



Transformer Less Single Phase PV Inverter with Dual Stage DC DC Converter

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Abstract — solar energy is a major source of a huge power, it is time dependent and intermittent energy resources. Most of these systems have an isolation transformer included, which if excluded from the system would increase the efficiency and decrease the size of PV installations, furthermore it would lead to a lower cost for the whole investment. A transformer less inverter concept for a PV system is combination of a DC/DC converter at front end with a DC/AC inverter. In the transformer less photovoltaic (PV) system, the common mode ground leakage current may appear due to the galvanic connection between the PV array and the ground, which causes the safety issues and reduces the efficiency. To solve this problem, a novel inverter topology is proposed in this paper. Finally, the proposed topology and modulation strategy are verified with simulation.

Keywords-photo voltaic inverter; transformer less topology; DC-DC converter; multi stage converter; MPPT

I. INTRODUCTION

Pollution free green-energy demand is increasing exponentially due to the change of world climate. With the increase of population of the world and the rapid growth of the global economic, the demand of the energy resources especially electricity is faced a tremendous increase [2]. Such rapid increase in electricity demand, using conventional and classical electricity generation by burning the fossil fuel to fulfil the electricity demand is no longer able fulfil the demand. Besides that, burning the fossil fuel will result in environmental problems. The emission of carbon dioxide, methane and other greenhouse gasses will result in global warming problem. This has given an opportunity for the renewable energy resources and technology to take over the electricity generation process. Therefore renewable energy sources play a very crucial role now a day in electric power generation due to its environmental friendly and pollution free green energy. Photovoltaic (PV) energy is one of the potential sources of renewable energy, which gets more preference due to its availability, simplicity, less maintenance and reliability options [2]. Generally, there are two types of PV systems, i.e., those with transformer and without transformer. The transformer used can be high frequency (HF) transformer on the dc side or low frequency transformer on the ac side. Besides stepping up the voltage, it plays an important role in safety purpose by providing galvanic isolation, and thus eliminating leakage current and avoiding dc current. Nevertheless, the transformers are bulky, heavy, and expensive. Even though significant size and weight reduction can be achieved with HF transformer, the use of transformer still reduces the efficiency of the entire PV system. Hence, transformer less PV systems are introduced to overcome these issues. They are smaller, lighter, lower in cost, and highly efficient [3]. The block diagram of proposed inverter is shown in Fig .1

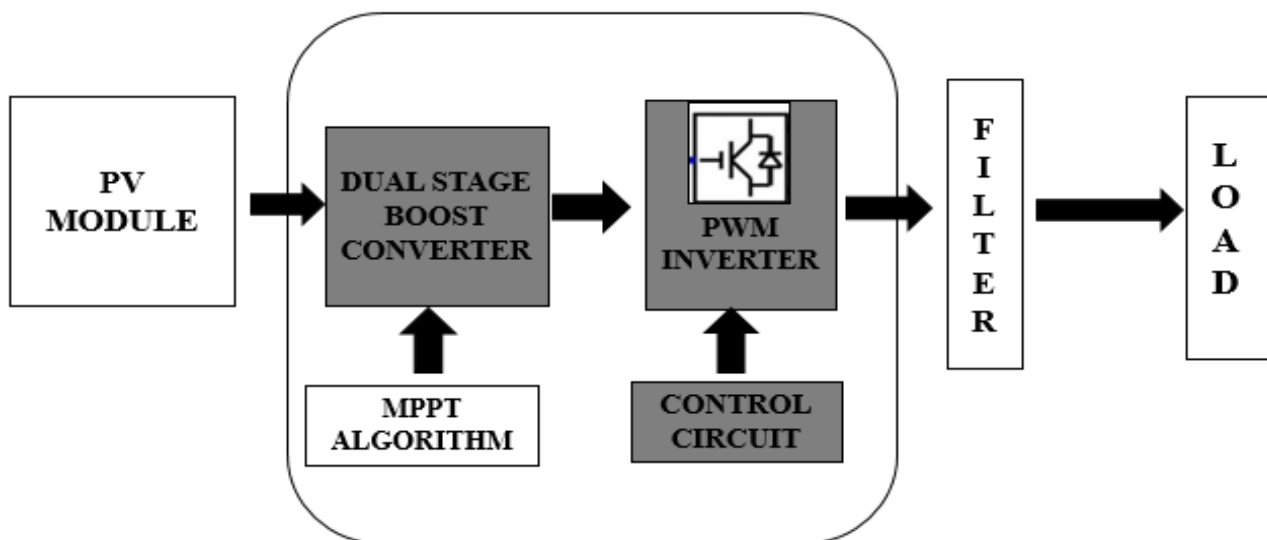


Figure.1. Block diagram of H6 transformer less inverter system

II. DESIGNE OF SOLAR PANEL

At first, under Standard Test Condition (STC) sun array S6B2609 panel with 210W maximum output power is being tested. At STC condition of 25-degree temperature and irradiance of 1000 W/m² the panel is simulated which output voltage is 52V and is shown in Fig.3 [2]. Table-I shows the system parameters of photovoltaic module.

