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Research Article

Intelligent Control of Mosfet Inverter Grid-Tied Photovoltaic System

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Abstract

This paper proposes a cost effective solar power generation in grid arrangement in a resourceful approach. The photovoltaic systems consist of two converter stations between PV array and to the utility. It composed of transformer less inverter controlled by the fuzzy logic controller. The power generated from the solar panel improved by the boost converter that are connected next to the solar panel. For the transfer of DC to AC, the power generated from the solar panel DC and that are converted to AC by means of single phase inverter which generate AC output. However, the MOSFETs are limited to use in transformer less PV inverter due to the low reverse recovery characteristics of the body diode. In this project, a family of new transformer less PV inverter topology for single-phase grid-tied operation is proposed using super-junction MOSFETs and Sic diodes as no reverse recovery issues are required for the main power switches for unity power operation. The added clamping branch clamps the freewheeling voltage at the half of dc input voltage during the freewheeling period. Results showed a low current distortion at output. Finally, a 1kw prototype is built and tested to verify the theoretical analysis. The experimental results show 98.5% maximum efficiency and 98.32% European efficiency. Furthermore, to show the effectiveness, the proposed topology is compared with the other transformer less topologies.

Keywords: Common Mode Voltage; Converter; European Efficiency; Grid connected; Leakage Current; High efficiency; Photovoltaic; Transformer less.

Introduction

In the later past, different distinctive inverter topologies have been proposed or are at present used for low power, single stage matrix associated photovoltaic (PV) frameworks. A full-connect inverter in mix with a line-recurrence transformer is a well-known and normal topology. The transformer, be that as it may, is not a need or prerequisite and inverters staying away from transformers give different favorable circumstances. Inverters without transformers outmatch those with nearness of transformers in regard to higher effectiveness, decreased cost, weight, encapsulated vitality, and microscopic size [1]. Aside from valuable and particular transformer less ideas, multilevel inverters guarantee better arrangements, as these inverters have the ability of creating ``stepped" yield voltage waveforms, which tends to approach the sinusoidal waveform superior to anything waveforms brought out by customary full-connect inverters. Multilevel inverters in this way require less channel exertion on the AC side, which makes the inverter less expensive, lighter and more minimal. With a specific end goal to produce the "multi-level" (ventured) yield voltage waveform, diverse DC voltage levels are required, which can be rendered by isolating a PV cluster in fitting sub-exhibits.

While keeping the utilization of transformer in the given topology there is no strategies for expanding the inverter yield voltage V_{inv} to the required RMS matrix voltage esteem. In this way, high DC transport voltages are required to ensure the power spill out of the two PV sub- exhibits to the framework. The framework can just capacity when the expansion of the DC transport voltages VPVA1+VPVA2 is more than the aggregate sufficiency of the network voltage at all minute. This limitation chooses the base power rating of the framework

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[2]. Most crystalline PV modules introduce on the stock today have 36 cells in arrangement and working voltages of about17 V at 258C and 1000 W/m2. Howsoever, when the temperature rises, the working voltage can tumble to as less as 12 V for every module Attributable to this nature, no less than 14 crystalline 36-cell-PV modules in arrangement are required for each of the two sub-exhibits considering framework control appraisals of 1.3 kW or more.

The two fundamental errands of the framework control are, (i) the vitality exchanged from the PV exhibits to the framework ought to be greatest, and (ii) the symphonious mutilation amid the era of a sinusoidal current I_{grid} ought to be less, even likewise under nearness of lattice voltage sounds. The control of the framework comprises of a MPPT, a DC transport voltage controller, the present reference esteem era and current controller. A control flag is produced by every controller which contains the data whether I_{inv} should be raised or brought down. Alongside the data which mode the inverter works in, the control flag is expected to determine the exchanging signals for the each switches of the inverter. A solitary full-connect has 16 inverter states, of which four permit bi-directional current stream and a settled inverter yield voltage. The undertaking is to pick the states so that, (i) each switch ought to be worried similarly keeping in mind the end goal to get equivalent misfortunes in every switch and with that an equivalent temperature conveyance, (ii) the exchanging recurrence ought to be less. To accomplish this, directing switches ought to be continued the length of required or conceivable, (iii) over one period the measure of force got from both clusters ought to be the same. Both sources must be stacked in a symmetric fashion and (iv) the nearness of swell on the DC transport capacitors ought to be low since with expanding swell misfortunes additionally Increment. To accomplish a low swell the two sources are required to be released consistently [3].

