Modeling and Simulation of a GRID-TIED Solar PV System

K.Sakthivel, V.Jayalakshmi, G.Rajakumari

***Abstract:** In this paper proposes P &O algorithm for a 1φ grid connected solar PV system using a Fly back converter. The Fly back converter is used in PV system to get DC output along with an AC output without using an Inverter. Here, P &O algorithm is implemented to control solar PV output and reduction of harmonics using Fly back converter. The aim of this algorithm is to identify the suitable duty ratio for the fly back converter to obtain the maximum power point tracking. The performance of PV array with fly back converter and boost converter in terms of output voltage is detailed. The simulation for PV model is formulated and carried out through Matlab/Simulink environment. The simulation results are compared with all the features of power profile smoothing capability.*

I. INTRODUCTION

Due to population growth and the modern industrial society, the energy demand increases which motivate the use alternative energy to improve power quality and the energy efficiency. Among all the renewable source of energy, the use of PV energy has emerged as primary resources because the solar energy is clean, green environmental friendly and in exhaustible. The PV system has the ability which converts solar radiation into DC voltage .Such a PV system can be either grid connected or stand alone. The grid connected PV system become more popular than standalone due to their application in distributed generations. The efficiency and stability of the PV system are improved by the power electronic conversion devices. The Photovoltaic system consists of a PV module, Fly back converter, MPPT controller and an electrical grid. The maximum power point algorithm (P&O) tracks the maximum power and the output can be matched with the loads. The main aim of this paper is to generate the electricity from PV and delivering power to industrial loads or domestic loads. In major, the PV panels are designed in to have an output voltage of 23-38V and rated power 160 W. This paper deals with the PV array is connected to the utility grid through a Fly back converter to optimize the PV output and AC inverter system. The proposed model are simulated in Matlab/Simulink Software.

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II. SOLAR PHOTO VOLTAIC SYSTEM

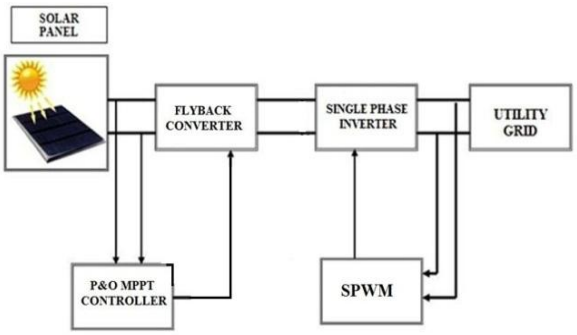

Fig. 1 Proposed System Block Diagram

The above model consists of PV arrays which is converted into DC power, a fly back converter to get DC output along with an AC output and an inverter. The converter convert the DC power to AC power. The generated AC power is injected into the utility grid or to the local loads.

Modeling of PV Panel

The Photovoltaic energy is directly extracted from the light energy without any intermediate process. A PV arrays are connected in series and parallel combination of solar cells. The efficiency of solar power can be achieved by the MPPT. The equivalent circuit of PV panel is shown in Fig 2

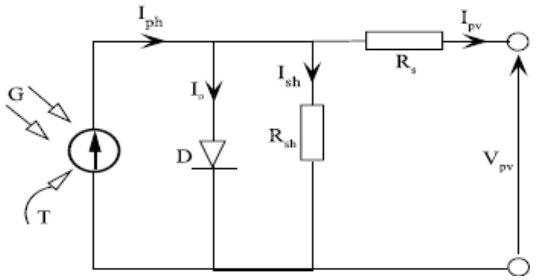

Fig. 2 Equivalent circuit of PV panel

By applying the KCL, to the above circuit we get,

$$I_{pv} = I_{ph} - I_D \quad (1)$$

The photocurrent is defined as

$$I_{Ph} = \left[I_{SC} + K_1\left(T_C - T_{C,Ref}\right)\right] \times \frac{G}{G_{REF}} \quad (2)$$

Where

Isc - short circuit current

Tcref - reference cell temperature.

Tc - operating temperature.

