ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

SIMULATION OF MODIFIED OCC CONTROLLER FOR THREE PHASE BOOST TYPE GRID CONNECTEDINVERTER WITH PHOTOVOLATIC ARRAY

S. Lahari[*1] & D. Narmitha[2]
[*1]P.G. Student, Department of Electrical and Electronics Engineering, Sri Padmavathi Mahila Visvavidyalayam, Tirupathi-517502
[2]Assistant Professor, Department of Electrical and Electronics Engineering, Sri Padmavathi MahilaVisvavidyalayam, Tirupathi-517502

DOI: 10.5281/zenodo.892145

ABSTRACT
Now-a-days serious concerns have been raised over the fossil fuel electricity generation, because it pollutes our environment and depletes the energy supply. As a result alternative energy sources such as solar energy and fuel cells have gained great attention because they are friendly to the environment and flexible for installation. In this paper, the one cycle control (OCC) method and the pulse width modulation (PWM) method have been proposed for a three phase boost type grid connected inverter. A cost effective maximum power point tracking method (MPPT) integrated within the OCC. When integrated with a three phase boost type inverter, the proposed method tracks MPP with good precision and solar power is converted into three phase ac power with a single phase power stage. One stage inverters for low dc voltage to high ac voltage conversion have been reported for non-grid connected inverters based on the topology of a current source inverter. The output current of the inverter can be adjusted according to the voltage of the photovoltaic array so as to extract the maximum power from it. Compared with previously proposed approaches, this OCC method preserves the advantages of simple circuitry, good stability, fast dynamic response and maximum power point tracking (MPPT) function can be conveniently integrated into the control core.

KEYWORDS: Boost type, grid connected, maximum power point tracking (MPPT), one cycle control (OCC), photovoltaic (PV), three phase inverter.

I. INTRODUCTION
Now-a-days the non-renewable energy sources are depleting and it pollutes our environment that's why we are mostly depending upon the renewable energy sources because these renewable energy sources are available in abundance in our environment. These renewable energy sources are friendly to our environment and flexible for installation. Apart from all the renewable energy sources solar energy is the best. However, these types of sources produce dc power, while the present power grid accepts ac power, therefore, grid connected inverters are necessary for dc-ac conversion. The inverters are designed to have high power quality, high efficiency, high reliability, low cost and simple circuitry. Compared to single phase inverters, three phase grid connected inverters have distinctive advantages:

- First, the power flow is constant, which results in a reduced dc capacitor number and value.
- Fewer switches are used for three phase dc-ac conversion.

As far as the alternative source is concerned, the photovoltaic (PV) module or fuel cell stack usually supplies a dc voltage lower than the peak grid voltage, and their output voltage varies in a wide range according to various operation conditions [1], [2]. Series connection of several such modules can be a simple way to increase their output voltage so as to employ a buck-type grid-connected inverter for powerconversion [1], [3]. However, this method may reduce the input power collection range because the inverter stops conversion when its input dc voltage drops below its output peak grid voltage. Additionally, series connection of PV modules may reduce the overall efficiency of the PV array (a PV array consists of several PV modules) when individual modules are running under different conditions [4]. For boosting PV output voltage in order to accommodate the buck-type grid-connected inverter, a two-stage topology that boosts the PV voltage by a dc–dc converter in the first stage and then inverts it into ac voltages by the second stage was reported in previous literature [5], [6]. In [4], a cascaded structure is used in which the individual PV voltage is stepped up to a higher module output voltage and such module output voltages are series connected to build up an array output voltage as the front-end of a buck-type grid-connected inverter. In [7], a multi-level topology is employed to increase the input voltage of the buck-type inverter. In [4]–[7], either two power stages or extra power switches are used for increasing the dc side voltage, which increases circuitry complexity and may reduce system overall efficiency. An alternative way to achieve dc-to-ac inversion without directly boosting input dc voltage is to use the power stage topology of a current source inverter (CSI) as reported in [8] and [9].

However, this type of circuit could be bulky, heavy and expensive for a high power application. In paper [8], a One-Cycle Controlled (OCC) boost-type three-phase grid connected inverter was proposed. It has a single power stage, a low value dc side inductor and its input dc voltage can vary over a wide range. These key features of OCC are alldesirable for low cost high efficiency PV power generation. As far as maximum power point tracking (MPPT) methods are concerned, many methods have been addressed previously. The Perturb and Observe (P&O) method needs to calculate dP/dV to determine the maximum power point (MPP) [9][10]. Though the method is relatively simple, it can't track the MPP when the irradiance changes rapidly; and it oscillates around the MPP instead of directly tracking it. The Incremental Conductance method tracks MPP rapidly but it has high algorithm complexity, which also employs the calculation of dI/dV [11]. Though this method can accurately determine MPPs, a digital signal processor (DSP) or a microprocessor is usually needed for these complex calculations. The Constant Voltage method [12], which uses 76% open circuit voltage as the MPP voltage, and the Short-Circuit Current method [13] 2are simple, but they do not always accurately track the real MPP.