The majority of the inverters depicted in the writing and monetarily accessible demonstrate the European productivity in the scope of 96%- 98%. These two issues (proficiency and spillage current) are the real constrain in pushing dynamic advancement of transformer less grid tied PV inverter. Keeping in mind the end goal to lessen the spillage ebb and flow, a ton of top to bottom looks into have been directed in the writing, where another freewheeling way has been acquainted with decouple the PV module from the lattice amid freewheeling period. Be that as it may, the switches intersection capacitance that can't be disregarded in the down to earth application may affect the spillage current. It is displayed in that to totally dispose of the spillage current, the CM voltage should be braced to the mid-purpose of dc information voltage rather than just separating the PV module from the lattice. Then again, to enhance the effectiveness, transformer less inverter can be actualized utilizing super-intersection MOSFET and Sic diodes [4]. The super-intersection MOSFETs can maintain a strategic distance from the settled voltage drop and kill misfortunes brought on by tail current, in this manner decreasing the conduction and exchanging misfortunes. Notwithstanding, because of poor turn around recuperation of MOSFETs moderate body-diode, it is constrained to use in transformer less inverter. In the accompanying, MOSFET based transformer less topologies for matrix tied PV application will be investigated and talked about in light of their circuit structure, effectiveness and CM voltage cinching capacity.

Proposed System

By joining these two stage legs, a group of new transformer less topologies is inferred in light of the air conditioner decoupling and deviated stage legs. The proposed transformer less PV inverter topology is determined by determination strategy depicted in the earlier area, where S1, S2, S4, and S5 are high recurrence switches, and S3 and S6 are low recurrence freewheeling switches. The unidirectional clasping branch is built utilizing switch S7 and diode D3 with a capacitor divider (Cdc1 and Cdc2) which cinches the CM voltage at the midpoint of dc connection. LA, LB, and Co make up the LC sort channel associated with the framework and V_{pv} speak to the info dc voltage. Proposed fuzzy controller with PWM based controlling topology builds proficiency of the framework [5]. Block diagram of the proposed work is shown in Fig. 1

Circuit configuration

The family of the proposed transformer less PV inverter topology is derived according to the derivation method described in the prior section, where S1, S2, S4, & S5are high frequency switches, and S3 & S6 are low frequency freewheeling switches. The unidirectional clamping branch is constructed using switch S7 and diode D3 with a capacitor divider (Cdc1 & Cdc2) which clamps the CM voltage at the midpoint of dc link. LA, LB, and Co make up the LC type filter connected to the grid and Vpv represent the input dc voltage. The unipolar SPWM can be employed to the proposed topology with three-level output voltage [6]. The MOSFET power switches are utilized as no reverse-recovery issues are required for the proposed configuration of the inverter for unity power factor operation. Consequently, the efficiency of the entire PV system is increased.

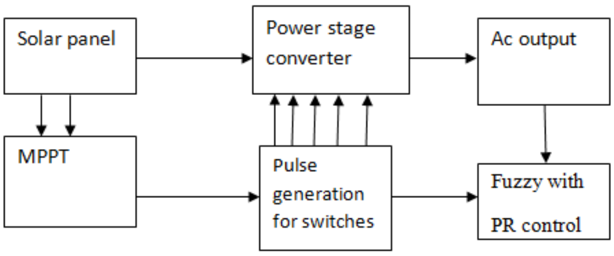

Fig. 1. Proposed block diagram

Fuzzy logic with proportional resonant controller

Fluffy rationale controller is utilized to lessen the ascent time, settling time to practically immaterial furthermore attempt to evacuate the time delay and rearranged reaction. It works with unverifiable and uncertain information. It gives a rough however compelling method for portraying the conduct of frameworks that are excessively unpredictable, poorly characterized, or not effectively broke down scientifically. Fluffy factors are prepared utilizing a framework called a fluffy rationale controller. It includes fuzzification, fluffy derivation, and defuzzification. The fuzzification procedure changes over a fresh information esteem to a fluffy esteem. The fluffy induction is in charge of reaching determinations from the information base. The defuzzification procedure changes over the fluffy control activities into a fresh control activity. Participation work qualities are relegated to the etymological factors, utilizing seven fluffy subsets: NB (negative huge), NS (negative little), ZE (zero), PS (positive little), and PB (positive huge). The arrangement of standards planned in fluffy rationale controller [8]. The proportional resonant (PR) controller has better performance of tracking the reference signal if compared to the normal PI controller and repetitive controller (RC).

