Integration of Large-Scale Renewable Energy Sources into a Low Inertia Power Grid with a Single Synchronous Controller

Gokulkannan. K[1], Shaalini. P.T[2], Balaji. G[3], Ramachandran. S[4],
[1]*P.G. Scholar, Department of Electrical and Electronics Engineering, Paavai Engineering College, Namakkal.*
[2]*P.G. Scholar, Department of Electrical and Electronics Engineering, Paavai Engineering College, Namakkal.*
[3]*Professor, Department of Electrical and Electronics Engineering, Paavai Engineering College, Namakkal.*
[4]*Assistant professor, Department of Electrical and Electronics Engineering, Paavai Engineering College, Namakkal.*

***Abstract*: Solar power is the conversion of solar energy into thermal or electrical energy. Solar technologies can harness this energy for a variety of purposes, including electricity generation. In the existing method Transformer, less single-phase symmetrical Z –Source Inverter having some drawbacks such as voltage unbalance, harmonic distortion, and low reducing leakage current when compared to the proposed method. So to overcome the drawback, this work proposes a quasi-Z-source inverter using the switched Inductor method. The converter with two capacitors, one diode, and two inductors for maintaining balance voltage and low leakage current losses in the output. Single Synchronous Controller based converter gives maximum boost control method results the relation of the voltage boost inversion ability. An inverter is an essential material in a solar energy system, it is a way to convert Direct Current (DC) power generated by a solar panel to Alternating Current (AC). The quasi-z-source converters are classed as continuous switched-quasi-z-source converters or discontinuous switched-quasi-z-source converters based on the sequence of inductor current and system setup. The output result is Hardware Prototype verifies the proficiency of the proposed control technique.**

1. INTRODUCTION

The disturbance of the voltage of the P.V. arrays during the Maximum Power Point (MPP) tracking always produces an inherent error produced by power fluctuations on the D.C. side, especially during steady-state operation, which is one of the most important prominent drivers of inter harmonics in P.V. systems. Based on the above analysis, a mitigating method for inter harmonics in P.V. systems is nothing more than randomly altering the MPPT's sampling rate between fast and slow. The solar panel's maximum power production is reached just for one precise working point, and P.V. generating efficiency is determined by the maximum amount of sunlight available.

Traditional electric power systems are built to rely on big baseload power plants with limited ability to ramp output quickly or decrease output below a particular threshold. The increased demand variability brought on by intermittent sources like photovoltaic devices creates new challenges for system adaptability. Solar systems have recently gotten a lot of interest since solar energy is everywhere, and the cost of a photovoltaic cell is falling. Photovoltaic systems are inherently intermittent and cannot meet all of the electricity needs throughout the year. As a result, grid-connected P.V. systems with advances are often selected to maintain an uninterrupted power supply.

P.V. array, diode, DC-link capacitor, voltage source inverter with harmonic reduction filter, step-up transformer, and power grid make up the system. The DC-link capacitor is charged by the D.C. power generated by the solar array. The grid connection inverter converts D.C. to A.C. power, which has the same frequency as the utility grid and sinusoidal voltage. The diode protects the P.V. array from receiving reverse current. The transformer provides electrical isolation between the P.V. system and the power grid by stepping up the output Voltage Source

Inverter (VSI), and DC-AC converter to the nominal value of the power grid.

By reorganization of the input side components, the Quasi-Impedance Source Inverter (QZSI) was produced from the basic impedance ZSI to achieve lower voltage stress and continuous input current. In the Shoot-through state, this inverter provides buck operation by regulating the modulation index and boosting operation. The Switched-Boost Inverter (SBI) was introduced as a simpler alternative to the impedance ZSI, with fewer components than the standard ZSI.

When performing a QZSI circuit analysis, all ZSI equations in the Continuous Conduction Mode (CCM) and Discontinuous Conduction Mode (DCM) are shown to be true for QZSI. As previously noted, there are two fundamental distinctions between the two topologies. The proposed circuit concentrates on two distinct aspects of the converter. First, the subject of how to increase the output power quality of the circuit is investigated. Second, the subject of how to enhance the circuit's output voltage is investigated. The circuit alterations described in the reference studies are assessed differently in these two queries.

