Layout of Single Stage Grid Connected Buck Boost Photovoltaic Inverter for Domicile Utilization

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Abstract— In this paper verified three change single deal with build cross segment related buck booster photovoltaic inverter topology for private application. the proposed buck boost photovoltaic inverter are used fuzzy logic controller for residential application, better use of photovoltaic, decreased size, less asking for control and higher sensibility. For trading of inverter control circuit we used a blend of sinusoidal pulse width heading (SPWM) square wave improvement under synchronization condition and also control SPWM duty cycle to deal with inverter. The effectiveness of the proposed method is verified by developed simulation model in MATLAB- Simulink program. The simulation result show that the proposed the buck boost inverter produced significant improvement control performance with compare other inverter.

Key words: SPWM, PV, GTI, DCM, MATLAB-Simulink

I. Introduction

Genral purpose used of photovoltaic is describe light energy strike the solar cell electrone are knocked loose from the atom is the semiconductor material if electrical conducter are attacted to positive and negative side froming an electrical circuit

The electrone can be captured in the form of an electric current by using of inverter circuit. The past time photovoltaic based inverter are problem can be occure in the corban di-oxide and methane gas leaks and inter in the atmosphere and effected by the dangerous biological degradation

It is affected by the all living organism they inverter not use by suitable perpose of the time based, controlling phenomena, realibility, etc the affected problem identied by Dependably, expert and investigators have conceptualized by doing examination and examinations remembering an authoritative focus to frame new thoughts and proposition to diminish the exceptional threat from the radiations of carbon-di-oxide.

In the present time renewable energy source play a crucial role now a day in electric power generation due to its environment friendly and pollution free clean energy. Photovoltaic (pv) energy is a one of the potential source of renewable energy, which get more preference due to its avaibility, simplicity, lower maintance and reliability option. Thus power electronics components such as an inverter offer a required means to convert the constant voltage output of the photovoltaic panel into a usable sinusodial ac power in grid connected system.Fig.1 shows the block diagram of the proposed PV power system.

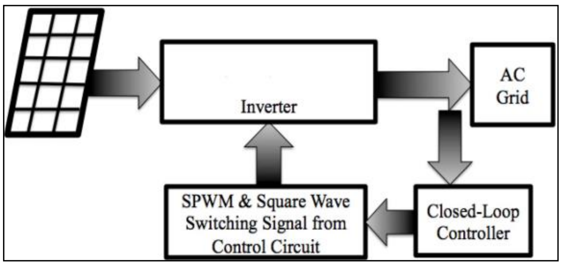


Fig. 1: Block diagram of proposed single-stage buck-boost PV inverter

Conventionally, the grid-connected inverters are classified as single-stage and two-stage configuration. Two-stage or multiple stage configuration of four-switch buck-boost GTI are commonly used in photovoltaic application. Such inverter systems have dc-dc or dc-ac-dc.

Converters added to achieve a raised dc voltage before inversion. Although a two-stage buck-boost inverter can reach a reasonably high power capacity, the additional power stage requires more power components, which condenses circuit complexity as well as shoots up the cost. Typically a single-stage inverter is an inverter with only one stage of conversion for both stepping-up and steppingdown the dc voltage from PV sources and modulating the sinusoidal output current or voltage. However, this paper proposed the design of a three-switch single stage grid connected buck-boost inverter, in which buck-boost dc-dc converter and f1yback operation principles are applied to transfer the energy from input PV dc side into output utility grid side. The inverter control circuit and grid synchronization methods are portrayed in detail in this paper. The inverter's parameters are designed mathematically, and the designed inverter is simulated via matlab software to verify the inverter's output performances. In addition, a closed-loop SPWM control scheme is implemented in the system to regulate the instantaneous ac output current of the inverte As compared to the conventional single stage buck-boost inverters two-stage buck-boost inverters and buck inverters with line-frequency transformers, both the component count, size and cost of the proposed buck-boost GTI is minimized, thus exhibiting a more reliable and cost-effective design with overall high efficiency for domestic photovoltaic system.