Proposed converter

The proposed converter joined with the sun powered exhibit which gets insolation changes because of sunlight based irradiance is appeared in figure.. Regardless to the irradiance variety, consistent yield voltage and current are kept up in the proposed control era framework. The exchanging design for solidarity control consider operation, where the G1, G2, G3, G4, G5, G6, and G7 are the door signs of the switches S1, S2, S3, S4,S5, S6, and S7 commutate at the exchanging recurrence with the indistinguishable compensation arrange in the positive and negative half cycle of the framework current, separately [9]. The proposed topology could be actualized using MOSFET switches. Be that as it may, the body-diode will be enacted if a stage move is happened in the inverter yield voltage and current. As needs be, the reliability of the framework will be decreased on account of the MOSFET hostile to parallel diode low invert recuperation issues.

Framework synchronization

Framework inverter needs an unadulterated sinusoidal reference voltage to guarantee that the sinusoidal yield of the inverter is synchronized to the matrix recurrence [10]. The voltage greatness of the inverter yield (V_{inv}) needs to surpass the framework voltage, (V_{grid}) to empower the inverter current (I_{inv}) to be provided to the network.

Simulation Results

Mode 1 is the active mode in the positive half cycle of the grid current (Fig. 2). When S1 and S4 are turned-on, the inductor current i_L increases linearly through grid. In this mode, $V_{AN} = V_{PV}$ and $V_{BN} = 0$, thus $V_{AB} = V_{PV}$ and the inductor current.

$$i_L(t) = \frac{V_{PV} - v_g}{L}(t) \qquad \text{......(1)}$$

Mode 2 is the freewheeling mode in the positive half cycle of the grid current (Fig. 3). The inductor current i_L flows through S6 and D2, and reduces linearly under the effect of grid voltage.

In this state, V_{AN} falls and V_{BN} rises until their values are equal. If the voltages ($V_{AN} \approx V_{BN}$) are higher than half of the dc link voltage, freewheeling current flows through S7 and D3 to the mid-point of the dc link, results V_{AN} and V_{BN} are clamped at $V_{PV/2}$. Therefore, at mode 2, $V_{AN} = V_{PV/2}$, $V_{BN} = V_{PV/2}$, the inverter output voltage $V_{AB} = 0$ and the inductor current:

$$i_L(t) = \frac{-v_g}{L}(t) \qquad \text{.......(2)}$$

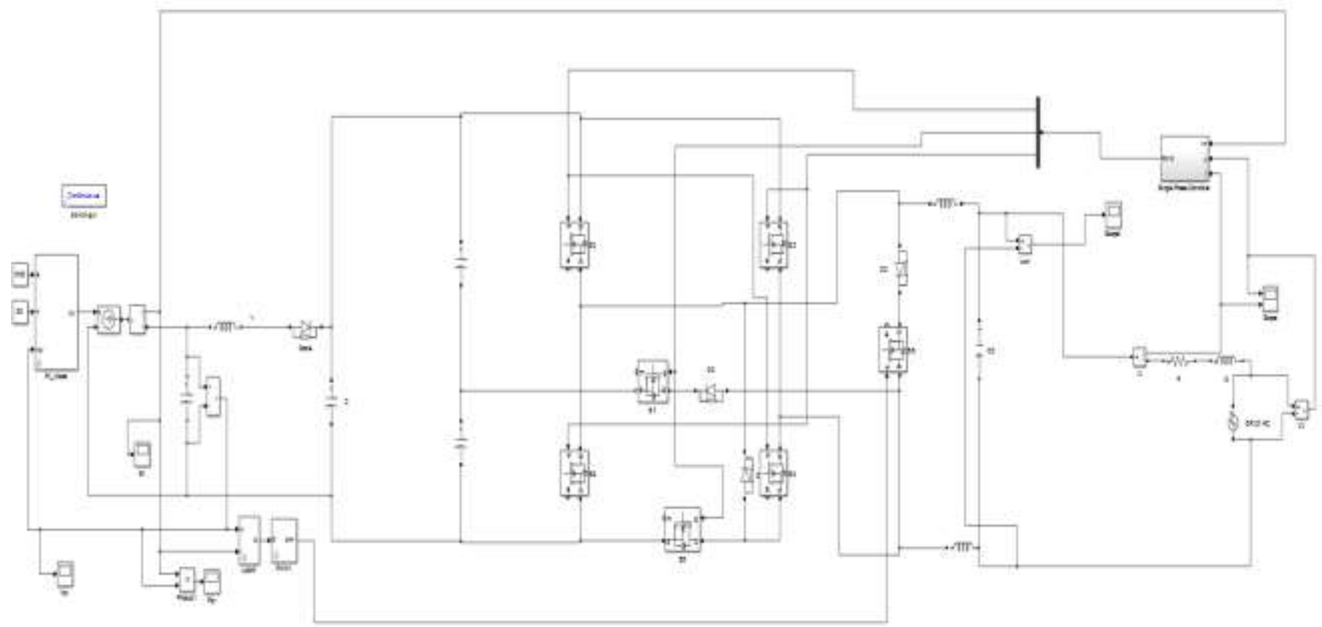

Fig. 2. Mode 1

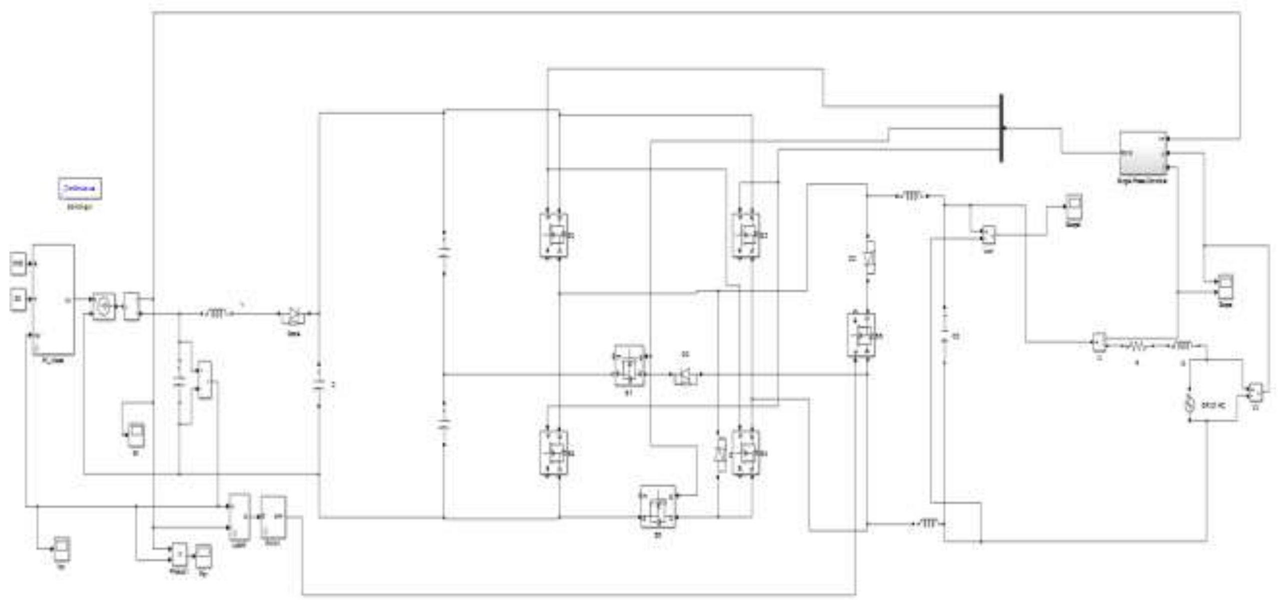

Fig. 3. Mode 2

Mode 3 is the active mode in the negative half cycle of grid current (Fig. 4). Similar to mode 1, when S2, S3 and S5 are turned-on, the inductor current increases in the opposite direction. In this mode, the voltage V_{AN} = 0 and V_{BN} = V_{PV}, thus V_{AB}= -V_{PV} and the inductor current.

