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Simulation of Photo Voltaic System for Irrigation Purpose

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Abstract: **This paper implements a design for a photo voltaic system in order to produce a 230V RMS ac from a solar panel for house hold and heating applications. The above design is a combination of converter, inverter which is simulated using P-Sim software and the analysis of the same is discussed in detail. The proposed system is well suited for environment with surplus solar energy to fed supply for lighting or irrigation purpose.**

Keywords: **Photovoltaic system; Solar Panel; Push Pull Converter; Three level SPWM inverter.**

1. INTRODUCTION

While a majority of the world's electricity supply is generated from fossil fuels these traditional energy sources face a number of challenges including rising prices, growing environmental concerns over the climate change risks associated with power generation using fossil fuels there is need to obtain electricity from cleaner form of energy. Renewable energy sources such as solar, hydroelectric and wind power generation have emerged as potential alternatives. Solar power generation has emerged as one of the most rapidly growing renewable sources of electricity [5] – [8], [14].

This paper deals with the design of a DC to AC inverter system for the solar panel [1] – [4]. The system converts very low DC voltage with highly variable power from the solar panel to the AC output voltage of 230 V / 50 Hz sinusoidal outputs. The output power obtained is well sufficient to source small AC powered appliances or lights in the destinations without a power grid.

Simple Block Diagram for the above system is as pictured in fig.1.

2. DC-DC CONVERTER

The aim of the work is to design and to analysis the push pull converter. Push pull is a type of dc - dc converter which is suitable to boost up the voltage from a very low level voltage to high voltage. This converter may be used in conjunction with a high frequency transformer to boost the output voltage with the advantage of providing isolation between the input and output stage.

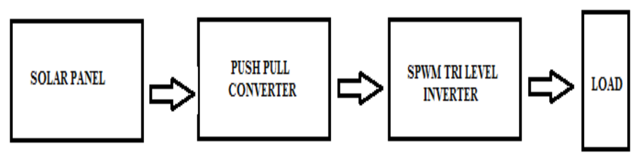


Fig.1. Block Diagram

In this paper push pull converter topology is used, to step up a 12V solar DC supply to 400V DC output voltage. P-SIM software is used to verify the output of this converter topology [9] - [10]. The circuit diagram for the push pull converter is revealed in fig 2. The working of the same is as follows:

A. Switch S1 Closed:

In the mode 1, switch1 is closed. The primary voltage, $V_{P1} = V_S$ (1)

The voltage across the primary is transformed to the three other windings, the equations governing the voltages are as given in (2) – (15)

Secondary1 voltage, $V_{S1} = V_S(N_S/N_P)$ (2)

Secondary2 voltage, $V_{S2} = V_S(N_S/N_P)$ (3)

Primary2 voltage, $V_{P2} = V_S$ (4)

Switch2 voltage, $V_{SW2} = 2V_S$ (5)

Diode *D*1 is forward-biased, *D*2 is reverse-biased, and the filter inductor voltage is deduced as

$V_{LX} = V_X - V_O = V_S(N_S/N_P) - V_O$ (6)

In the interval when Sw1 is closed, the change in current in *Lx* is as given in equation (7).

$(\Delta i_{Lx})_{closed} = (Vs(NS/NP)\text{-}Vo)DT/L_x$ (7)

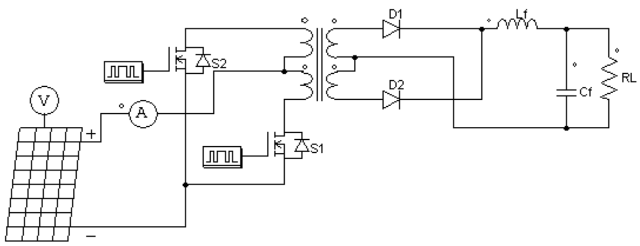


Fig. 2. Push pull topology circuit diagram.