To achieve this, a unique unipolar PWM approach is used to reduce distortion. To provide buck-boost capabilities, the ZSI uses an impedance network consisting of two identical capacitors and inductors arranged between the input source and the power MOSFETs. Power MOSFETs on the same leg can be triggered at the same time in the ZSI topology, eliminating the dead period. As a result, the circuit is kept free of EMI, and its stability is improved.

2. PREVIOUS RESEARCH WORK

A novel dynamic midpoint voltage idea because solar PV has environmental effects on its I-V characteristics, the dynamics of a solar PV fed inverter differs from that of a constant battery storage-based system. The common mode voltage is an important characteristic in the operation of a three-phase inverter and its accompanying drives. It generates high-frequency switching noise pulse, current flow through bearings, and electromagnetic interference issues. In this method relationship between PV source dynamics and inverter common mode voltage. A novel mathematical model for common mode voltage has been presented, with a link to source dynamics.

The electrical output voltage of a solar PV cell and a battery storage system is similar. Both of these electrical sources provide a voltage that is Direct Current (DC). The voltage-current characteristics of these two sources, however, are quite different. Based on its charging status, the battery storage has distinct output characteristics. The output characteristics of a PV cell are determined by the amount of solar irradiation that falls on it. A battery source's midpoint is a fake location that corresponds to the fictitious position at which half of the voltage is obtained. This midpoint voltage is important for inverter operation.

Therefore, with high penetration of PV energy sources, a high portion of injected power into the grid will be intermittent. Even a slight change in weather conditions, for example, a cloud cover can reduce the output power of a PV system significantly, which will cause a sudden change in a generation. This intermittency on the energy generation side is new to the existing power network and consequently, with large-scale integration of PV energy sources, it may lead to several technical challenges to the power system operation and stability.

With high penetration of intermittent energy sources like solar PV systems, it is essential to assess the voltage stability of the power grid to devise corrective actions to ensure the reliability of the power grid. Several efforts have been reported in the literature to analyse the voltage stability impact of large-scale penetration of solar PV systems into the grid. For example, the study presented shows that the impact of the integration of a PV system on the voltage stability of a power grid may be both detrimental and beneficial depending on the penetration level and the location of integration. A similar conclusion has been presented which states that optimum penetration and location of a solar PV system can improve the voltage stability margin of a power grid.

Renewable energy is being increasingly utilized in electric power systems due to environmental concerns and energy cost escalation associated with conventional energy sources. Photovoltaic and wind energy sources can significantly offset costly fuel in small isolated systems and considerably impact system reliability. The utilization of renewable energy in capacity planning requires realistic cost/reliability evaluation models that can recognize the highly erratic nature of these energy sources while maintaining the chronology and interdependence of the random variables inherent in them.

This method evaluation model applies to analyse optimum generation expansion of small isolated systems using P.V. and wind energy sources. Considerable attention has been given to renewable energy sources in recent years due to concerns with dwindling fuel reserves and the potential impact of conventional energy systems on the environment. However, the conventional probabilistic risk indices do not provide any information on the available system capacity reserve and have not been readily accepted in SIPS. SIPS is presented in the following section.

Solar energy is currently one of the renewable energy sources available in the Republic. Solar power is more environmentally benign and easier to implement than other renewable energy sources. Solar power is frequently used to meet direct electricity needs with the assistance of a PV system and power electronic gadgets. Because of the value and life potency restrictions of the energy storage device, energy generated by the PV array is quickly transmitted to the grid. The PV array transforms radiation into voltage, and the electrical converter converts DC energy into AC energy

The integrated system responds quickly, and control precision is possible, particularly at the grid end. The inverter power can also be managed separately thanks to the control approach. The current and voltage controllers operate poorly at any location where the irradiance is changing, while the grid voltage and current function well. Furthermore, this method's examination was performed in the temporal domain. The grid-connected power converter completes the power supply by converting DC to AC electricity. To demonstrate this, the PV system's power is converted from DC to AC via a grid-connected electrical converter. The current and frequency are synchronized with the national or local grid. For added voltage, the output voltage is booted from the grid to be somewhat higher than the grid voltage. The grid-connected three-phase electrical converter

The grid-connected solar panel is a distributed power generating device that uses an inverter to convert DC power from a photovoltaic array to AC power. To control the inverter, a voltage regulator and a current regulator are necessary to keep the capacitor voltage at a specified reference level. It primarily focuses on inverter control intending to get the optimum amount of power from the solar panel. In this dissertation, a fractional order proportional integral controller is proposed for controlling the inverter.