In this paper, the one-cycle control (OCC) method and the conventional pulse width modulation (PWM) method are proposed based on the CSI topology for a grid-connected application. The property of single power stage is preserved and the input dc voltage of the inverter is lower than the output peak grid voltage, which perfectly suits the property of wide output voltage range in PV or fuel cells. The dc side inductance can be kept small in a balanced three-phase system, so the size, weight, and power dissipation of the dc inductor are reduced and system dynamic response is improved.

II. POWER STAGE AND SWITCHING STRATEGY

Fig. 1 shows the power stage of the three-phase boost-type grid-connected inverter, where Vg is a dc voltage source, va, vb and vc are three-phase grid voltages, and Lfa, Lfb, Lfc and Ca, Cb, Cc form an output filter. Each switch of the bridge is realized by an insulated gate bipolar transistor (IGBT) in series with a diode as shown in the dashed line box. According to the zero-crossing points of grid voltages, each line cycle can be divided into six regions as shown in Fig. 2. In each region, two line-to-neutral voltages have the opposite polarity of the third one. For example,in Region I (0~60), va>0, vc>0 and vb<0. The line to line voltages are:

vab$\geq \sqrt{6}/2$Vrms, vcb$\geq \sqrt{6}/2$Vrms

Vrms is the rms value of the line to neutral voltage.

Similarly, in the other regions, two voltages can always be selected so as to obtain the two line to line voltages referred to the third voltage with the amplitude greater than $(\sqrt{6}/2)$ Vrms. At any given instant, one of the upper switches (Sap, Sbp, Scp) and one of the lower switches (San, Sbn, Scn) are kept on to form the inductor currentflow passage. For example, in Region I, San and Scn are kept off and Sbn is on for the entire region, while switches Sap, Sbp and Scp are operated at the switching frequency. There are three stages with different switching strategies in Region I: 1) In Stage I [Fig. 3(a)], Sbp is turned on and Sap,Scp are off. The inductor current IL increases, andoutput currents are supplied by Ca,Cb, Cc.2) In Stage II [Fig. 3(b)], Sap is turned on and Sbp, Scp are off.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

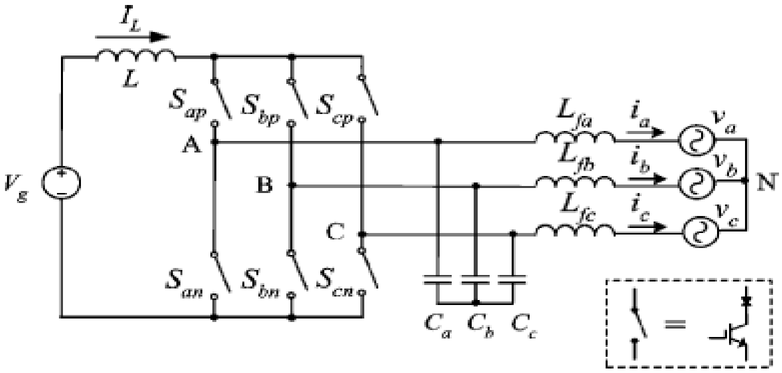

Fig. 1. Power stage of the boost-type inverter.

The inductor current IL discharges through Ca, Cb and the grid voltages va, vb. Then the current is supplied by Cc, Cb. 3) In Stage III [Fig.3(c)], switch Scp is turned on and the switches Sap, Sbp are off and the inductor current IL decreases through Cc, Cb and vc, vb. Therefore the current ia is supplied by Ca, Cb.