$$i_L(t) = \frac{V_{PV} - v_g}{L}(t) \quad \text{.......(3)}$$

Mode 4 is the freewheeling mode in the negative half cycle of grid current (Fig. 5). When S5 and S2 are turned-off, the inductor current flows through S3 and D1. Similar to mode 2, If the voltages (V_{AN}≈V_{BN}) are higher than half of the dc link voltage, freewheeling current flows through S7 and D3 to the mid-point of the dc link, results the voltages V_{AN} and V_{BN} are clamped at $V_{PV/2}$. Therefore, in this mode, V_{AN} = V_{BN} = $V_{PV/2}$, V_{AB} = 0, and the inductor current.

$$i_L(t) = \frac{-v_g}{L}(t) \quad \text{.......(4)}$$

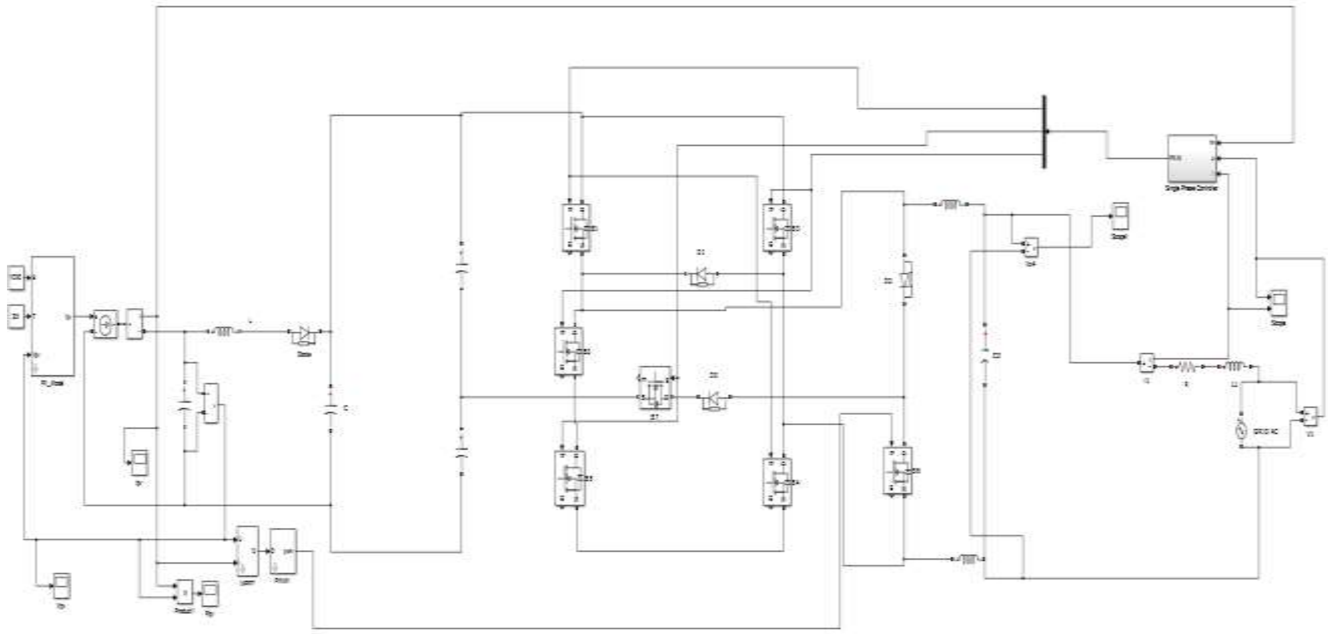

Fig. 4. Mode 3

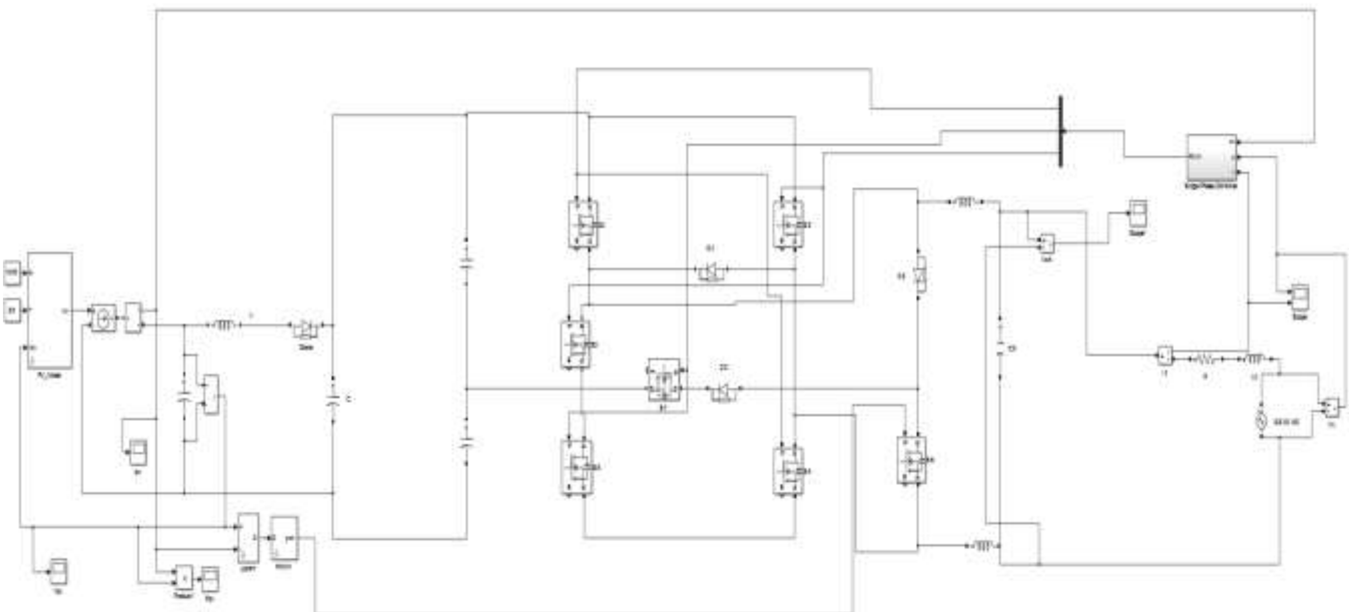

Fig. 5. Mode 4

The output obtained usig the simulations models are shown in Fig. 6 to 9.