TABLE-I System parameters of photovoltaic module

Parameter	Value
Manufacturer	Sun array
Solar Panel Model	S6B2609
I_{sc}	8.51A
V_{oc}	33.50V
I_{mp}	7.84A
V_{mp}	26.63V
P_{max}	210W
Characteristic constant	0.007

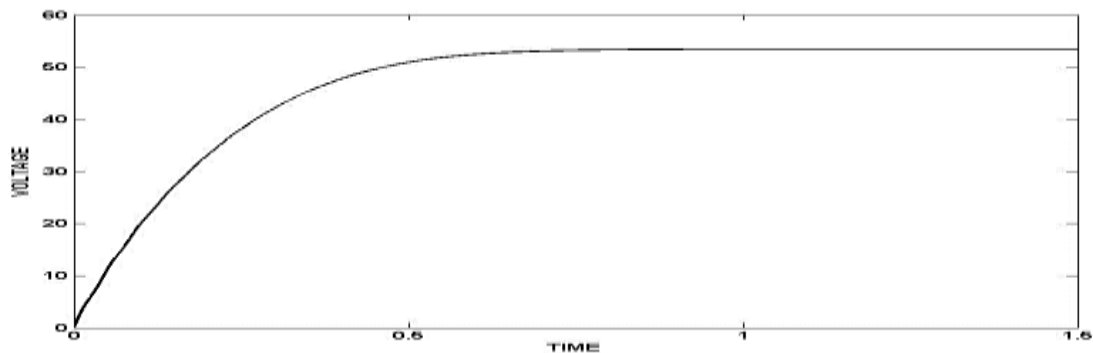


Figure.2. PV array voltage

Fig.2 is indicating the voltage after performing MPPT and connect the PV module in series and parallel as per power and current requirement. For the MPPT algorithm in this system Incremental and Conductance is used.

III. DESIGN OF DUAL STAGE BOOST CONVERTER

Boost converter converts a source of direct current from one voltage level to another, by storing the input energy momentarily and then releasing that energy to the output at a different voltage. A DC converter is equivalent to an AC transformer with a continuously variable turn's ratio. It can be used to step down or step up a DC voltage source, as a transformer. Here in this system Dual stage DC-DC boost converter is used. Dual stage is nothing but converting 52V to 325V in two stage (52V to 130V and 130V to 325V) because of one limitation of the simple one stage boost converter is that single-stage boost converter would be large duty ratio for 52V to 325V voltage conversion 0.84 it is above 80%, for this voltage conversion which is not convenient for MOSFET switching (practically) it is increasing stress on MOSFET [2]. That's why Dual stage boost converter are used for this conversion.

3.1 Duty cycle

Duty cycle for the first stage is,

$$D_1 = 1 - \frac{V_{in1}}{V_{out1}} \quad (1)$$

Duty cycle for the second stage is,

$$D_2 = 1 - \frac{V_{in2}}{V_{out2}} \quad (2)$$

3.2 Inductor Selection

Here inductor is connected in series with the input voltage to boosting the voltage and storing the energy. Therefore, from the following equations find the value of inductor for both stage,

$$L_1 = \frac{V_{in1} * D_1}{f_{s1} * \Delta I_{O1}} \quad (3)$$

Here, ΔI is the output current ripple

$$L_2 = \frac{V_{in2} * D_2}{f_{s2} * \Delta I_{o2}} \quad (4)$$

3.3 Capacitor Selection

From, the following equation find the value of the capacitor for the desired output voltage ripple. Value of capacitor for the first stage is,