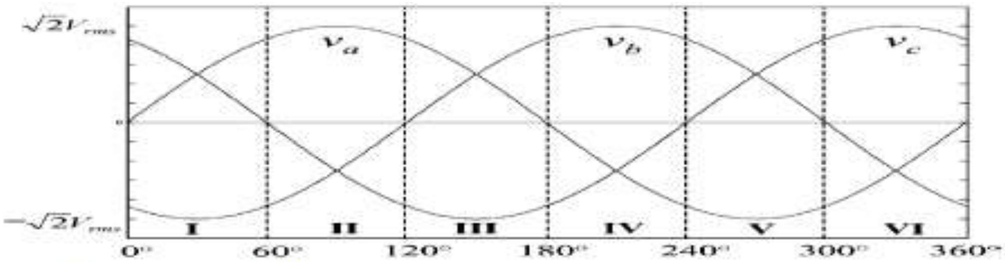

Fig. 2. Six regions in a line cycle.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

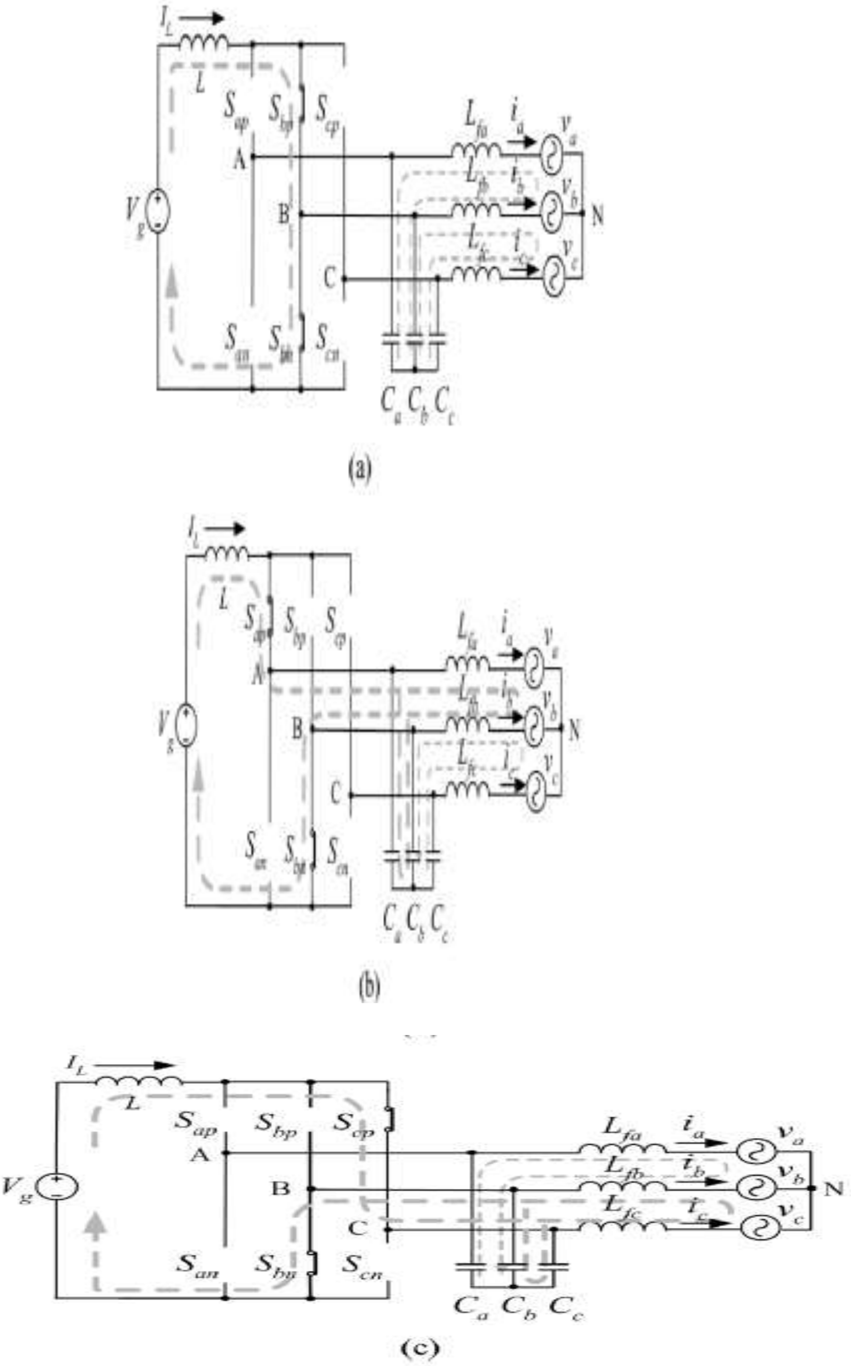

Fig. 3. Three stages for different switching patterns in Region I. (a) Stage I. (b) Stage II. (c) Stage III.