The diode diffusion current I_D is given by,

$$I_D = I_S\left[e^{\left(\frac{qv_{pv}}{AKT_C}\right)} - 1\right] \quad (3)$$

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Where A –is the diode ideality factor
K-Boltzmann's constant
Q-charge electron
The diode saturation current is given by,

$$I_S = I_{RS}\left(\frac{T_C}{T_{Ref}}\right)^3 \exp\left[\frac{qE_{gap}}{AK}\left(\frac{1}{T_{cRef}} - \frac{1}{T_C}\right)\right] \quad (4)$$

Where
I_{RS} - reverse saturation current of PV.
E_{gap}- semiconductor gap energy of PV
The expression for PV array output current is given by,

$$I_{PV} = I_{Ph} - I_S \times \left[\exp\left(\frac{q\times(V_{PV}+I_{PV}\times R_S)}{A\times K\times T_C}\right) - 1\right] \quad (5)$$

Vpv –Output voltage of the PV cell
Ipv –Output current of the PV cell
Rs -diode series resistance.

Fly back Converter

The Fig3 shows the usual configuration of the fly back converter. It is an isolated buck-boost converter with an inductor split which consist of less number of components than the conventional boost converter and it operate with a low inductance value. The MOSFET switch is connected to the primary side of the gate drive circuit and maintains the desired output voltage. The transformer polarity is used for voltage isolation between input and output voltage. The unregulated dc voltage from the PV arrays is given as input to the fly back converter. The transformer secondary side winding voltage is rectified and filtered by using a diode and capacitor

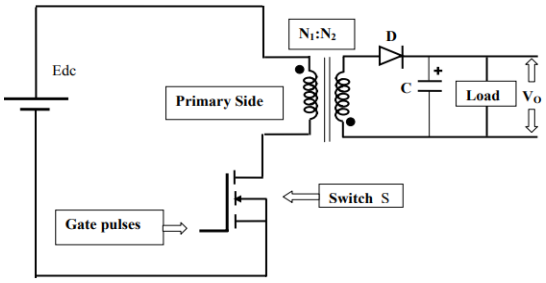

Fig. 3 Basic circuit of FLY back converter

The input and output of the fly back converter is given by equation.

$$\frac{V_O}{V_S} = \frac{N_2}{N_1}\left(\frac{D}{1-D}\right) \quad (6)$$

Single Phase Inverter

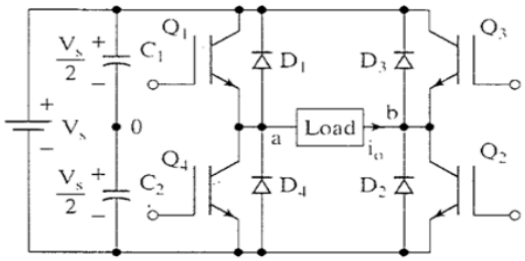

Fig. 4 Single phase inverter circuitry connection

Fig 4 shows the single phase inverter circuit. The PV array is connected to AC grid via common DC-AC inverter. The PWM inverter was used in current control method to make the inductance current closely to the reference current and obtain a low THD injected current.

III. CONTROL STRATEGY

The Following control strategy are used for the proposed grid connected PV system:
(1) Maximum power point tracking controller
(2) Grid synchronization controller
(3) PV inverter controller

Perturb & Observe MPPT Algorithm

This MPPT algorithm continuously maximizes the power generated by PV systems by controlling the voltage. The P and O algorithm is widely used MPPT techniques for solar PV applications due to its simplicity in design and implementation with good performance. This algorithm track Maximum Power Point by measuring the PV characteristics are perturbs the operating point of PV module to obtain the position change in direction. When there is a rate of change of power with respect to voltage is zero, the maximum power point is reached. When the PV panel voltage is perturbed by a small increment, the resulting in change power of is positive then the system is going in the direction of MPP and to keep on perturbing in the same direction i.e δ' is increased. If P is negative, then the system going away from the direction of MPP and the sign of perturbation supplied has to be changed i.e δ' is decreased. The same step is to continue till maximum power point is reached. The corresponding voltage at which MPP is reached is known as reference point (Vref).