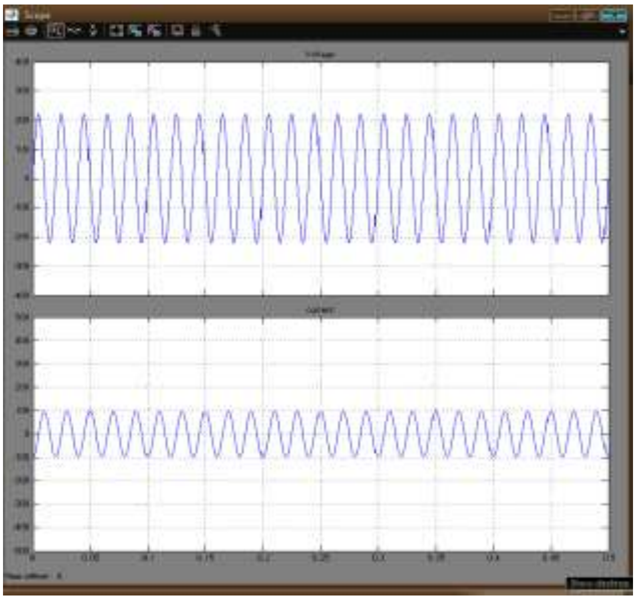

Fig. 6. Grid voltage and current

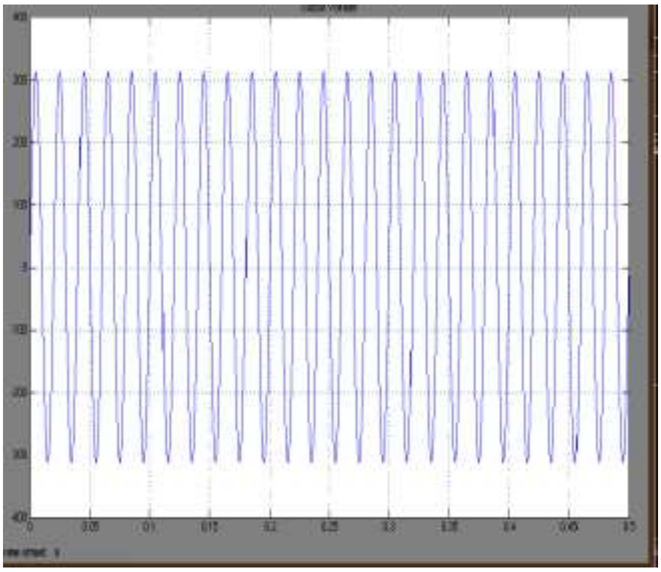

Fig. 7. Inverter voltage

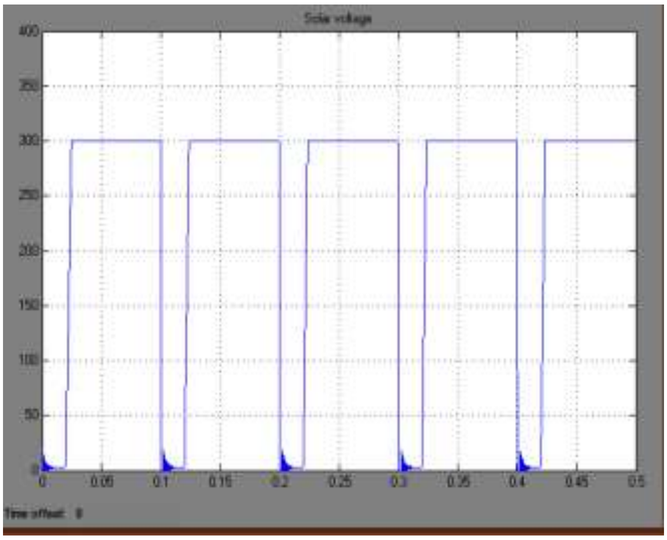

Fig. 8. Solar voltage

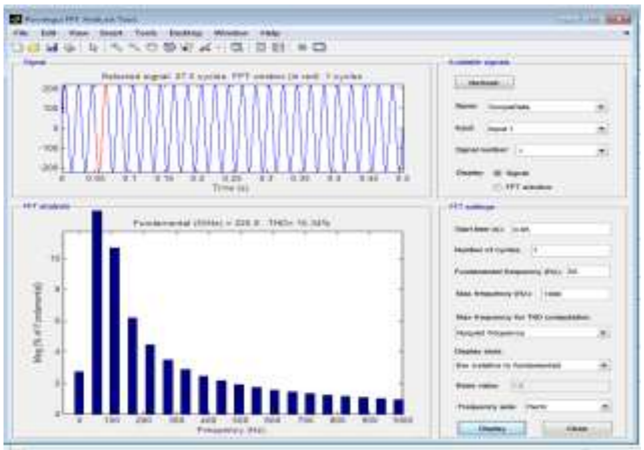

Fig. 9. THD value

Conclusions

In this paper, a group of new effective transformer less inverter for framework tied photovoltaic power era framework is exhibited utilizing super-intersection MOSFETs as primary power switches. The fundamental focal points of the proposed topology are as per the following: (i) High effectiveness over a wide load range is accomplished by utilizing MOSFETs and Sic diodes, (ii) CM voltage stays consistent amid all operation modes due to the additional clasping branch, comes about low spillage current, comes about low mutilation at yield. At last, the proposed topology has been re-enacted. The exploratory results indicate low THD rate. Thus, it can be inferred that the proposed inverter is exceptionally reasonable for a solitary stage matrix tied PV application. Therefore, it can be concluded that the proposed inverter is very suitable for a single-phase grid-tied PV applications.

Conflict of interest

Authors declare there are no conflicts of interest.

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