II. Requirement Grid Synchronization

the grid tie inverter (GTI) must match the phase of the grid and maintance the output slightly higher then the grid voltage at any instant.the inverter has an on-board computer which sence the current AC grid waveform and output voltage correspond with the grid

1) Voltage magnitude and phase of inverter must be same as grid.
2) The GTI output frequency must match with the grid frequency (50 Hz in INDIA)

III. DESIGN OF PROPOSED BUCK-BOOST GTI

A. *Power Circuit Design*

Schematic diagram of three-switch buck-boost inverter power circuit. The proposed single-stage grid-connected buck-boost inverter power circuit configuration consists of three MOSFET switches Q1, Q2, and Q3, three diodes, D1, D2, and D3, two coupled inductors L1, L2 and a capacitor C. The two coupled inductors have equal inductance L and same turns, which is used to transfer energy from the input PV array dc side to the utility grid figure shows. Since only one MOSFET switch is turned ON in each state and inductor is always connected with charging and discharging circuit. The inverter operation can be divided into: charge and discharge operation working in the (1) Negative half cycle and (2) Positive half cycle as discussed in the later section.

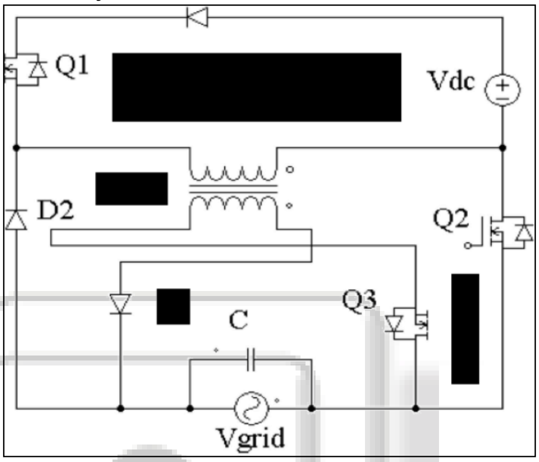


Fig. 2: Power circuit of proposed buck-boost GTI

B. *Negative Half Cycle*

Switch Q2 is always turned off in the negative half cycle state of the inverter. The equivalent circuit of the inverter on negative half cycle is illustrated in Fig. 4. When the inverter works in negative half cycle, its function can be further divide into: (3) charging state and (4) discharging state. During charging state in the negative half cycle, the switches Q2 and Q3 are turned off, and the switch QI is turned ON to charge the inductor LI through the diode DI. At that state capacitor provides continuous current to load. During discharging state, the switch QI and Q2 are turned off, and the switch Q3 is turned on. The stored energy in L I will be transferred to the coupled inductor L2 which discharge to the load through switch Q3 and diode D3

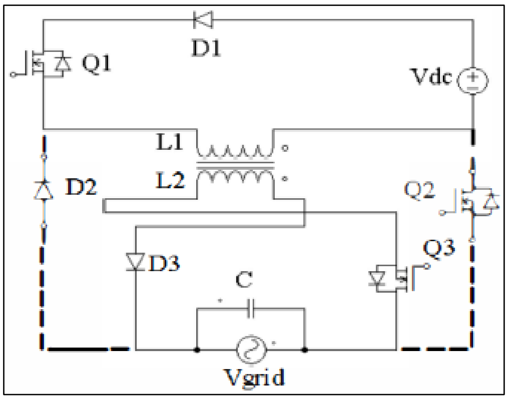


Fig. 3: Equivalent circuit of negative half cycle

C. *Positive Half Cycle*

Switch Q3 is always turned off in the positive half cycle state of the inverter. The equivalent circuit of the inverter on positive cycle is illustrated in Fig. 3. The inverter operation in the positive half cycle can be divided into: (1) charging state (2) discharging state. During charging state in positive half cycle, the switches Q2 and Q3 are turned off, and the switch QI is turned on to charge the inductor LI through the diode DI. At that time the capacitor provides continuous current to the load. During discharging state, the switches QI and Q3 are turned off, and energy that was stored in inductor, LI releases through the switch Q2, to the grid utility.