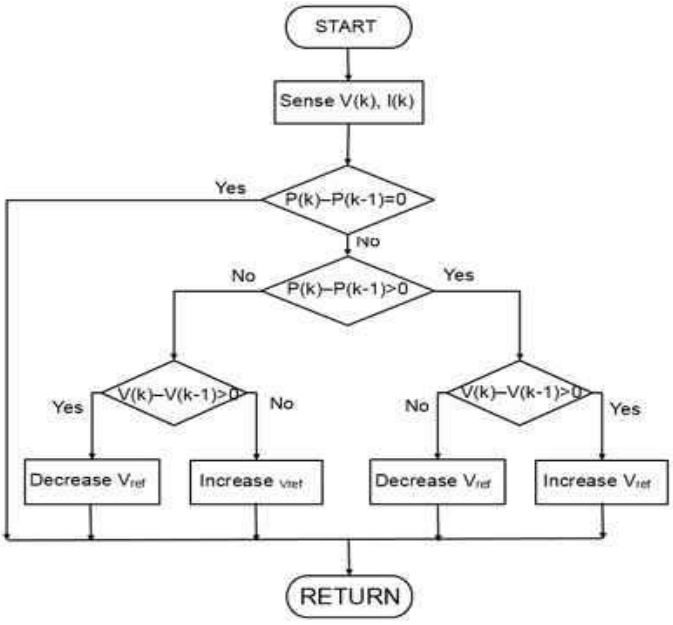

Fig. 5 Shows Flowchart of P and O algorithm

IV. SIMULATION RESULTS AND OUTPUT

The performances of the proposed system are now illustrated by simulation. The proposed setup described in Fig 1 is simulated using MATLAB is shown in Fig 6

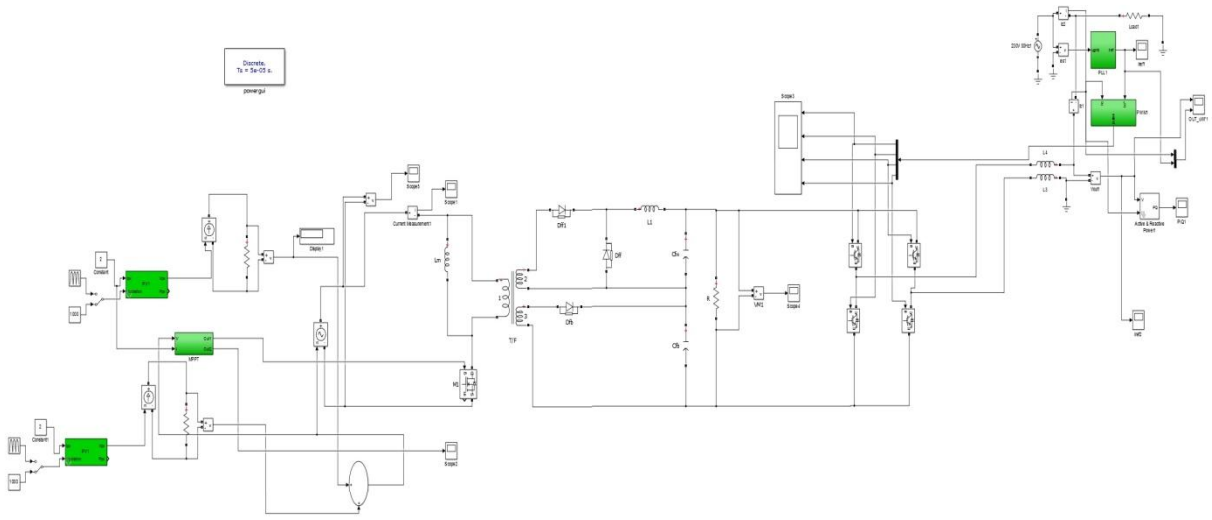

Fig. 6 simulation of proposed system

The solar power generation system is as shown in the figure 7 which use the referred values from real time solar panel.