$$C_1 = \frac{I_{o1} * D_1}{f_{s1} * \Delta V_{o1}} \quad (5)$$

Value of the capacitor for the second stage is,

$$C_2 = \frac{I_{o2} * D_2}{f_{s2} * \Delta V_{o2}} \quad (6)$$

3.4 The designed 52V to 325V DC-DC boost converter

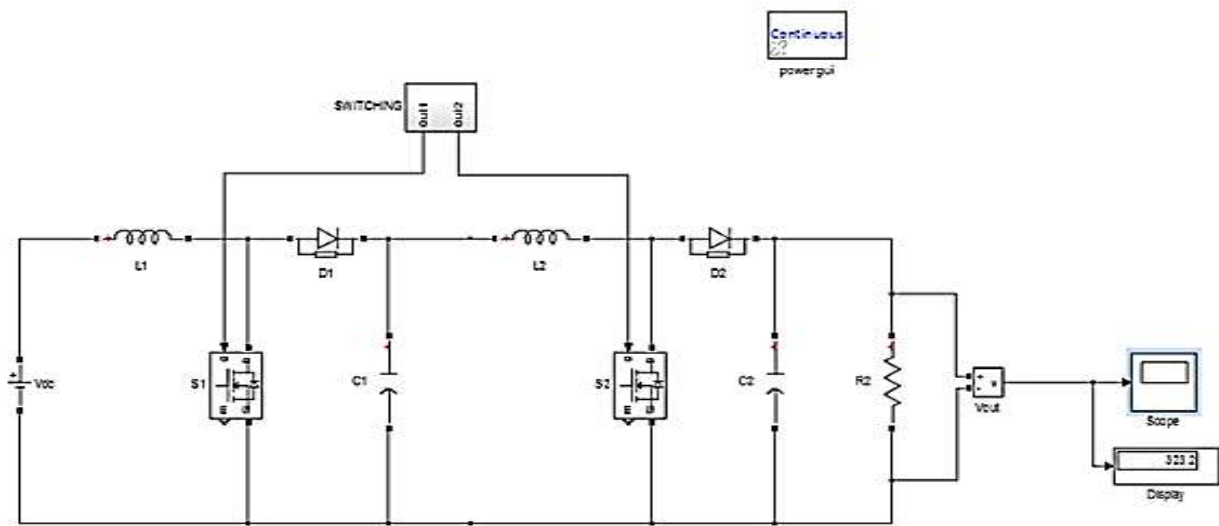


Figure.3. Simulation circuit diagram of two stage boost converter

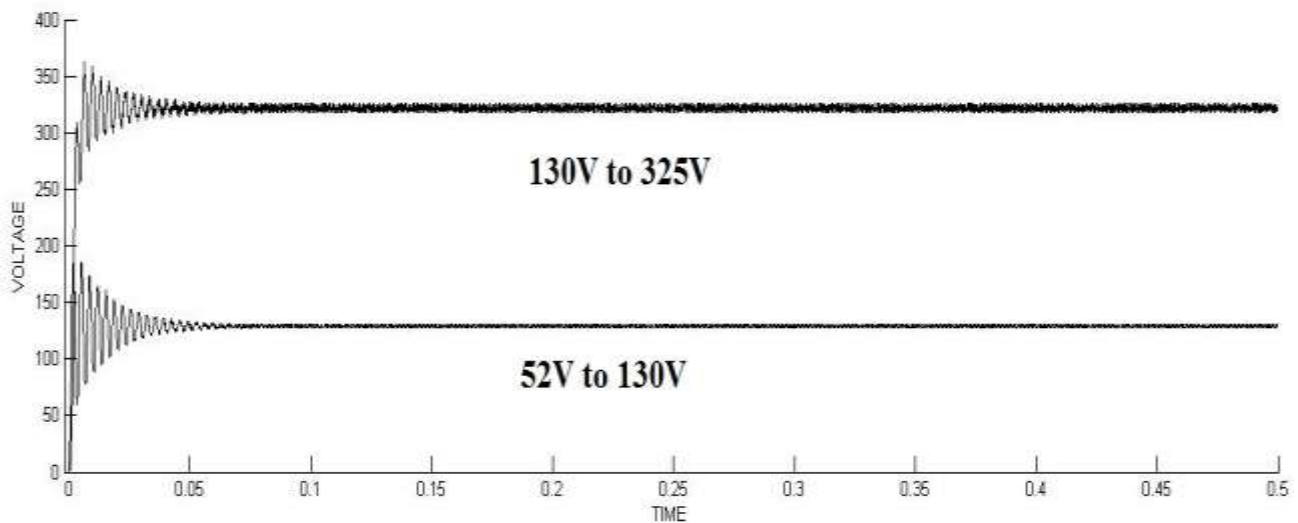


Figure.4 Output voltage wave form of two stage boost converter

Here open loop model of dual stage boost converter is shown in the Fig. 4. But in the system first stage is operate with the MPPT tracking to get constant power and second stage is operate with the closed loop system to get constant voltage.

IV. SINGLE PHASE H6 INVERTER

Transformer less inverter having a three big issues like galvanic isolation, leakage problem, and common-mode voltage. And H-bridge single phase inverter is fails to solve this three problem and also conventional inverter having more harmonic distortion, so solve these problems uses a new H6 single phase inverter which discuss as below.

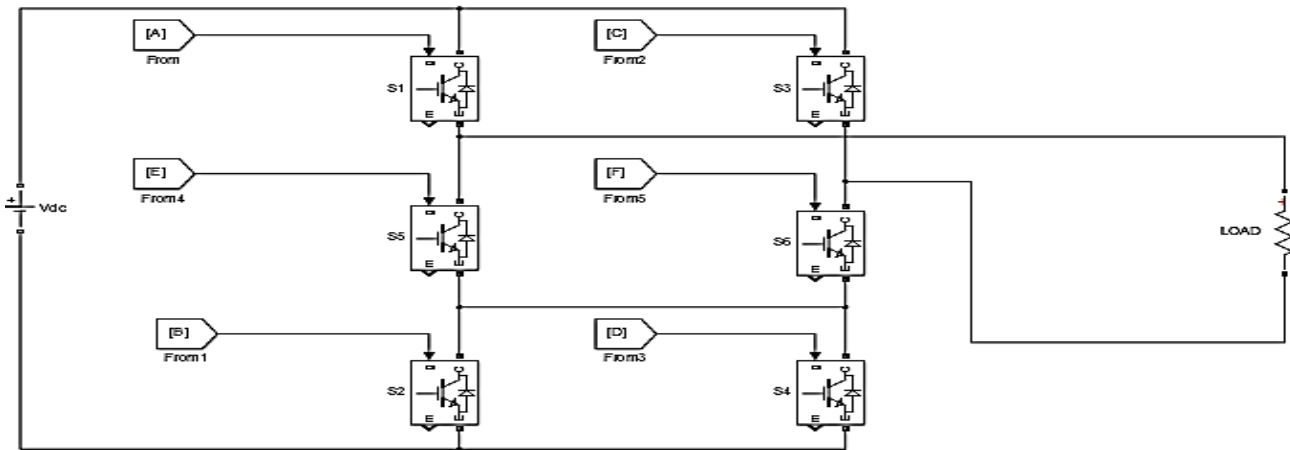


Figure.5 H6 transformer-less inverter topology

Fig.6 shows the gate drive signal for the proposed circuit structure. It can be seen that when a phase shift is occurred between the voltage and current, the i_g remains negative, in the short beginning of positive half period and positive, in the short beginning of negative half period. Therefore the proposed inverter is forced to operate at mode 3 and mode 6.