B. Switch Sw2 Closed:

When switch S2 is ON, the voltage established across primary winding P2, $V_{P2} = -Vs$ (8)

The voltage across primary P2 is transformed to the multi-windings, ensuing in the equations (9) – (12).
Primary1 voltage, $V_{P1} = -Vs$ (9)

Secondary1 voltage, $V_{S1} = -Vs(Ns/Np)$ (10)

Secondary2 voltage, $V_{S2} = -Vs(Ns/Np)$ (11)

Secondary1 voltage, $V_{S1} = 2Vs$ (12)

Diode D2 is forward biased, D1 is reverse biased similarly the voltage across the filter inductor is

$V_{Lx} = Vs(Ns/Np)\text{-}Vo$ (13)

The current through Lx increases linearly while Sw2 is closed and change in inductor current is same as equation (6).

C. Both Switches Open:

With both switches open, the current in each of the primary windings is zero. Diodes *D*1 and *D*2 are forward-biased, hence filter inductor current divides evenly between the transformer secondary windings. The voltage across each secondary winding is zero i.e..

$V_x = 0$ (14)

$V_{Lx} = V_x\text{-}Vo = -Vo$ (15)

The change in current while both switches are open is
$(\Delta i_{Lx})_{open} = -(Vo/L_x)(1/2 - D)T$ (16)

At steady state operation,
$(\Delta i_{Lx})_{open} + (\Delta i_{Lx})_{closed} = 0$ (17)

Hence output voltage Vo = 2Vs(Ns/Np)D (18)

where *D* is the duty ratio of each switch. The above analysis assumes continuous current in the inductor. The output ripple for the push-pull converter is given by

Output voltage ripple = $(1\text{-}2D)/(32L_xCf^2)$ (19)

D. Converter Simulation Analysis

The push pull converter is modelled using ideal switch which is supplied with a gating signal of 20 kHz switching frequency. The gating pulses given for both the switches on input side are fed with complementary pulses of duty cycle of 0.47.The simulated output of pulses are shown in Fig. 3. The converter is designed with the equations (1) – (19) and simulated for the specifications mentioned in Table 1. The designed values of filter inductance and capacitor are 370µH and 1000µF. An input of 12V DC power supply is fed as the input to the push pull converter. The open loop simulation output voltage and current of 400V output voltage and 1.25A peak amplitude output current for the push pull converter block are presented in Fig 4.

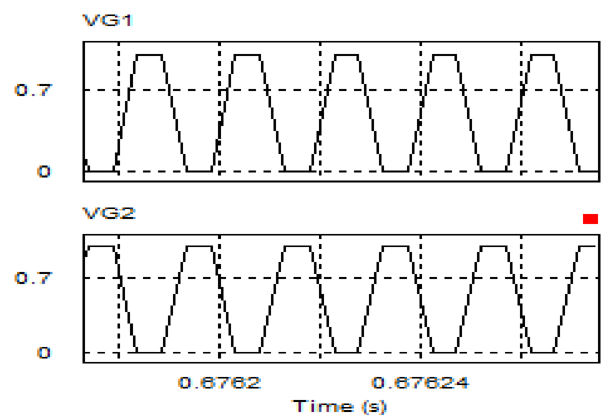
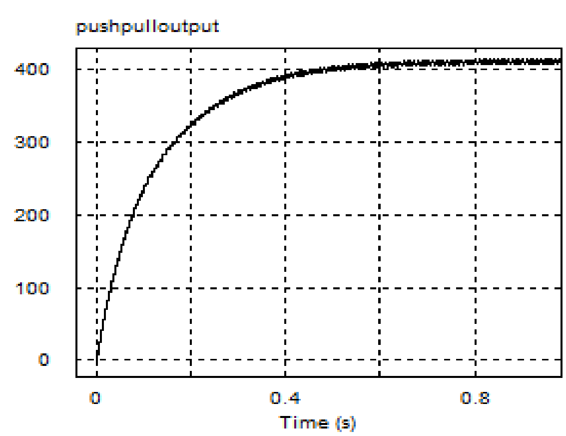