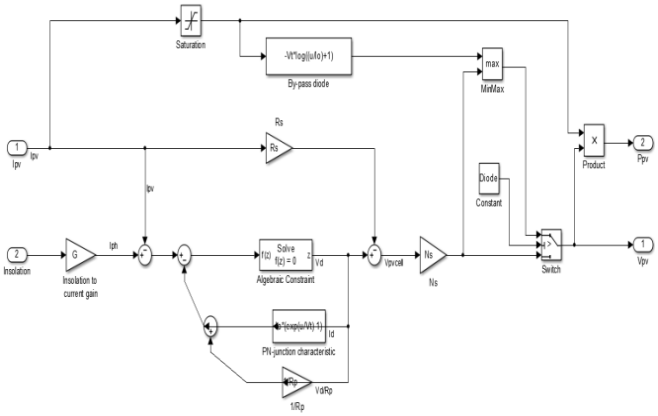

Fig. 7 Simulation model of Solar PV system

The improved P and O MPPT algorithm is also implemented in the simulation software as shown in the figure 8.

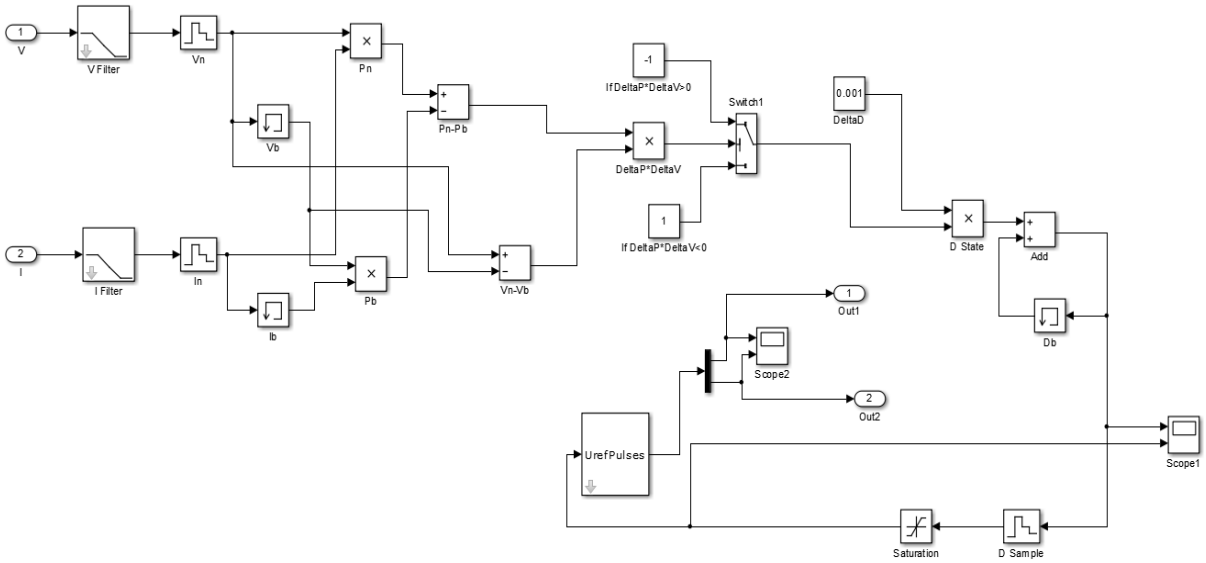

Fig. 8 MPPT technique with P and O algorithm

For the synchronization of grid with the PV system a Phase locked Loop (PLL) system is implemented is as shown in the figure 9.