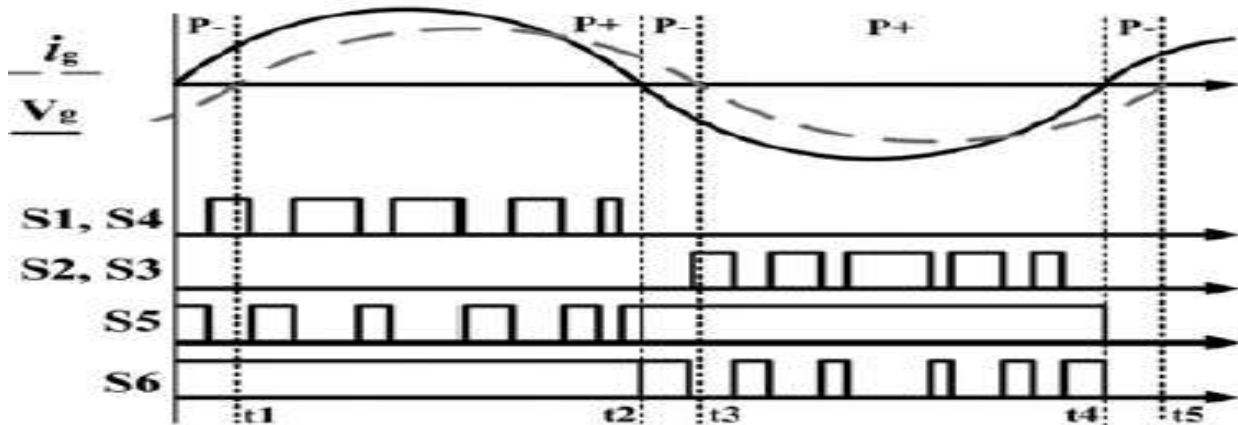


Figure.6 Control signal of H6 inverter

4.1 Switching of H6 Inverter

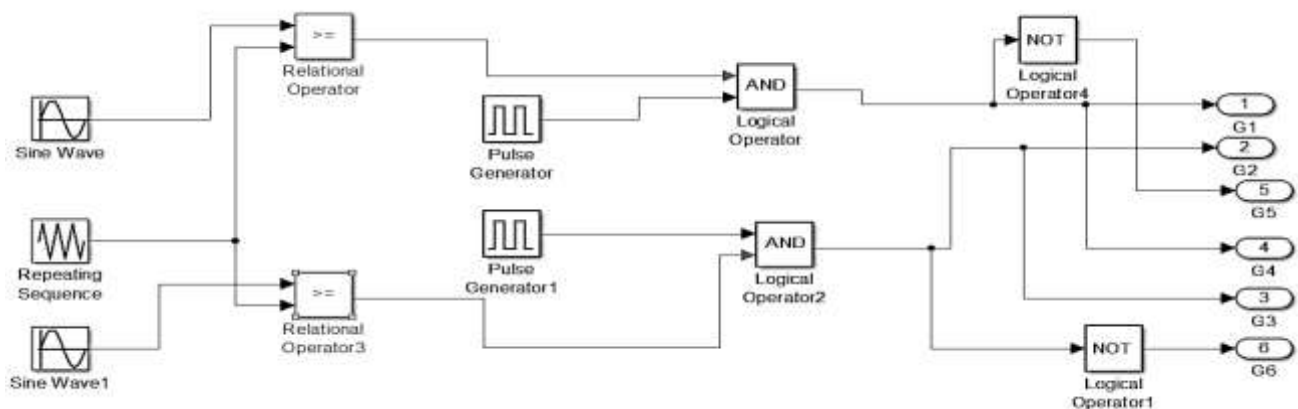


Figure.7 (a) Switching scheme of H6 inverter

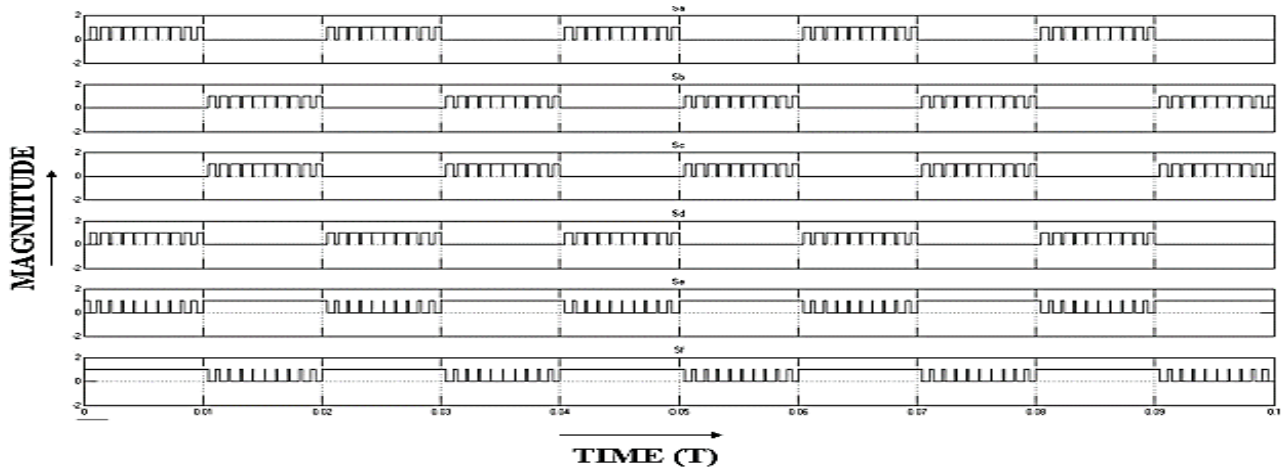


Figure.7 (b) Switching pulses of H6 inverter

Fig.7 (a) is indicate the switching scheme of the inverter and Fig.7 (b) is shown the switching pulses of the H6 inverter. Output voltage is shown in Fig. 8