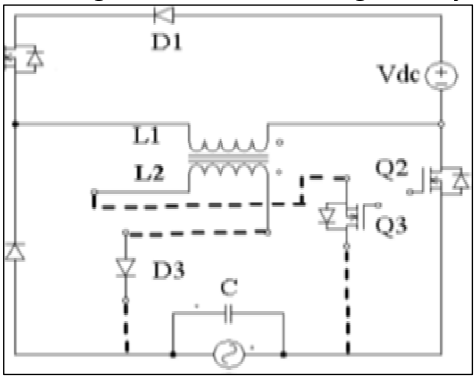


Fig. 4: Equivalent circuit of positive half cycle

IV. MATHEMATICAL DESIGN OF BUCK-BOOST INVERTER CIRCUIT

The three-switch grid-connected buck-boost inverter design. Table-1 illustrates the design specifications of our proposed 600W PV three-switch buck-boost GTI

Symbol	Actual Meaning	Value
V_{dc}	Input PV array voltage	24v
V_{out}	Maximum output voltage	312v
Fsw	Switching frequency	10khz
Ts	Switching period	100μs
m_a	Modulation index	93%
ΔI	Inductor ripple current	0.02
K	Co-efficient factor	3.2
P_{out}	Maximum output power	600w

Table 1. Design Specification of Three Switch Buck-Boost GTI

A. *Modulation Index*

For the Discontinuous Current Mode operation (DCM), the peak modulation index Mo, can be adjusted by using following equations [7]

$$M_a = \frac{\sqrt{2}V_{rms}}{V_{dc}+\sqrt{2}V_{rms}} = \frac{220\times\sqrt{2}}{24+220\times\sqrt{2}} \cong 93\% \quad (3)$$

B. *Coupled Inductor selection*

For a grid-connected inverter a simple critical method, based on input-output power balance, is applied to unearth the mathematical control-to-output solution and to determine the inductance value. The value of coupled inductance, L for DCM operation is calculated by using following equation [7]:

$$L = \frac{M_a^2 V_{dc}^2}{4Pf_{sw}} = \frac{0.93^2\times 24^2}{4\times 600\times 10,000} \cong 20\mu H \quad (4)$$

C. Dedication Cycle

The duty cycle D is determined by following equation [8],[10] where Vdc is PV array voltage and It is maximum output voltage of inverter.

$$D = \frac{V_{out}}{V_{out} + V_{dc}} = \frac{220 \times \sqrt{2}}{220 \times \sqrt{2} + 24} = 93\% \tag{5}$$

D. Channel Inductor Selection

In order to limit the current ripple a filter inductor is being used in the inverter circuit. And the critical inductance value of the inductor L_{filter} can be expressed as [8], [10]:

$$\begin{aligned} L_{filter} &= \frac{1}{\Delta I \times f_D \times \left(\frac{1}{V_{dc}} + \frac{1}{V_{out}} \right)} \\ &= \frac{1}{0.02 \times 10,000 \times \left(\frac{1}{24} + \frac{1}{220 \times \sqrt{2}} \right)} \\ &= 115 \mu H \end{aligned} \tag{6}$$

E. Output Capacitor Selection

The average differential equation for output filter capacitor is specified below [8], [10]:

$$C \frac{dv_c}{dt} = (1 - D)\, i_L - \frac{V_{out}}{R} \tag{7}$$

The duty cycle of the circuit is 0.93 and by solving the equation (7) the capacitor of the filter can be selected C=10mF where cutoff frequency is 50 Hz. Thus, the output filter capacitor is responsible for desire ripple voltage, ripple current and loop stability.

F. Yield Current

Considering that the resistance of coupled inductor, switches and diodes are negligible and the inverter is worked at DCM; the output current Iou/ of the inverter can be expresses by using following equation [8], [10]:

$$\begin{aligned} I_{out} &= \frac{V_{dc}^2 \times T_s \times k^2}{2\sqrt{2} \times L} \sin \omega t \\ &= \frac{24^2 \times \frac{1}{10000} \times 3.2^2}{2\sqrt{2} \times 20 \times 10^{-3}} \sin \omega t \\ &\cong 10.5 \sin \omega t \end{aligned} \tag{8}$$

G. Control Circuit Design

In conventional inverter design, only one type switching method is used. But, in this proposed design instead of using one type of switching signal to switch the inverter, a combination of square wave and SPWM is employed. Block diagram of the proposed switching control circuit is shown in Fig.5