Wind power, hydropower, solar energy, geothermal energy, bioenergy, and wave energy are the most popular renewable energy technologies. Solar energy is gaining popularity in academia and industry due to its sustainability and environmental benefits. Solar energy is a more efficient and feasible renewable energy choice since it is abundant. A photovoltaic array is a device that uses the sun to generate power. Solar energy was first developed for space applications, where cost was not a problem. The photovoltaic (PV) system was then introduced for use in residential applications. Multifunctional inverters with a fuel cell or battery as an auxiliary system was proposed. If the system's storage device, such as a battery, is not attached.

The amplitude of the grid voltage is detected and set as the reference value for the PV inverter's output voltage, and the phase difference between the inverter and grid voltage is regulated using MPPT control to monitor the maximum power point. The downside is that grid information must always be detected in real time. A unique solution combining MPPT with droop control is proposed, but the DC voltage controller's reaction is too slow and the design is too complicated to employ. To study and design the entire PV system in detail, a novel control technique is offered.

High-power DC-DC converters are utilized for DC driving applications and as power conditioners for renewable energy sources. Cuk, fly back, sepic, and quasi Z source DC-DC converters are some of the specific types of DC-DC converters utilized for high-power applications. With the help of energy storage devices, all of these converters are designed to provide a single output. A simple circuit modification is attempted to convert the aforementioned converter to provide dual output. Quasi Z source DC-DC converter is the converter of interest. A quasi Z-source DC-DC converter uses an LC impedance network to buck and boost the input voltage depending on the duty ratio.

2.1 Problem Statement of Previous Research Work

- It will give only low output

- Maintenance cost increases
- Installation cost is high
- Reliability is less
- Efficiency is low
- It the difficult to calculate the precise location and timing of events.

3. MATERIALS AND METHOD

PV systems are grid-connected via an interface converter that uses a Maximum Power Point Tracking (MPPT) controller to supply the grid with the maximum allowed solar power. This is due to the fly-back topology's ability to merge the energy storage inductor (the inductor in the buck-boost converter) with the transformer. The maximum power point tracking technology is used to increase solar panel efficiency and the Maximum Power Transfer approach states that the output power of a circuit is highest when the source impedance equals the load impedance. If the output power increases, the voltage is increased continuously until the output power begins to decrease. When the output power begins to fall, the voltage to the cell is reduced until maximum power is attained, and the process is repeated until the MPPT is obtained. This system ensures that the load demand is met under fluctuating solar irradiation circumstances and that a consistent voltage is maintained under various load situations

In this method, Single Synchronous Controller technique-based parameters such as sampling rate and Improved Perturb and observe values significantly impact the inter harmonic form characteristic of P.V. systems. The non-isolated switched Inductor quasi Z-source connected based inductors are recovered by the passive clamp circuit, which also limits the switch, the voltage gain of the converter is increased by configuring the passive clamp and voltage multiplier circuits. From the controller technique, maximum power point tracking produces inter harmonic emission, and Inter harmonics are one of the most important sources of improving the source voltage and current. The battery load source indicates the battery level, while connected bidirectional DC-DC converter and Quasi Z-source Converter (QZSI) is circuit converts coming from Direct Current (D.C.) the power source into Direct Current (D.C.) with the flow of Limiter and battery storage. The output result is better power quality and better gain without any distortion of the output from Hardware Prototype output.