Fig. 3. Gating pulses for push pull



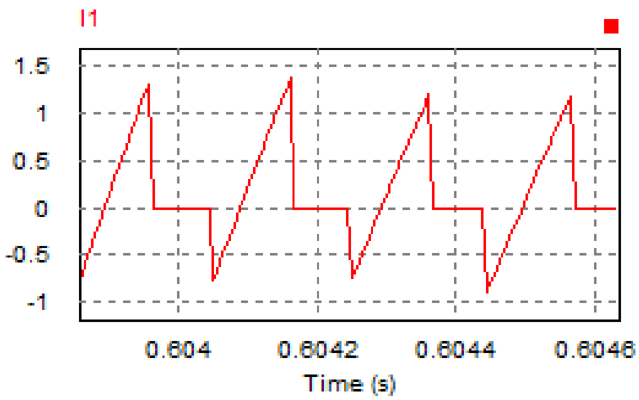


Fig. 4. Open loop output voltage and output current

Table 1: Specifications of push pull converter

Input voltage	12V ± 5 %
Output voltage	400 V ± 10 %
Output power	15W
Switching frequency of Push-pull Mosfet	50kHz

3. INVERTER

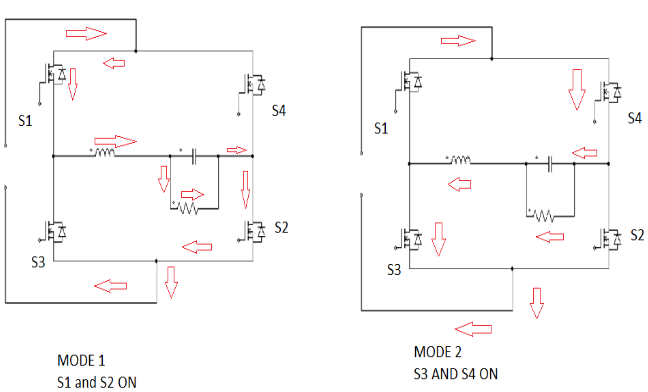
The DC power obtained from the converter block is converted into AC power at desired output voltage and frequency with the Inverter block explained detailed in this section.

A. SPWM H Bridge Inverter

MODE 1: This mode starts when switches S1 and S2 are turned on, positive DC voltage appears across the load

MODE 2: Switches S3 and S4 are turned on so as to obtain a negative DC voltage across the load.

MODE 3: In this mode S1 and S4 are turned on and the inductor charged in mode1 finds a discharging path through the internal closed loop formed.



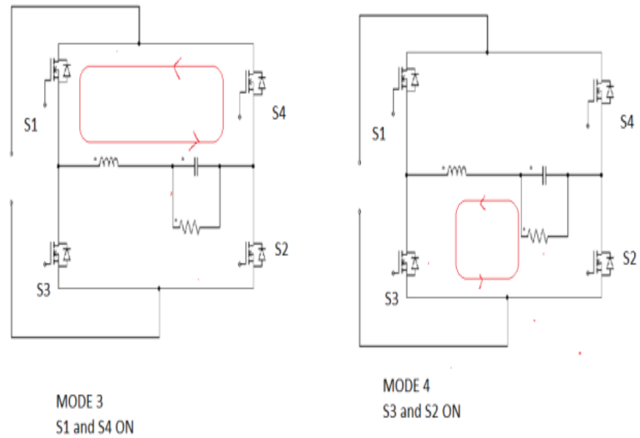


Fig. 5. Modes of operation of SPWM H Bridge Inverter

MODE 4: This mode starts after mode 2 when S3 and S2 are turned on so as to make an internal closed path.

B. Trilevel Unipolar SPWM Technique

In SPWM unipolar technique 3 different signals are used to obtain four gate signals. The first set of gate signals is obtained by comparing a reference sine wave signal of 50Hz frequency with a carrier signal of triangular shape and 2.5kHz frequency. Similarly the inverted sine wave is also compared with the carrier signal to obtain the other gate pulse [11] – [13], [15] – [16].