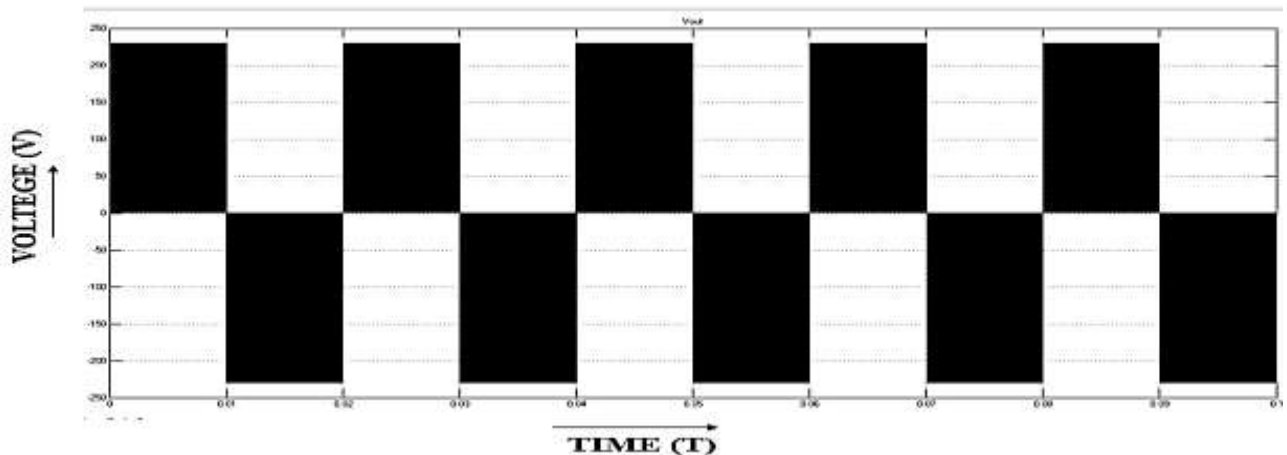


Figure. 8 Output voltage of H6 inverter

V. MAXIMUM POWER POINT TRACKING

To maximize power extracted from PV module an MPPT (Maximum power point tracker) is utilized. An MPPT is a device that finds maximum power point of a PV module and keeps it at that operating point. Several algorithms exist for tracking MPPT like hill climbing, Perturb and Observe (P&O) method, and incremental conductance method [13]. In this implementation, incremental conductance is used. The switch mode DC-DC boost converter circuit for MPP tracking is designed to match impedance between load and PV panel and maximum power transfer to load.