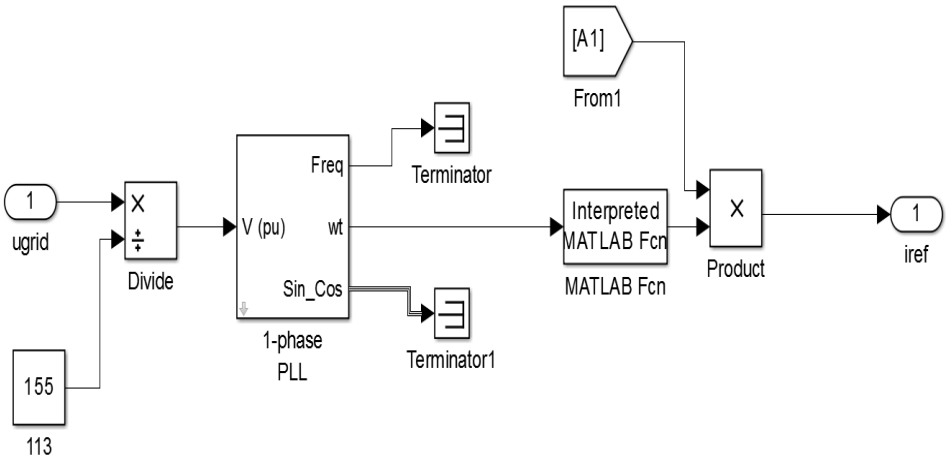

Fig. 9 PLL simulation model

The proposed system model is simulated in MATLAB simulation software. The output power from the PV system is as shown in the figure 10. The output voltage from PV power system is of about 114 voltage constant dc output voltage waveform.

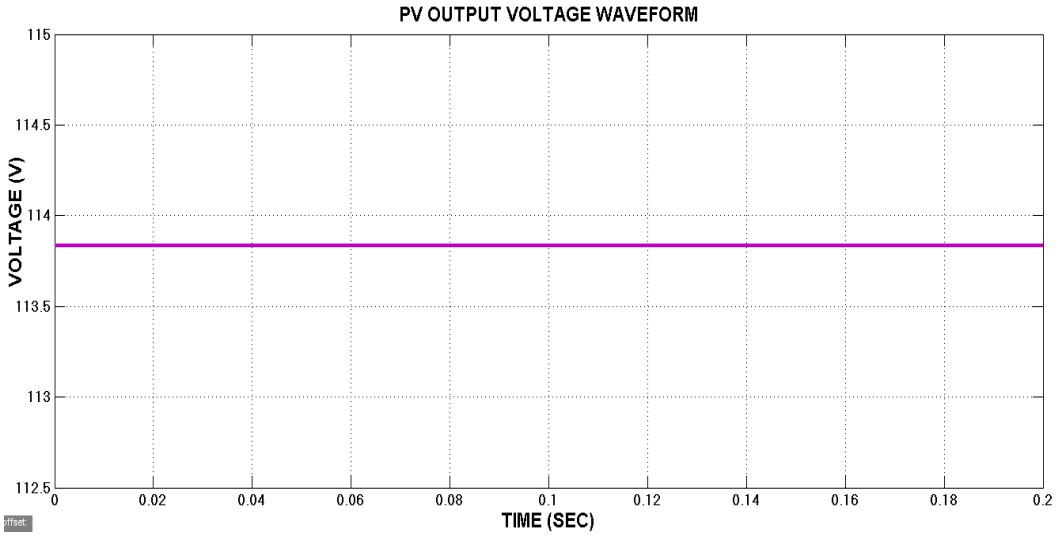

Fig. 10 PV output Voltage waveform

The current output of the PV output waveform is as shown in the figure 10. The current waveform from the PV panel is distorted can be observed from the figure 11.