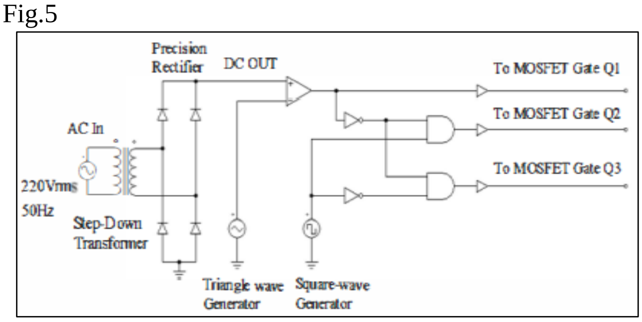


Fig. 5: Control circuit design of inverter

After sampling, the sine wave is rectified with a precision rectifier. In addition, a high frequency triangle wave of 10KHz frequency is used. Then the two signals are passed through a comparator to generate the unipolar SPWM signal. This unipolar signal only has positive values, which changes from +5V to OV and again back to +5V. A square wave signal is used as the line frequency (50Hz for india) and is in phase with the SPWM signal. The three sets of switching signals can be categorized in three groups. The first group contains MOSFETs Q1, while the second group contains MOSFETs Q2 and the third group contains MOSFETs Q3. The resulting switching gate pulses of the inverter power circuits from control circuit are illustrated in Fig. 6, Fig. 7 and Fig. 8 respectively.

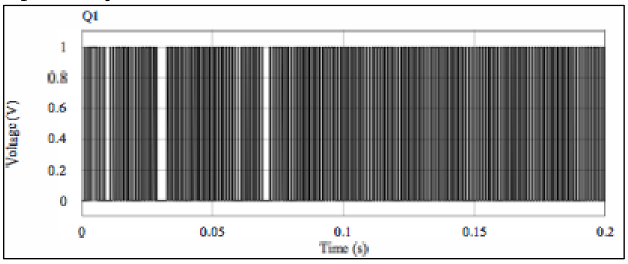


Fig. 6: Switching entryway beat for MOSFET Ql

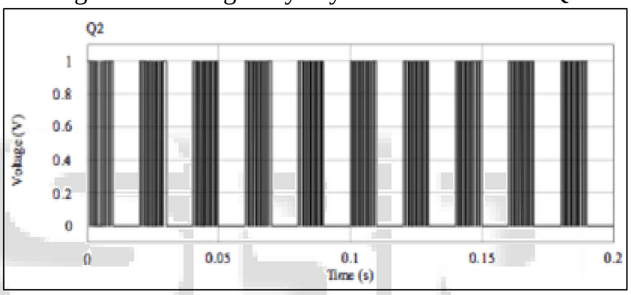


Fig. 7: Switching entryway beat for MOSFET Q2

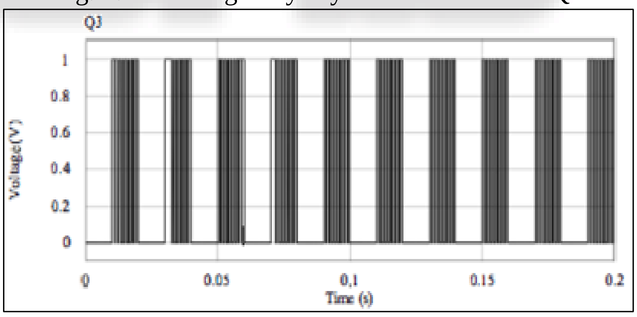


Fig. 8: Switching entryway beat for MOSFET Q3

H. Closed-loop Control

Fig. 9 shows the block diagram of real-time waveform feedback closed-loop SPWM control method. In this proposed GTI design, we used a closed-loop controller scheme where the output current is measured and compared with an ac reference current.

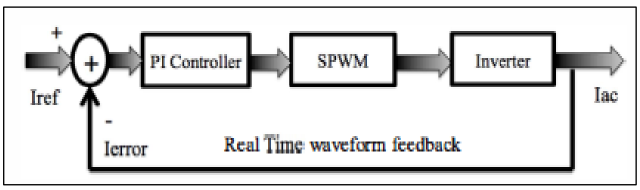


Fig. 9: Closed-loop control block diagram

In this closed-loop operation initially we calculate the peak modulation index Ma for 50 Hz grid voltage cycle by using of equation (4) and then this peak value is used to produce the sinusoidal modulation index [7]. The error in between the measured output current and the reference current is compensate by a Proportional Integral (PI) controller and is used to generate the desired SPWM switching gate signals for MOSFET Q1, Q2 and Q3.