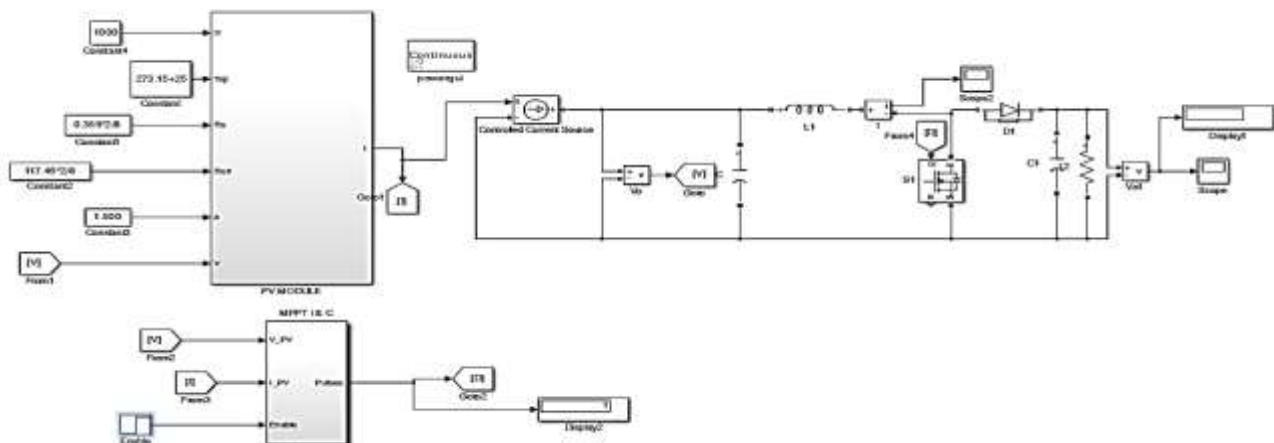


Figure.9 Simulink model of MPPT with boost converter

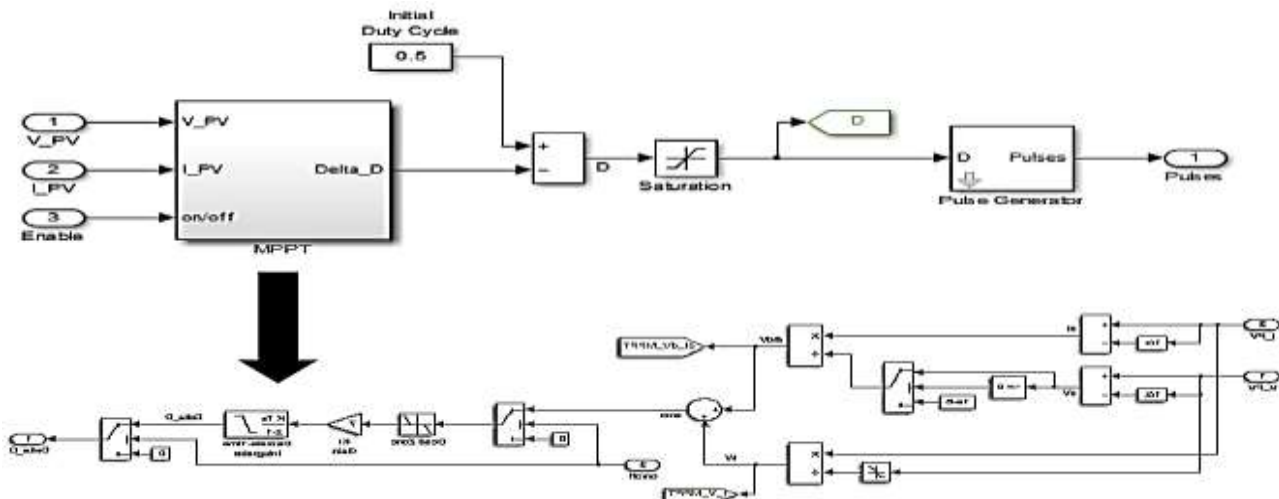


Figure.10 Simulink model of I & C

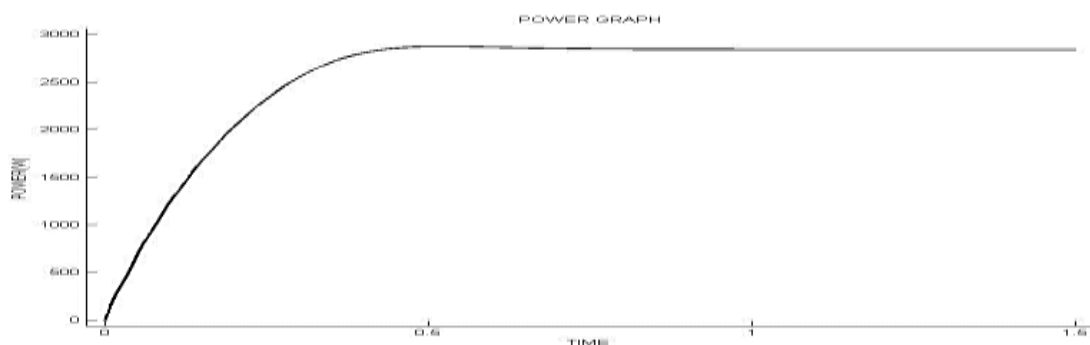


Figure.11 Output power

Here above Fig. 10 and Fig. 11 are shown MPPT model and its output constant power with the help of incremental and conduction method.

VI. SIMULATION RESULTS AND DISCUSSION

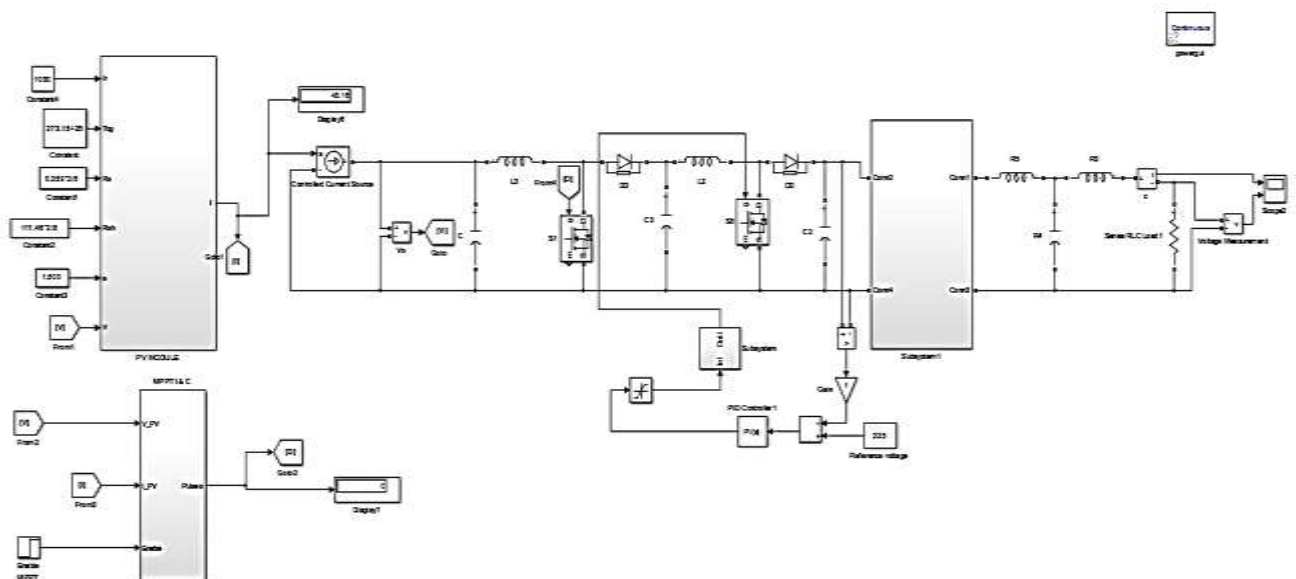


Figure.12 Simulink model of transformer less system

Above Fig.12. is indicate the full system simulation circuit diagram of the transformer less inverter in this diagram dual stage boost converter, H6 single phase inverter and filter circuit are connector with the 2.4kW load. This system's output voltage and current waveform with filter and without filter is shown in Fig.13, Fig.14, Fig 15, and Fig.16