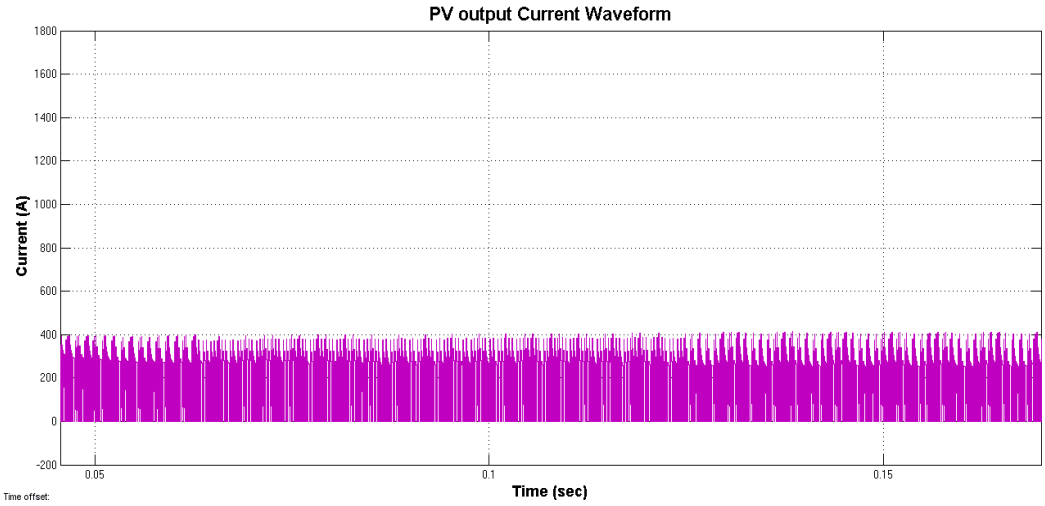

Fig. 11 PV current output waveform

The current waveform is distorted due to changes in PV system.

The FLY back converter output is as shown in the figure 12. The voltage is boosted to 1030 Volt output DC waveform. The voltage generated through proposed P and O algorithm with fly back converter is a constant DC output voltage waveform.

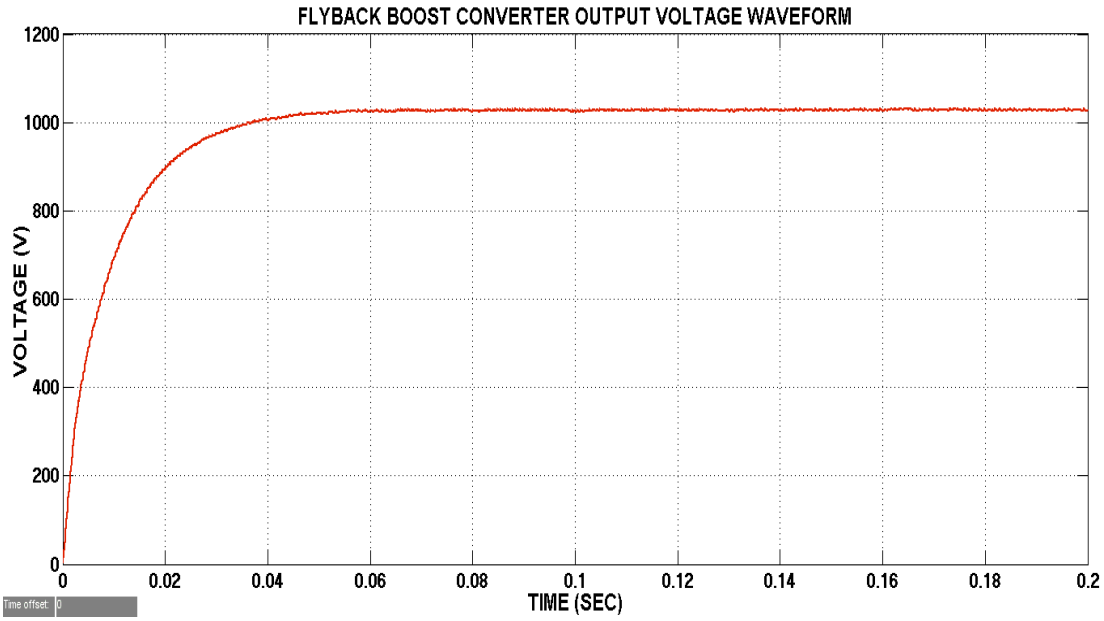

Fig. 12 DC Voltage output waveform

The proposed MPPT P and O algorithm technique is generating a pulse for the high voltage output for fly backboost converter is then fed into DC/AC inverter. The output of MPPT Pulse is as shown in the figure 13.