I. Grid Synchronization

This proposed grid-connected inverter design operation involves a grid synchronization part. During synchronization, the inverter produces output in phase with grid. The sine wave from grid is sampled and phase shift is set to zero. PWM signal is then undergoes an AND operation with square wave and generates three sets of switching signals. With this kind of switching and zero phase shifts, the output voltage and current of GTI controlled with the same phase with the grid

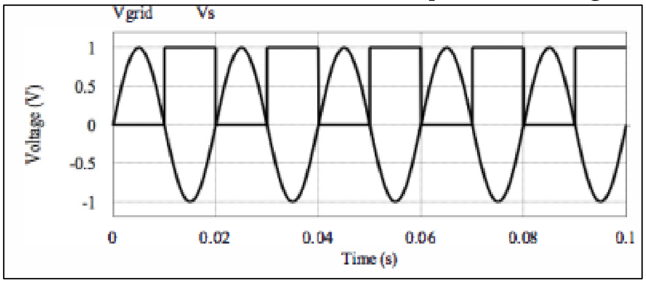


Fig. 10: Zero-intersection yield aftereffect of GTI

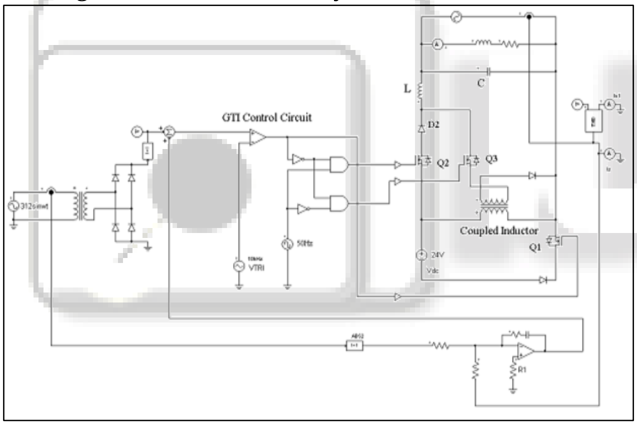


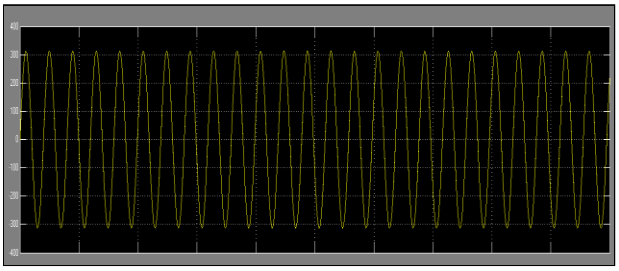
Fig. 11: Circuit Diagram of new approached system

Implement in this paper fuzzy logic controller use increasing the efficiency and output power, where the grid signal and square wave shows the zero point at falling and rising edge. After both voltages are tied, the inverter begins to inject power into the grid. To avoid the grid to having power from the inverter when the grid is down and create undesirable accident, the freewheeling diode is employed between the grid and the inverter MOSFET power circuit that will block the reverse power flow from grid. This isolation process is to avoid the grid to become live part on the time when it should not be.

V. SIMULATION RESULT AND DISCUSSION

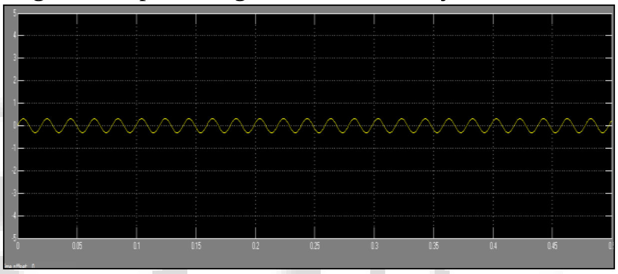
The proposed GTI design will undergo a computer simulation using MATLAB software To confirm the mathematical modeling analysis in the previous section, 600W of the proposed three-switch single-stage GTI is simulated. The complete simulated schematic diagram of the proposed buckboost GTI is shown in Fig. 11. In fuzzy logic controller photovoltaic exploitation significat renewable energy source based MPPT is able to Differ PV operating voltage and seek for the maximum power that the PV panel can produced. The performance of fuzzy logic with various analyzed to optimize the MPPT. The operation of the inverter is simulated for different level of input source voltages from 12V dc to IOOV dc, as if it were from a PV panel. Fig. 12 shows the sinusoidal ac output voltage waveform that is 220Vrms and 50Hz after tied the inverter to the grid. Fig. 13 represents the simulation result of grid-connected power converter, where we observed that both the output current and voltage are in same phase. Fig. 14 shows the simulation result of the GT! Output current is lO.SA at 600W when the input voltage is 24V dc.