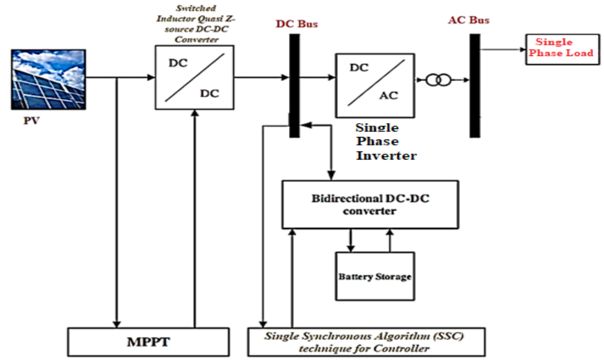


Figure 1 Proposed block diagram

3.1 Block Diagram Explanation

3.2 Switched Inductor Quasi Z-Source DC-DC Converter.

The novel switched-inductor quasi-Z-source inverter, proposed topology's boost ability is enhanced when compared to classic topologies. Voltage stress is reduced in capacitors, diodes, and power devices, and the current ripple in the DC voltage source is suppressed. The efficiency of conversion is also improved and the topology's operation principle is thoroughly examined and compared to that of similar topologies. Experiments and experiments on a laboratory prototype are used to validate the feasibility of the proposed topology.

DC-DC converters generate controlled variable DC voltage from fixed DC voltage, which can be step up or step down voltage depending on the system's power circuit. Various converter classifications were devised based on operation, such as buck, boost, and buck-boost converters. Primitive converters only produce a single output, and for applications that require multiple sources, the circuit becomes cumbersome. Hence In the material, single inductor multiple output DC-DC converters were proposed to obtain multiple outputs from a single circuit for various electronic applications. This circuitry employs additional switches to distribute the inductor current among the various output voltages generally suitable for low-power applications.

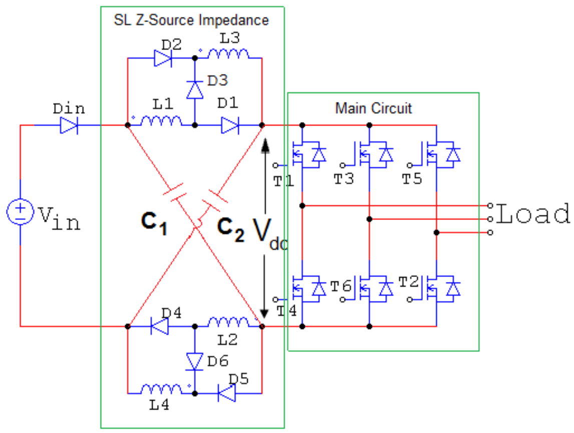


Figure 2 Circuit diagram of Switched Inductor Quasi Z-source DC-DC Converter

With a simple change in the circuitry, an attempt is made to convert the aforementioned converter to produce dual output. The converter of interest is a DC-DC converter with a quasi Z source. The benefit of this converter is that it has a high boost value while putting less strain on the components. To generate dual output, the new modified isolated quasi Z source DC-DC converter employs mutually coupled devices such as transformers. DC-DC converters are used solely as a power conditioning unit for renewable energy sources. They convert fixed DC to variable DC by continuously switching the switching device ON and OFF. DC-DC converters are classified as buck, boost, or buck-boost depending on their operation.

3.2 Solar Panel

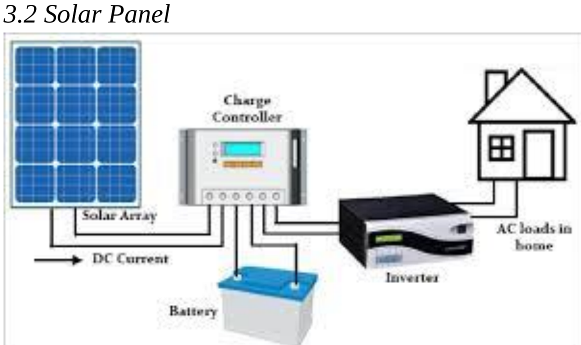


Figure 3 Application and working of PV Module.