III. CONTROL PRINCIPLE

A. One Cycle Control Method

Figure 4 shows the diagram of OCC core for the boost type inverter. It comprises an integrator with reset, two comparators, two flip-flops and other linear and logic components, where V_{ref} is an adjustable constant and related to output power. R_1 and C_1 are integration components, and t=R1C1=Ts/2. Ts represents the period of a

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

switching cycle.V_p and V_n are selected from v_a, v_b and v_c in each region respectively; k is the voltage sensing ratio; I_L is the dc side current; and R_s is the current sensing resistance. PWM signal Q_p, Q_n and Q_t are distributed to the corresponding switches for driving IGBTs. In a balanced three-phase system, the dc side current can be derived as

$$IL=1/Rs(Vref-3k/2Vg\ Vrms^2)$$

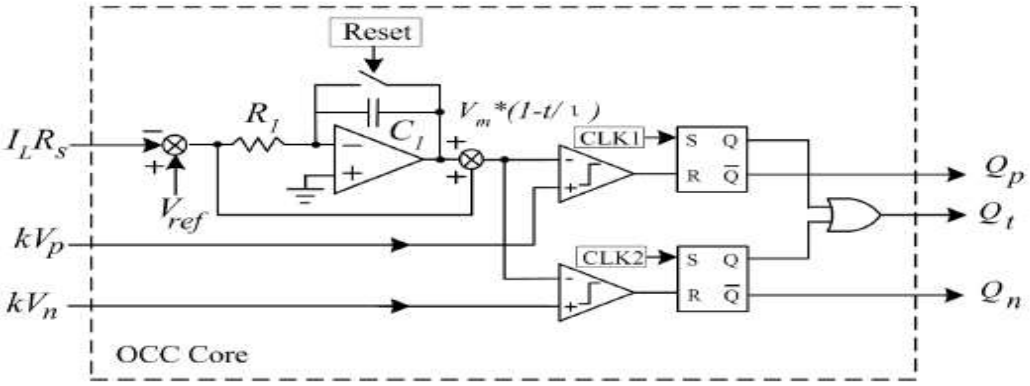

Fig.4 Diagram of the OCC core for the boost type inverter

The operation procedures are as follows (e.g., in Region I): at the beginning of each switching cycle, CLK1 sets Qt=1 in the upper flip flop. Then the switch Sbp is turned on and the power stage is operated in stage I. Wheneverthe falling ramp Vm(1-t/T) meets KVp, then the flip flop resets. At that time Qt=0 and Qp=1, which turns off Sbp and turns on Sap. Then the power stage switches to Stage II. At that time of Ts/2, the lower flip flop is set by CLK2 and Qt=1 then the power stage turns back to Stage I again. Similarly the falling ramp Vm(1-t/T) intersects KVn, then Qt=0 and Qn=1. Therefore the power stage switches to Stage III until the next switching cycle begins.

B. Conventional Pwm Method

Boost type inverter can also be controlled by the Conventional PWM control method. Fig. 5 shows the Conventional PWM control core which comprises two multipliers, saw tooth generation circuit, two comparators and other linear or logical components. The time sequence operation procedure of the Conventional PWM method as follows (e.g.. in Region I): Saw tooth 1 and Saw tooth 2 are out of phase for half of the switching period. The peak voltage Vm of saw tooth 1 or saw tooth 2 is a constant and t=Ts/2.

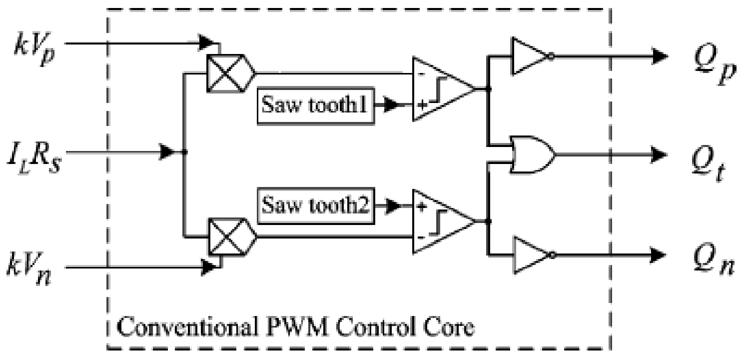

Fig.5. Conventional PWM Control Core

In the first half cycle when Vm(1-t/T) is greater than IL Rs*KVp then Qt=1 and Qp=0. At that time the circuit is in Stage I. At that time the ramp signal Vm(1-t/T) is greater than IL Rs *KVp. Therefore the upper comparator flips and Qt=0, Qp=1. Therefore the circuit then switches to stage II. In the second half cycle when Vm(1-t/T) is greater than IL Rs*KVn then Qt=1 and Qn=0. Therefore the circuit switches back to Stage I again. As soon as

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

vm(1-t/T) is less than IL Rs*KVn then the lower comparator flips then Qt=0 and Qn=1 therefore the circuit then switches to Stage III.