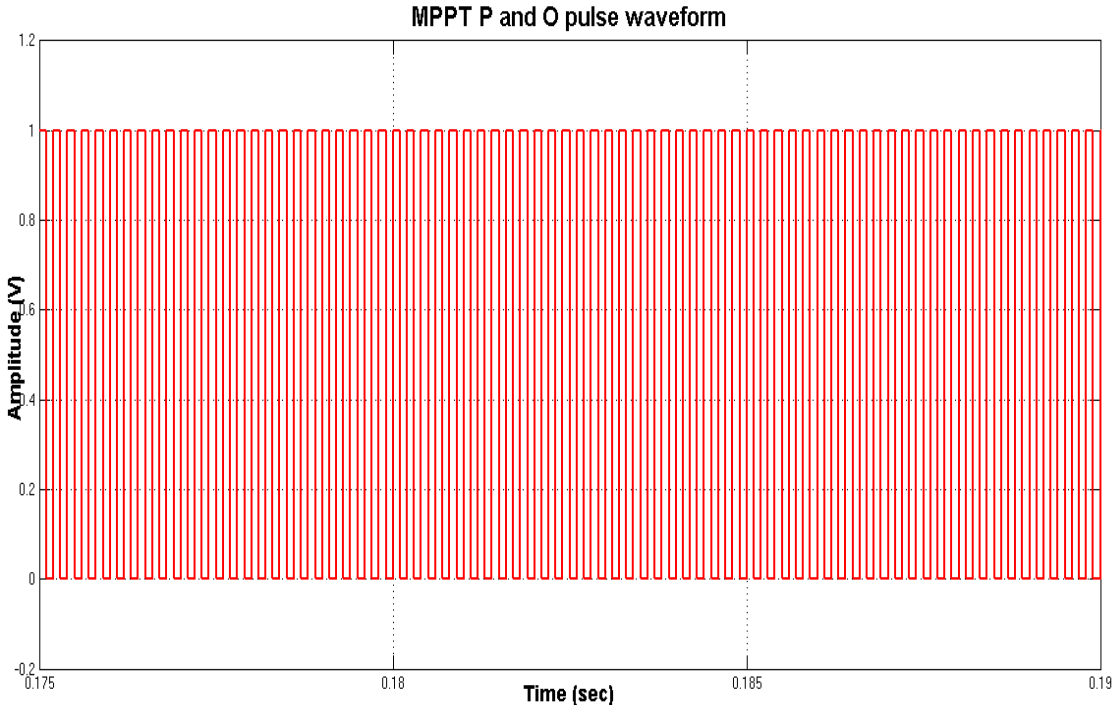

Fig. 13 MPPT pulse Generation waveform

A PWM wave generator is implemented with the inverter circuit, this PWM wave generates four pulses for four semiconductor switches the output of the PWM pulse waveform is as shown in the figure 14.