Photovoltaic power generation is a technology that converts light energy directly into electrical energy by implementing the photovoltaic cell of the electrode surface. The much more essential key element of this technology is solar cells. After encapsulating a series of solar cells, it could form a large area solar cell module, which could be coupled with the power controller and other elements to form a photovoltaic system device. If light shines on solar cells and is consumed by the semiconductor interface, a photon with sufficient energy can enhance electrons from the covalent between P-type and N-type silicon to produce electron-hole pairs.

The electric field of the space charge will separate the complex of the atomic nucleus and particle that is near the interfacial region of the transistor. The electron will move into the N region, which is charged positively, and the electron hole will move into the N region, which is charged negatively way. The charge separation of the semiconducting interfacial region produces a voltage between the P and N regions. A typical open-circuit voltage for crystalline silicon solar cells. The greater the number of electron holes produced at the semiconductor interface, the greater the electric current.

Solar energy is a type of energy that is radiated. Energy converters can convert it into electrical energy. A solar cell serves as the converter. Once light shines on the P-N knot of the transistor, this should invent different electron-hole pairs; under the component of electromagnetic current in the P-N knot, the electron-hole will flow to zone from area, and the charged particles will flow to boundary from boundary, and start producing electric charge after being connected to the race track.

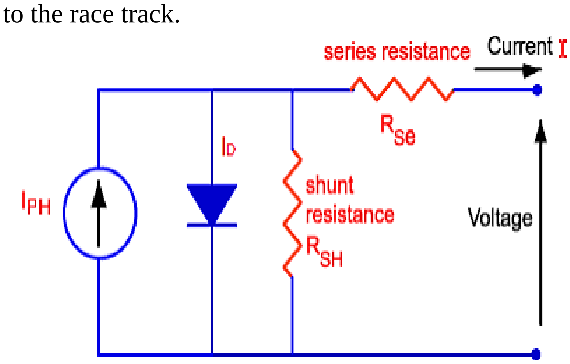


Figure 4 Equivalent circuits of solar cell

3.3 Battery Charging Control

The purpose of this study is the topology of circuits and control techniques for fast charging of batteries in solar energy storage systems. Analysis and comparison of fast charge characteristics for different charge control are presented. The charge / discharge monitoring system is set based on the State of Charge (SOC).

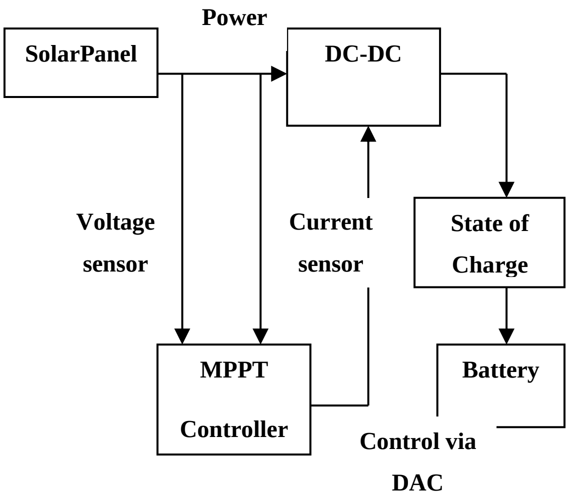


Figure 5 Battery Charging Control

Overview on DC/DC Converter

DC / DC converter operation includes switches, filter circuits, and loads. Another way is to classify DC / DC converters and based on it can be one of the basic techniques of separation to be classified into two types.

1) Isolated DC/DC converter.

2) Non-Isolated DC/DC converter.

The input and output of the isolated DC / DC converter are isolated using an electrical transformer. It requires more bulky space and is more expensive than non-isolated DC / DC converters. Non-isolated DC / DC converters can be further distinguished by connecting components such as buck converters, boost converters, buck-boost converters, CUK converters, and SEPIC converters. DC / DC converters are used to convert unregulated DC inputs to widely regulated DC outputs. The DC-DC converter is a hardware implementation of MPPT to Hart. MPPT uses any of the above converters to regulate the MPP solar input voltage and provides load impedance matching for maximum power transfer.