IV. MODIFIED OCC CONTROLLER WITH MPPT FUNCTION

When the dc source in Fig. 1 is a PV array, the operation conditions, such as Vg and output current from PV are determined by the actual input power of the boost inverter as well as the solar irradiance and cell temperature at any instant.

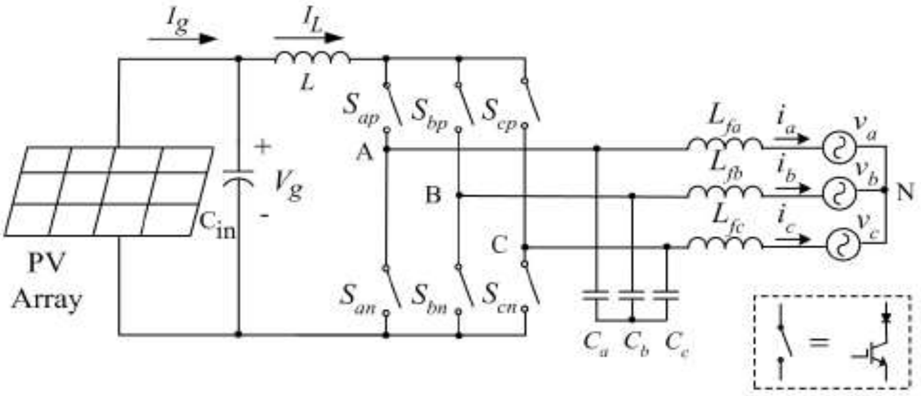

FIG.6. Power Stage PV Array Connection

For a generic PV array that is comprised of M modules in parallel and N cells in series in each module, the output power is:

$$Pg=Vg.Ig=Vg.M.\{ILG\text{-}Ios[e^{q(Vg+Ig.Rgs)/NAKT}\text{-}1]\}$$

In order to extract the maximum power from the PV array, the boost inverter should: i) allow input voltage to vary in a large range; ii) make input power track the MPP for different operating circumstances (e.g., temperature,irradiance). In order to make Pin approach MPPs automatically, a cost-effective MPPT method is proposed in this paper. Figure 7 shows the diagram of the controller with the MPPT function integrated in the OCC core.

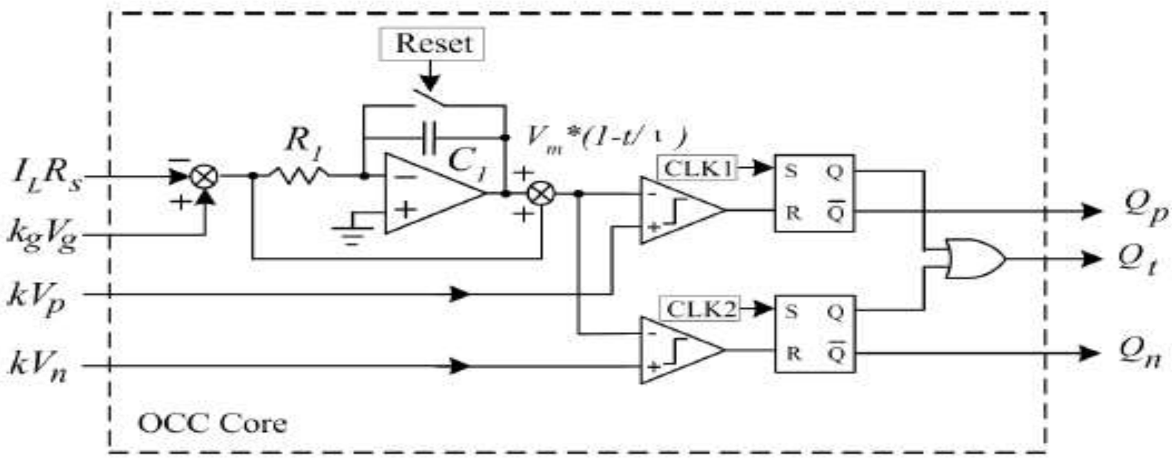

FIG.7. OCC Controller with MPPT Function

Only V_{ref} (in Fig.4) is replaced by $k_g.V_g$ in order to achieve a better MPPT tracking capability. K_g is the voltage sensing ratio and V_g is the output voltage of the PV array. Thus:

$$Vref=Kg.Vg$$

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

Simulation diagram

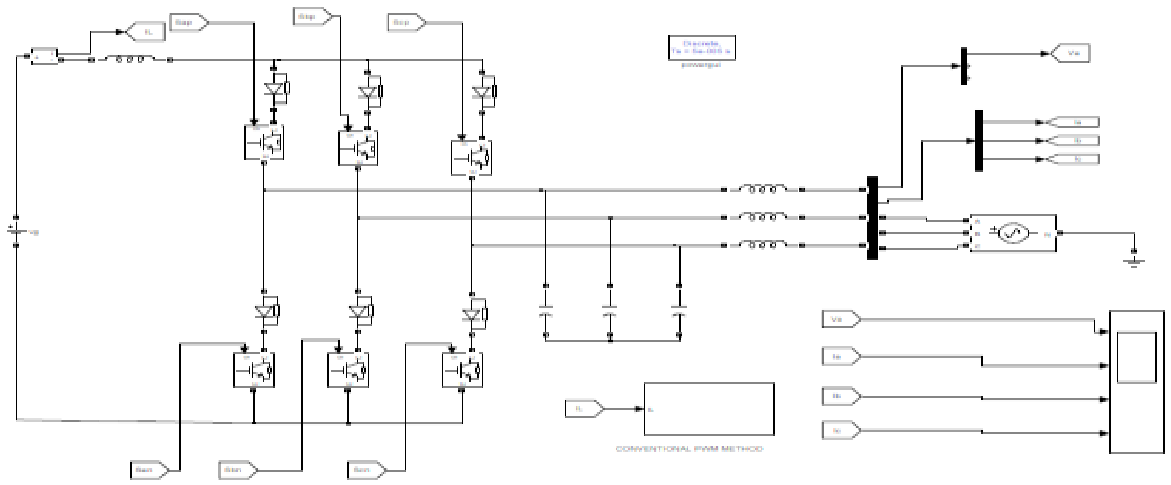

Fig. Simulation diagram for Conventional PWM Method

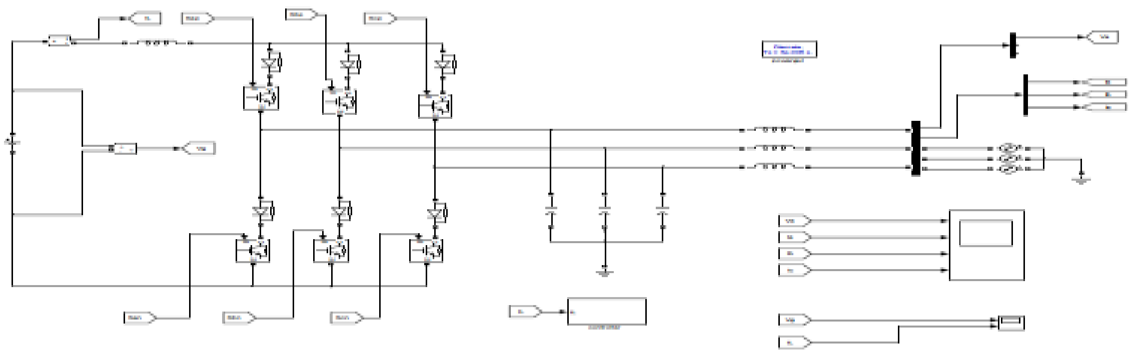

Fig. Simulation diagram for OCC Core for a boost type inverter

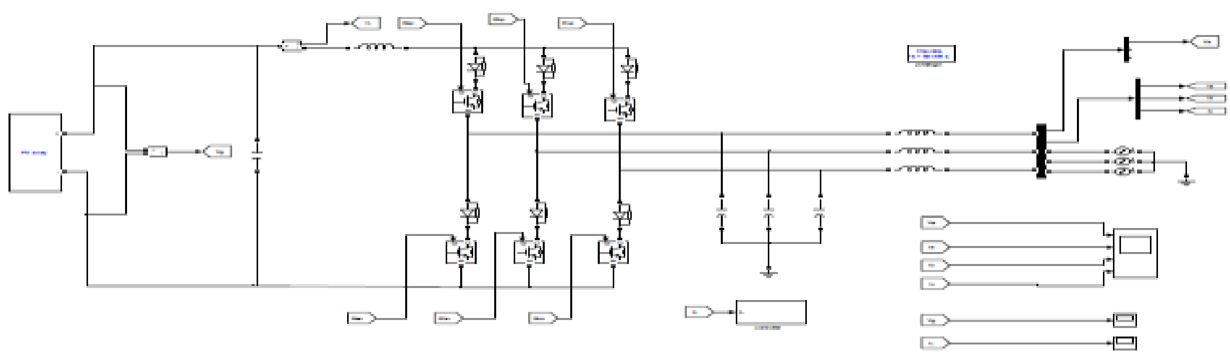

Fig. Simulation diagram for OCC Controller with MPPT function

Simulation results

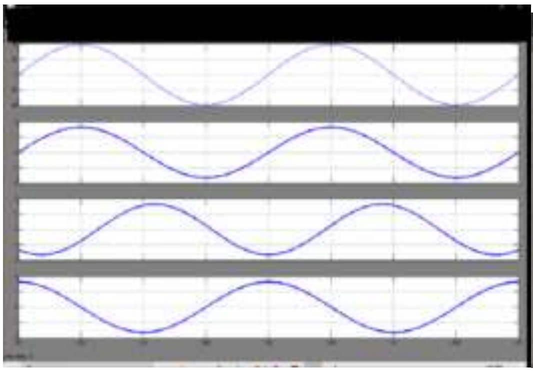

Fig. Simulation results for Conventional PWM Method

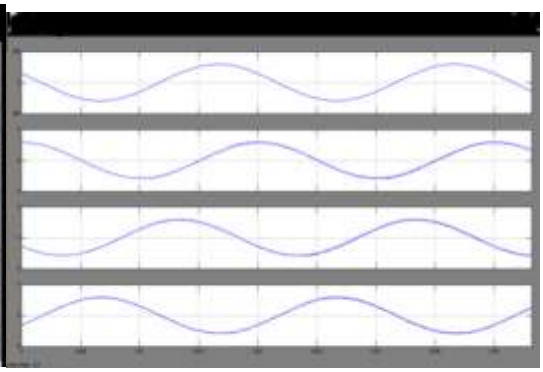

Fig. Simulation results for OCC Core Method

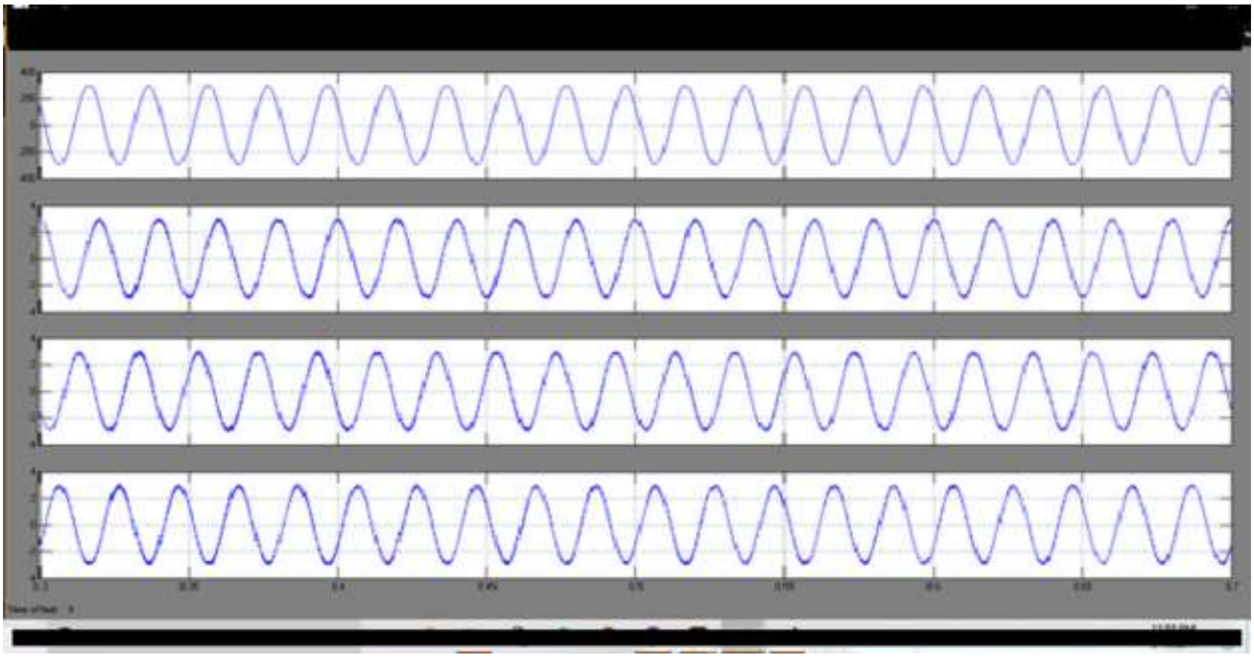

Fig. Simulation results for OCC Controller with MPPT Function

V. CONCLUSION

In this paper, a cost effective MPPT method is proposed for the three phase boost type grid connected inverter. The control method is simple and can be integrated within the OCC Core by adding a few simple components. Complex power calculation is not needed and multipliers or microprocessors are not necessary .The proposed circuit requires only one power stage to achieve the MPPT function and dc-to-ac power conversion. Compared to a buck type inverter which needs an additional dc-dc converter to boost the dc side voltage over 294V, the boost type inverter can accommodate a low dc voltage with a much wider range. The average dc current is maintained constant in each switching cycle in a balanced three phase system, so the dc side inductance can be kept small.