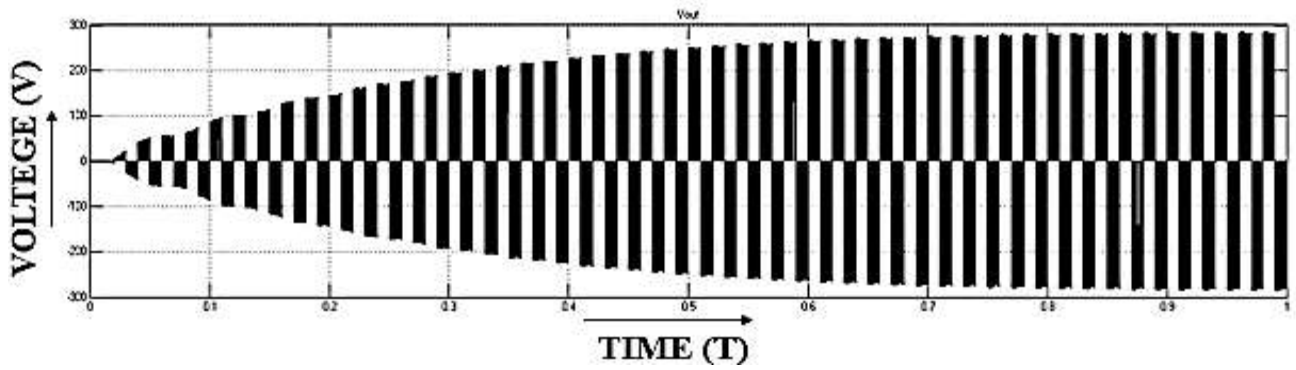


Figure.13 Voltage waveform without filter

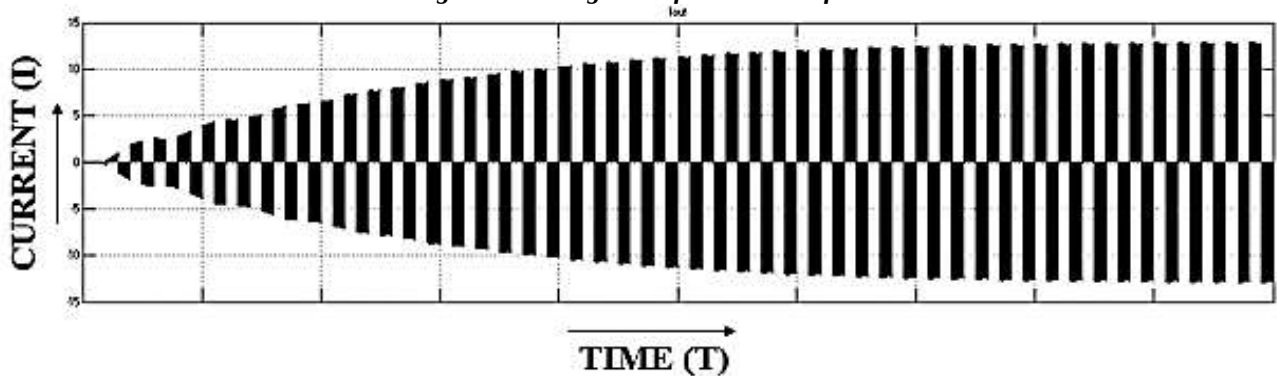


Figure.14 Current waveform without filter

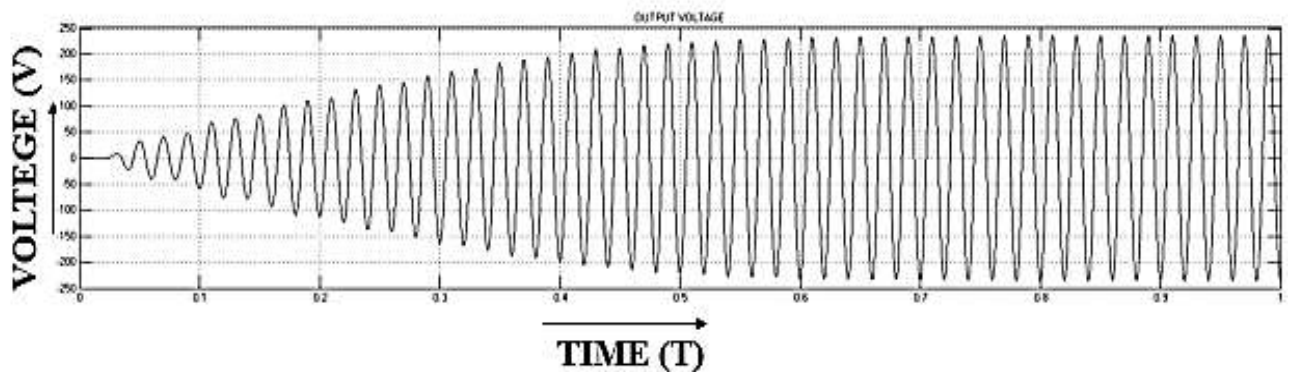


Figure.15 Voltage waveform with filter

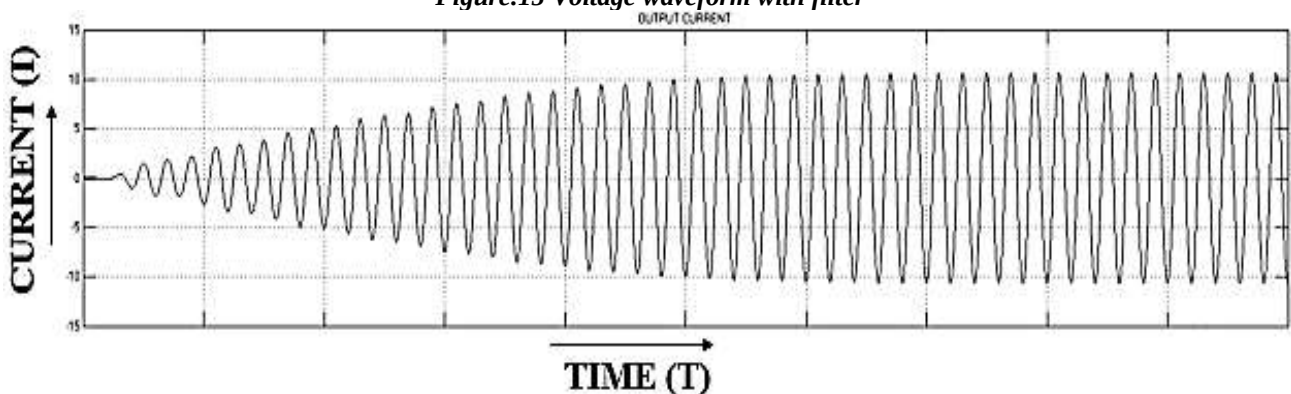


Figure.16 Current waveform with filter

Fig.13 and Fig.14 shows the simulated output voltage and current waveform, which is non-sinusoidal and distorted, and contains excessive harmonics. A low-pass T-LCL filter is employed at the output terminal of the inverter to reduce the harmonics thereby producing a pure sinusoidal output voltage and current. It is observed that the output voltage of proposed inverter becomes stable after couple of cycles since it is connected to the load. Which is shown in Fig.15 and Fig.16.

