modulating signal is shown in the Fig.6. (b) it consists of both the fundamental frequency and multi level sinusoidal pulse width modulation pulses.

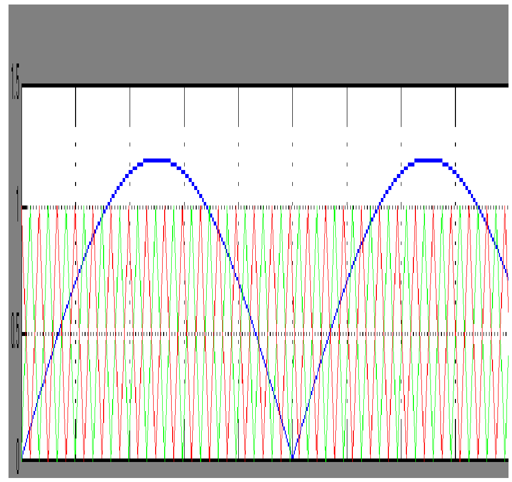

Fig.7. (a) Simulated AC output voltage.

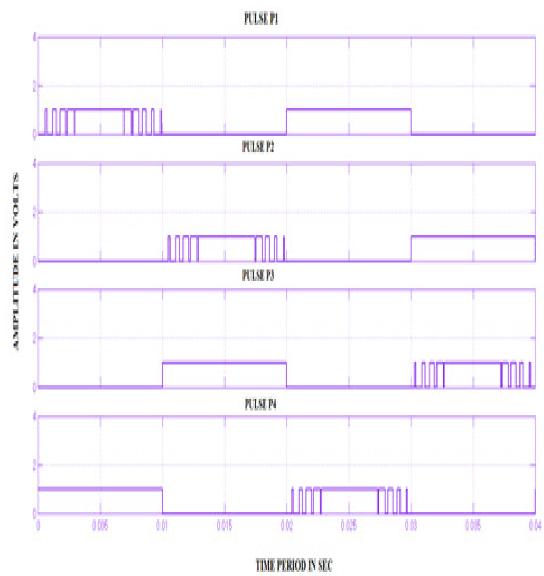

Fig.7.(b) Simulated AC output voltage.

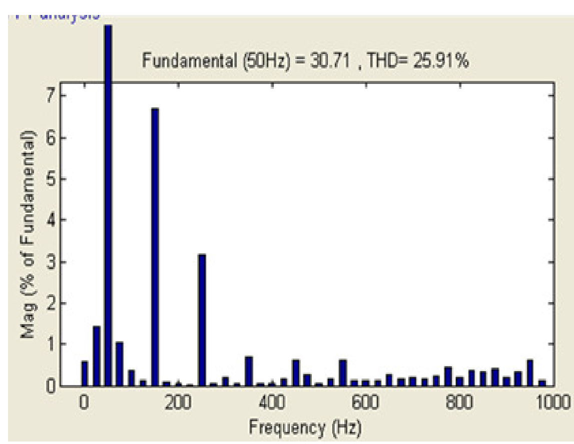

Fig.8. FFT analysis for the AC output waveform.

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE)
Vol. 2, Issue 4, April 2016

VI. CONCLUSION

A hybrid DMPPT–CPG control concept has been proposed for grid connected PV inverters by considering the long-term mission profiles and the system level power management requirements, allowing the optimal selection of the power control limit depending on specific mission profiles. The proposed control strategy enables to increase the utilization factor of PV inverters and to reduce the temperature variations on power devices. Moreover, it is beneficial to system level power management by smoothing and limiting the PV inverter output power to some extent. This benefit is especially important to increase the PV installations with the existing grid infrastructure under a high PV penetration degree in the future. The effectiveness of the proposed topology and control algorithm was tested using simulations and results are presented. The results demonstrate that the proposed system is able to control ac-side current, and battery charging and discharging currents.

REFERENCES

[1] I. S. Kim, M. B. Kim, and M. Y. Youn, "New maximum power point tracking using sliding-mode observe for estimation of solar array current in the grid-connected photovoltaic system," IEEE Trans. Ind. Electron., Vol. 53, pp. 1027–1035, 2006.

[2] T. L. Kottas, Y. S. Boutalis, and A. D. Karlis, "New maximum power point tracker for PV arrays using fuzzy controller in close cooperation with fuzzy cognitive network," IEEE Trans. Energy Conv., Vol. 21, pp. 793–803,2006..

[3] K. H. Hussein, I. Muta, T. Hoshino, and M. Osakada, "Maximum power point tracking: an algorithm for rapidly changing atmospheric conditions," IEE Proc.-Gener. Transm. Distrib., Vol. 142, pp. 59–64, 1995.

[4] D. P. Hohm and M. E. Ropp, "Comparative study of maximum power point tracking algorithms using an experimental, programmable, maximum power point tracking test bed," in Proc. Photovoltaic Specialist Conference, pp. 1699–1702, 2000.

[5] C. Hua and C. Shen, "Comparative study of peak power tracking techniques for solar storage system," in Proc. APEC, pp. 679–685, 1998.

[6] W. Wu, N. Pongratananukul, W. Qiu, K. Rustom, T. Kasparis, and I. Batarseh, "DSP-based multiple peack power tracking for expandable power system," in Proc. APEC, pp. 525–530, 2003.

[7] N. Femia, D. Granozio, G. Petrone, G. Spaguuolo, and M. Vitelli, "Optimized one-cycle control in photovoltaic grid connected applications," IEEE Trans. Aerosp. Electron. Syst., Vol. 42, pp. 954–972, 2006.

[8] J. Schaefer, "Review of photovoltaic power plant performance and economics," IEEE Trans. Energy Convers., EC-5, pp. 232–238, 1990.

[9] C. Govindaraju and K. Baskaran, "Efficient sequential switching hybrid modulation techniques for cascaded multilevel inverters," IEEE Trans. Power Electron., vol. 26, no.6, June.2011.

[10] T. Noguchi, S. Togashi, and R. Nakamoto, "Short-current pulse-based maximum-power-point tracking method for multiple photovoltaic-and-converter module system," IEEE Trans. Ind. Electron., Vol. 49, pp. 217–223, 2002.

[11] D. Y. Lee, H. J. Noh, D. S. Hyun, and I. Choy, "An improved MPPT converter using current compensation method for small scaled PV-applications," in Proc. APEC, pp. 540–545, 2003.

AUTHORS BIOGRAPHY

Saravana Kumar S born in Thanjavur, Tamilnadu on 12th January, 1985. He received the Diploma from Shanmuga Polytechnic College, Thirumalaisamduram, Thanjavur (2005) and B.E Degree from Anjalai Ammal Mahalingam Engineering College, Kovilvenni, Thanjavur (2008) in Electrical and Electronics Engineering. He also finished M.B.A in Marketing from Bharathidasan University, Trichirappalli (2011) and currently doing the Master's Degree M.E in Power Electronics and Drives from Vandayar Engineering College, Thanjavur, Tamilnadu, India in 2016. His area of interest relies on Distributed maximum power point tracking based PV module.