VI. REFERENCES

[1] Y. Chen and K. M. Smedley, "A cost-effective single-stage inverter with maximum power point tracking," *IEEE Trans. Power Electron.*, vol. 19, no. 5, pp. 1289–1294, Sep. 2004.

[2] G. K. Andersen, C. Klumpner, S. B. Kjaer, and F. Blaabjerg, "A new green power inverter for fuel cells," in *Proc. Power Electron. Specialists Conf. (PESC'02)*, Cairns, Queensland, Australia, Jun. 23–27, 2002, vol. 2, pp. 727–733.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

[3] C. Qiao and K. M. Smedley,“Three-phase grid-connected inverters interface for alternative energy sources with unified constant-frequency integration control,” in *Proc. Ind. Applicat. Conf. 2001*, Chicago, IL, Sep.-Oct. 30–4, 2001, vol. 4, pp. 2675–2682.
[4] G. R.Walker and P. C.Sernia “Cascaded DC-DC converter connection of photovoltaic modules,”*IEEE Trans. Power Electron.*vol. 19, no. 4, pp. 1130–1139, Jul. 2004.
[5] F. Antunes and A. M.Torres “A three-phase grid-connected PV system,”in *Proc. Ind. Electron. Soc. (IECON 2000)*, Nagoya, Aichi, Japan, Oct. 22–28, 2000, vol. 1, pp. 723–728.
[6] J. C. Lima, J. M. Corleta, A. Medeiros, V. M. Canalli, F. Antunes, F. B. Libano, and F. S. Dos Reis, “A PIC controller for grid connectedPV system using a FPGA based inverter,” in *Proc. Ind. Electron. (ISIE2000)*, Cholula, Puebla, Mexico, Dec. 4–8, 2000, vol. 1, pp. 169–173.
[7] M. Calais, V. G. Agelidis, L. J. Borle, and M. S. Dymond, “A transformerless five level cascaded inverter based single phase photovoltaic system,” in *Proc. Power Electron. Specialists Conf. (PESC’00)*, Ireland, Jun. 18–23, 2000, vol. 3, pp. 1173–1178.
[8] M. Kazerani, Z. C. Zhang, and B. T. Ooi, “Linearly controllable boost voltages from Tri-Level PWM current-source inverter,” *IEEE Trans. Ind. Electron.*, vol. 42, no. 1, pp. 72–77, Feb. 1995.
[9] O. Wasynczuk, “Dynamic behavior of a class of photovoltaic power systems,” IEEE Trans. Power App. Syst., vol. PAS-102, pp.3031–3037, Sept. 1983
[10] E. Koutroulis, K. Kalaitzakis, N.C. Voulgaris, “Development of a Microcontroller-Based, Photovoltaic Maximum Power Point Tracking Control System”, IEEE Transactions on Power Electronics, Vol.16, No.1, pp.46-54, January 2001
[11] K.H. Hussein, I. Muta, “Maximum Photovoltaic Power Tracking: An Algorithm for Rapidly Changing Atmospheric Conditions”, IEEE Proceedings on Generation, Transmission and Distribution., Vol.142, No.1, pp.59-64, January 1995
[12] T. Noguchi, S. Togashi, R.Nakamoto, “Short-Current Pulse-Based Adaptive Maximum-Power-Point Tracking for a Photovoltaic Power Generation System”, Electrical Engineering in Japan, Vol.139, No.1, pp65-72, 2002[Denki Gakkai Ronbunshi, Vol.121-D, No.1, pp.78-83, January 2001]
[13] J.H.R. Enslin, M.S. Wolf, D.B. Snyman, W. Swiegers, “Integrated Photovoltaic Maximum Power Point Tracking Converter”, IEEE Transactions on Industrial Electronics, Vol.44, No.6, pp.769-773, December 1997

CITE AN ARTICLE

Lahari, S., & Narmitha, D. (2017). SIMULATION OF MODIFIED OCC CONTROLLER FOR THREE PHASE BOOST TYPE GRID CONNECTEDINVERTER WITH PHOTOVOLATIC ARRAY. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*, *6*(9), 424-432. Retrieved September 15, 2017.