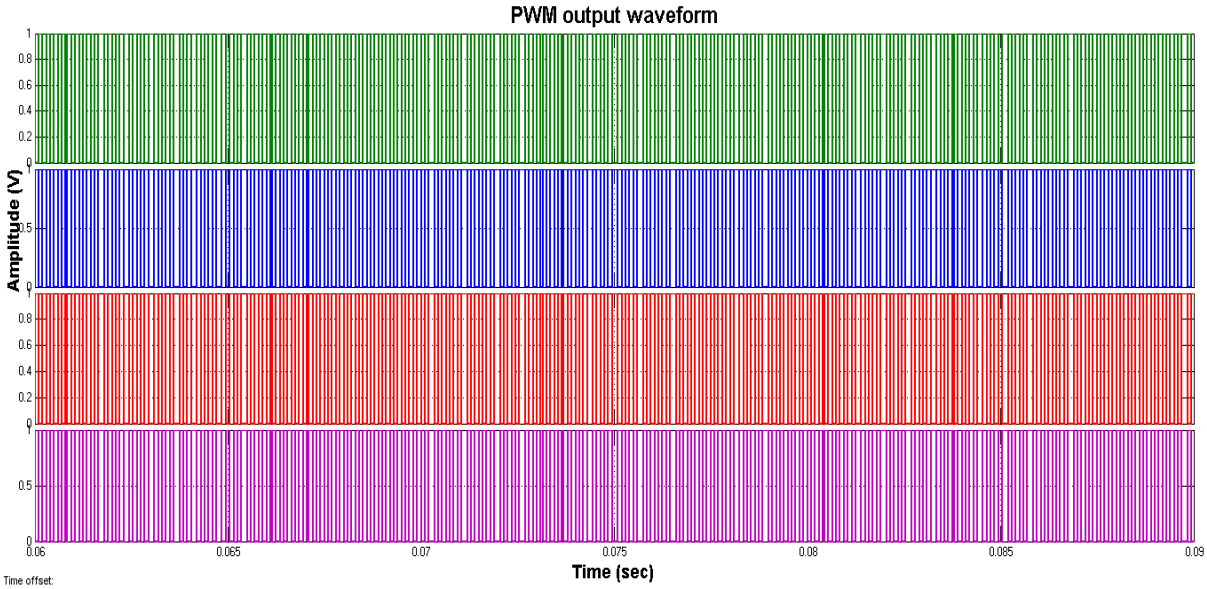

Fig. 14 PWM pulse generation waveform

With the help of inverter circuit and PWM generator and with PLL the voltage and frequency synchronized output voltage is as shown in the fig. 15.

The AC output voltage waveform has constant single phase ac with the amplitude of about 230 Volt and 50 Hz frequency. The AC current output waveform is also a single phase output with the amplitude of about 4.75 A.

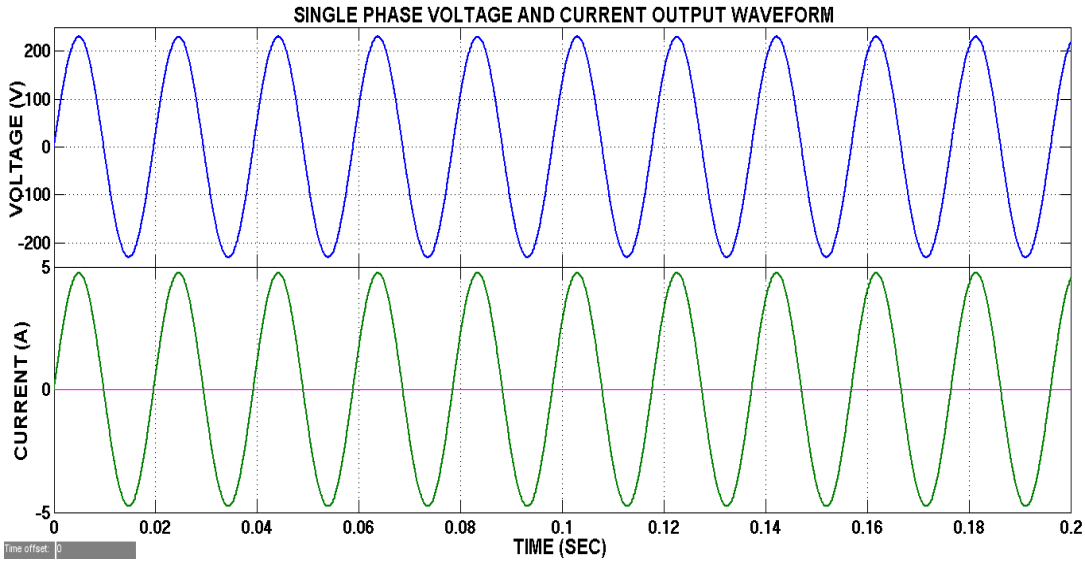

Fig. 15 Single Phase voltage and Current output Waveform

Table. 1 Comparison of Existing Traditional boost converters and Proposed Fly Back Converter with MPPT

PARAMETERS FOR 1 KW PV PANEL	FLY BACK CONVERTER WITH MPPT	TRADITIONAL BOOST CONVERTER
Solar PV output Voltage	114 V	114 V
Boost Converter Output Voltage	1030 V	300 V
AC output Voltage	230 V	150 V
AC output Current	4.75 A	3 A
Frequency	50 Hz	50 HZ

V. CONCLUSION

P&O algorithm for a grid tied solar PV system using fly back converter is implemented in this paper. The performance assessment of PV array with MPPT controller using fly back converter and boost converter is detailed. The simulation results validates the proposed control technique and regulates the output voltage of the Fly back converter and gives better output with less ripple voltage than Boost converter.

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Mr.K.Sakthivel, is currently working as an assistant professor in the department of EEE, Bharath Institute of Higher Education and Research. He has 8 years of academic experience in the field of electrical drives and renewable energy. He has Completed his U.G. Degree from Vel Tech engineering, college and P.G.Degree from Jeppiaar engineering college. Presently he is a Member of ISTE.

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