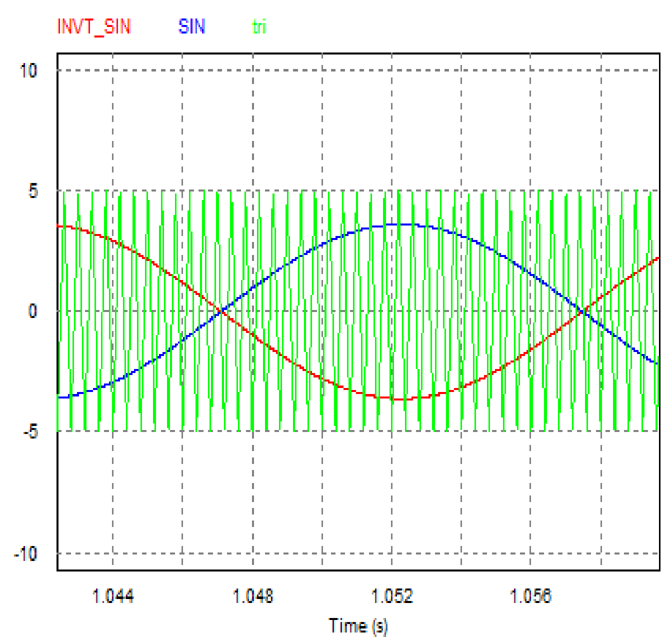


Fig. 6. Comparison of Sine, Inverted Sine and Triangular Wave.

Triangular wave compared with sine and inverted sine wave is as depicted in Fig. 6. The PWM pulses for the four switches in H-Bridge are generated by using Op-Amp as shown in Fig. 7. The switching frequency for the Inverter switches are 2.5 kHz and fundamental frequency for the output voltage is 50Hz. Hence, for obtaining the PWM, the triangular wave of 2.5 KHz and 10 Vpp is fed to the inverting terminal of Op-Amp and Sine wave of 50Hz and 8Vpp is fed to non-inverting terminal of Op-amp. The gating pulses obtained for the all the four mosfets are as shown in Fig 8.

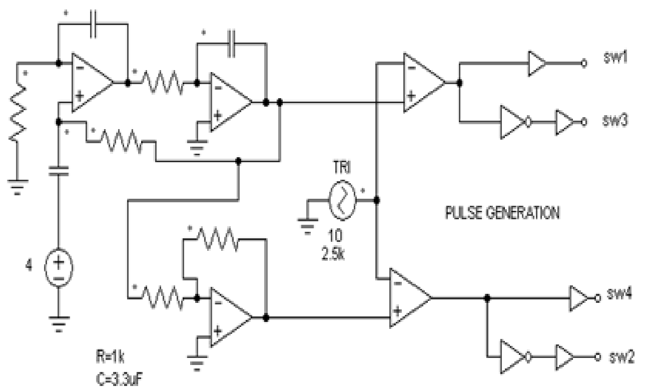


Fig. 7. Pulse Generation circuit.

4. PROPOSED CIRCUIT SIMUALTION

The complete overall setup of the proposed work is as shown in Fig. 9. The simulation results are presented and analyzed in detail in this section for R load.

The input for the push pull topology is fed from the solar panel and the boosted output obtained from push pull converter is fed to the inverter block, the unfiltered output obtained is shown in Fig 10. Filtered output after the filter across the load is shown in Fig 12.

A. Unfiltered Output

The unfiltered output voltage for R load is a pulsating square pulse, both zoomed and overall are as revealed in Fig 10.The input fed to the inverter is 400V DC which is obtained as an output from the push pull converter circuit. The FFT analysis of the unfiltered output shows that there are many harmonics up to frequency of 80MHz.The FFT analysis is shown in Fig 11. The magnitude of the harmonics also is very high 14 in magnitude. Hence filtering the output obtained becomes a necessary factor.

B. Filtered Output

The Output voltage for the R load with filter is as shown in Fig 12.The inductor along with capacitor acts as LC filter tuning to a pure sine wave of 50 Hz. The FFT analysis for the Filtered output is shown in Fig 13.The analysis shows that there are very less number of harmonic components in filtered output compared to unfiltered.