Buck and boost converters are basic and simple, with simple circuitry and few components required. Boost converter was selected for this project

- This is a step-up DC / DC converter that increases the input voltage and gives a predetermined voltage to the output.
- Step-up converters temporarily store input energy and then release energy at higher voltage level outputs.
- If the switching device fails, the load is continuously connected to the source.

Need of DC/DC Converter

The DC / DC converters are an integral part of any MPPT circuit system. Without a DC / DC converter, MPPT circuits cannot be designed. When performed between a directly connected source and a load, the output of the PV module is sometimes filtered in terms of maximum power. This problem must be overcome by adapting the circuit between the source and the load. MPPT control circuit with DC-DC converter circuit is used as adaptive circuit. Additional circuitry is needed to transfer the maximum power from the power supply to the load to support the load so that it matches the impedance of the source impedance.

Boost Converter

The output voltage of a step-up converter or converter regulator is called the input voltage of a "boost" regulator, which is lower than the conversion circuit, which means subtracting the input voltage. The boost circuit includes an energy storage element such as a BJT and switching elements such as inductors, capacitors, diodes, and MOSFETs,

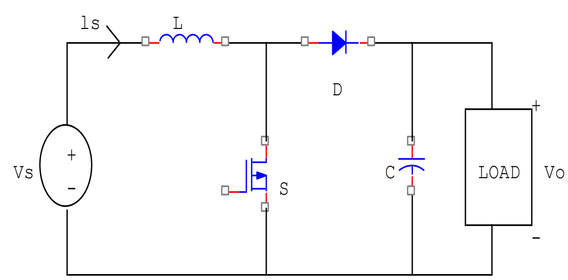


Figure 6 Circuit diagram for the boost converter

Buck Converter

The Step-down converters are mainly DC-DC power converters (while clamping current) dropping the voltage from the input (power supply) to its output (load). Transducers mainly consist of transistors, diodes, (mainly used as energy storage elements), capacitors and inductors. These converters plus filter outputs and capacitors or inductors to reduce ripple voltage. In other words, a load-side filter and an input filter are added. Buck converters are mainly used as switching converters, which provide higher energy efficiency because DC-DC converters are better than linear regulators.

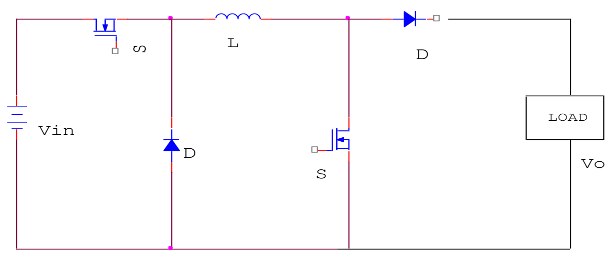


Figure 7 Circuit diagram for Buck converter

Buck-Boost Converter

In order to get higher and lower the stable voltage from the input power supply (PV battery) higher than the system converter power output, high efficiency, minimum ripple. When it comes to converting DC voltage to lower or higher voltage step-down converters, it is possible to do this very effectively. Buck-boost converters are especially useful for monitoring maximum photovoltaic. In these cases, the goal is to consume the maximum possible power from the solar panels at all times, regardless of the type of usage.

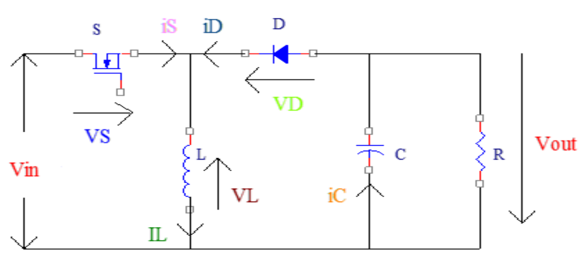


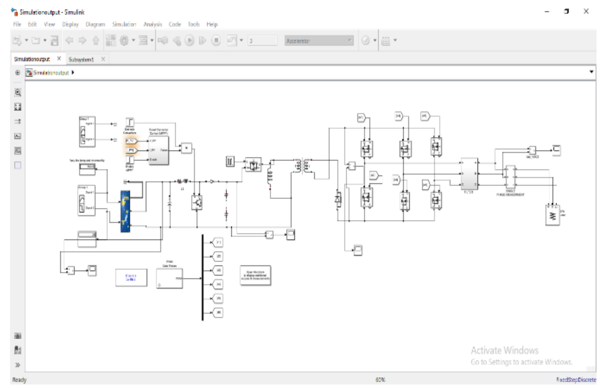
Figure 8 Circuit diagram for the Buck-boost converter