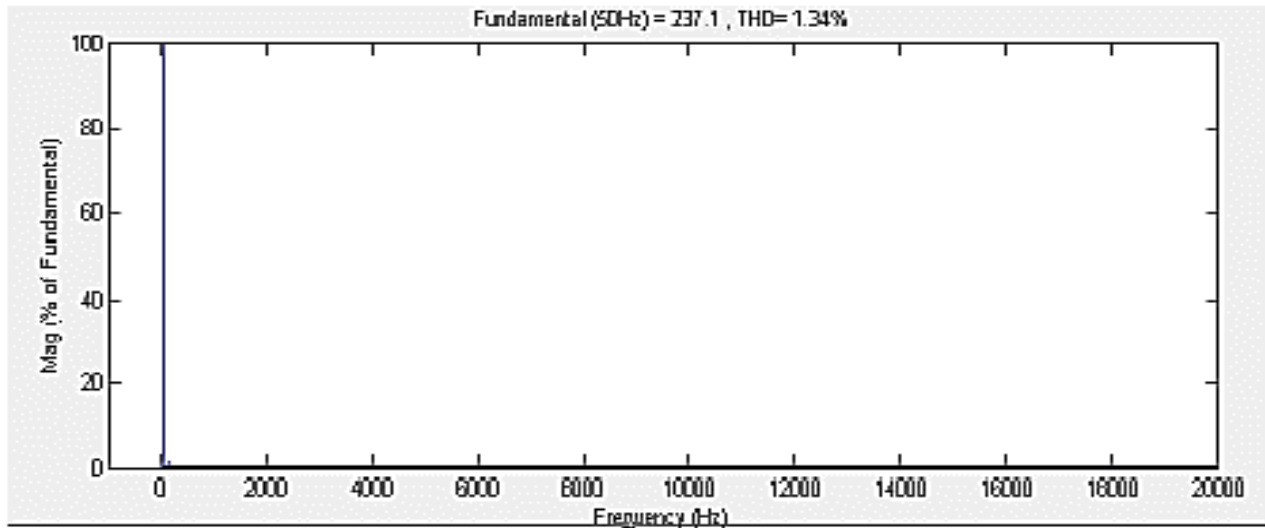


Figure.17 %THD Analysis

VII. CONCLUSION

This paper presents a transformerless photovoltaic inverter for residential application, the output of which is 230V rms at grid to meet the future power crisis. The simulation result ensures that the frequency of the inverter output voltage is exactly 50Hz with a magnitude of 230V rms and is in phase with the voltage. The total harmonic distortion (THD) of the inverter output is less than 1.5% which is shown in Fig. 17. It is much lower than the IEEE519 standard. Therefore, the proposed inverter is highly efficient, cost effective as well as compact in size for being transformer-less, and it is appropriate for supplying constant current and dynamic load with T-LCL filter.

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