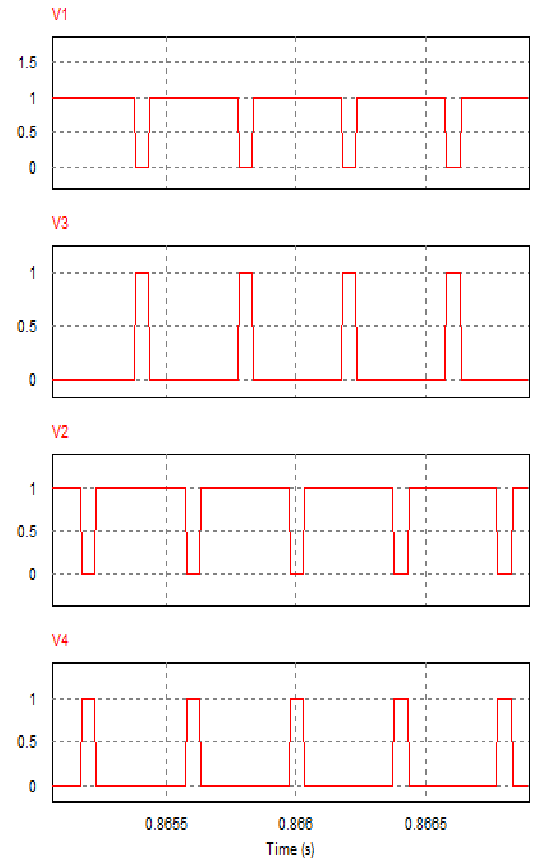


Fig. 8. Gating pulses for inverter switches

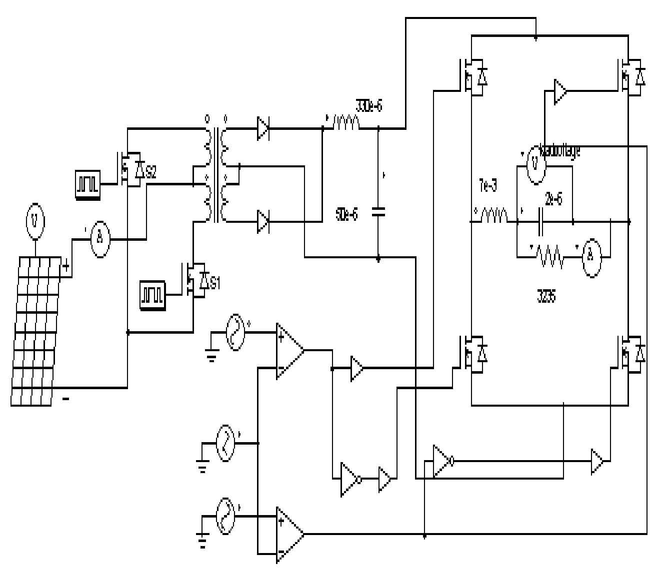


Fig. 9. Complete simulation diagram

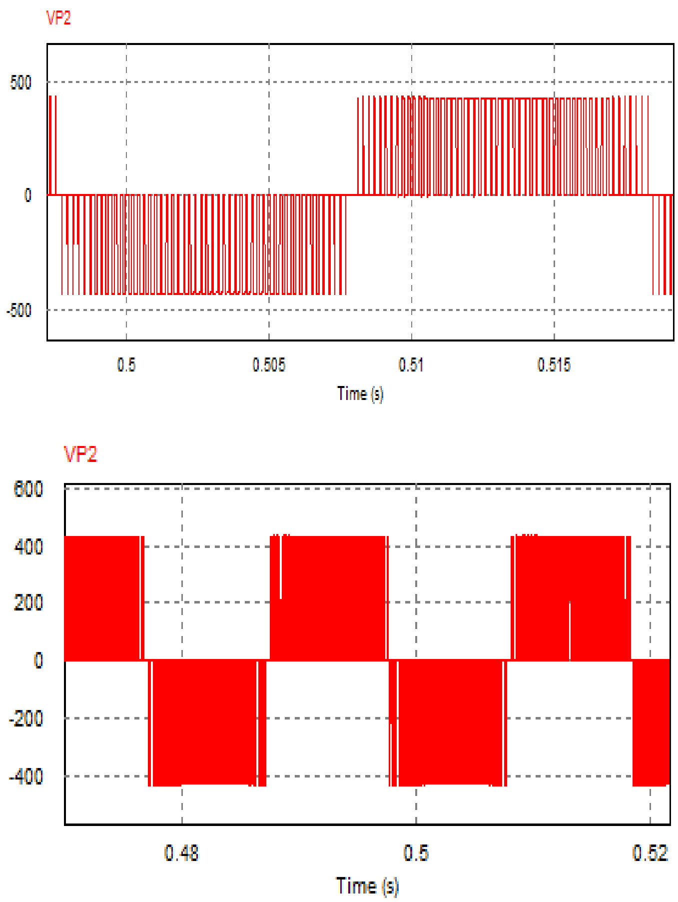


Fig 10. Unfiltered simulation output

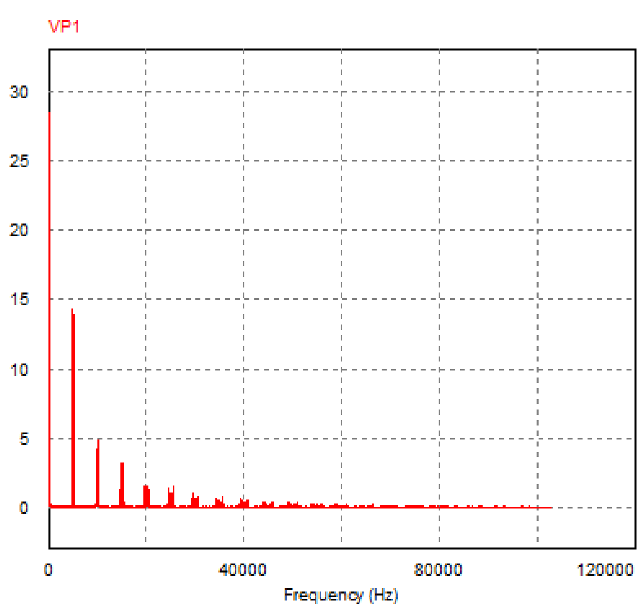


Fig. 11. FFT analysis for unfiltered output.

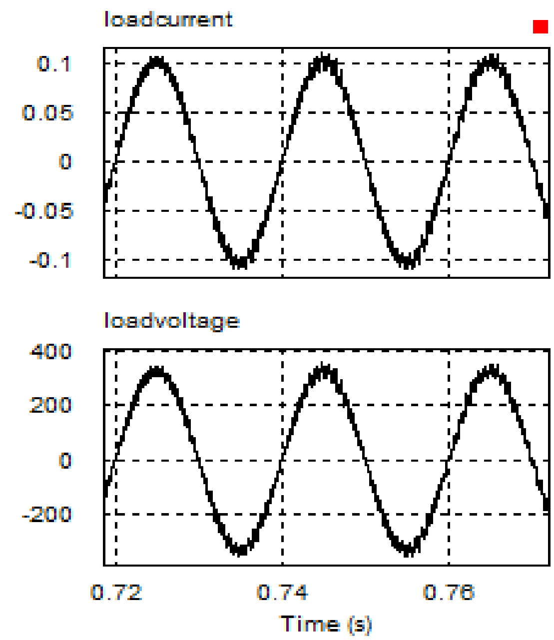


Fig.12. Filtered output for RL load.

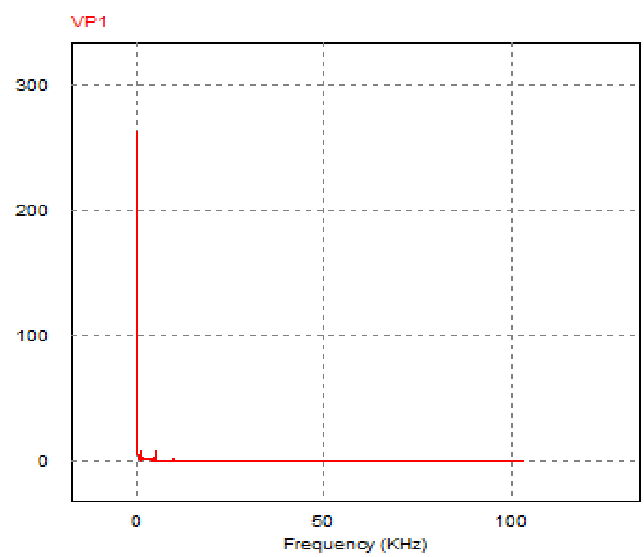


Fig. 13. FFT analysis for filtered output.

5. CONCLUSION

In the simulation study, an ideal condition that solar panel gives 12V was taken into consideration in accordance with the results obtained from the P-V characteristics of the panel. For the input of 12V from the panel, push pull converter acts as a dc booster to boost the voltage from 12V to 400V DC and a current of 0.7A is obtained as output from push pull. This 400V DC is fed as an input to the inverter circuit which produces a peak AC output of 230V. Thus the proposed circuit with fewer harmonic is a better solution in the area of less power production for lighting, water pumping applications in remote villages.

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