A. Vout



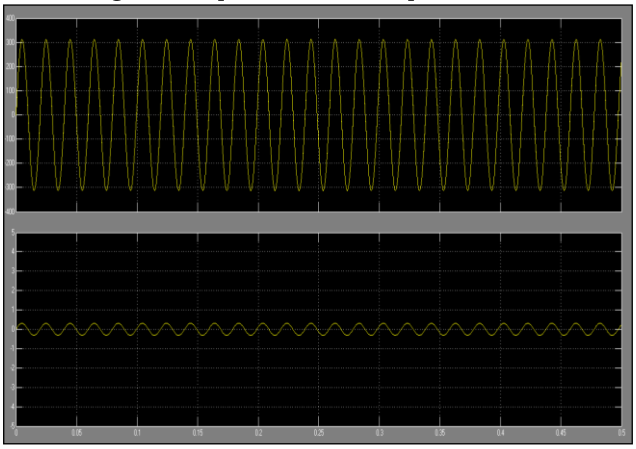
Time (sec)

Fig. 12: Output voltage of GTI and utility Grid line Iout



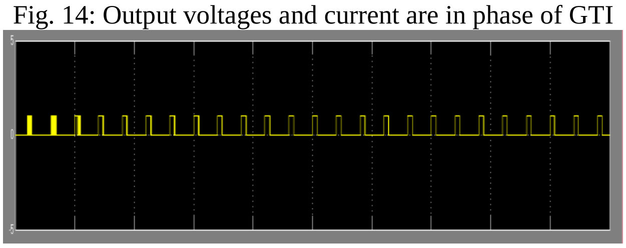
Time(sec)

Fig. 13: Output current are in phase of GTI



Time(sec)

Fig. 14: Output voltages and current are in phase of GTI



Time(sec)

Fig. 15: Output current THO of GTI

Fig. 15 shows the simulation results, where the Total Harmonic Distortion (THD) of output current is about 0.9% and the value of output capacitor is used only 10mF. However, fig. 16 Show that fuzzy logic output current and output voltage.

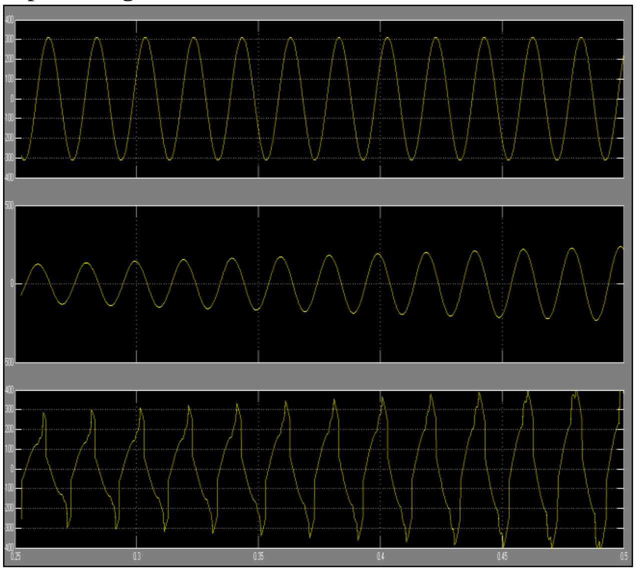


Fig. 16: Output voltages and current are in fuzzy logic o/p

VI. CONCLUSION

Mathematical modeling, analysis of working principle and computer simulation of this proposed single-phase single stage buck-boost GTI is presented in this paper. Further, adoption of a simple control scheme and grid synchronization strategy that would make the inverter more reliable. Since it uses only three switches, the cost and size of this inverter would also be relatively low as minimum number of power devices is used to execute this configuration as compared to movable types of photovoltaic panel the increasing of efficiency and output power The physical fabrication and test of the proposed grid connected inverter is yet to be done and will be implemented in future

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