3.4 Advantages

- Improve the stability of the system.
- Reduce the Total Harmonics Distortion.
- To reduce the transient voltage disturbances and load compensation.
- To improve the energy efficiency of the system.
- To minimize the reactive power generation using the synchronizing unit.
- Minimization of generators voltage deviation.

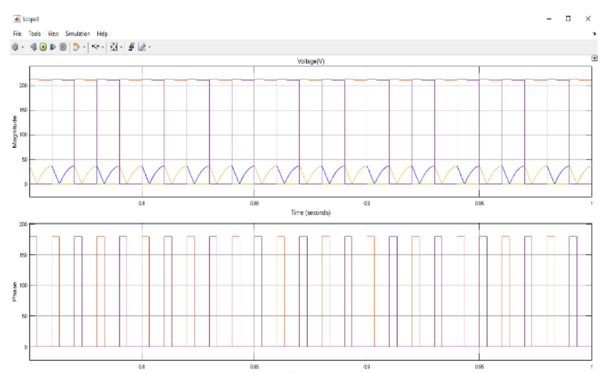
4. *RESULT AND DISCUSSION*

4.1 Mat Lab Simulation Output



The fly-back unit serves as a DC-DC converter, isolating transformer, and tracking device for the maximum power of the PV panel that is connected to it. It has both primary and secondary windings. Through a switching device, the fly-back transformer's primary will receive the output from the PV panel, and the secondary will produce the required output. The size of the core, the quantity of primary and secondary turns, the air gap, and other variables all affect the fly-back transformer's output. The impact of these factors on the output is explained in the section that follows.

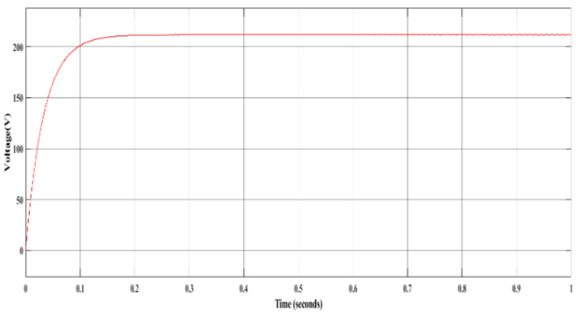
4.2 PWM output



Pulse Width Modulation (PWM) control is the most effective way to accomplish this. By altering the on and off durations of the inverter components, a controlled AC voltage can be produced in this method even though the inverter is fed by a set input voltage.

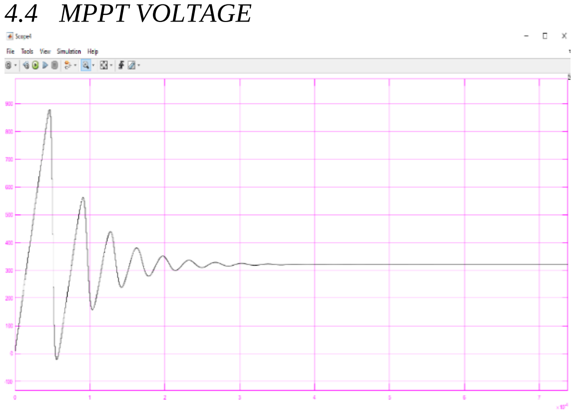
The PWM control scheme's benefits without the installation of any more parts, the output voltage can be controlled. PWM reduces the lower-order harmonics, whereas a filter can eliminate the higher-order harmonics.

4.3 PV output waveform



This mathematically based concept is explained by an equivalent circuit that consists of a photocurrent source, a diode, a series resistor, and a shunt resistor. The created model enables the prediction of PV cell behaviour under various physical and environmental conditions. The physical characteristics of a certain solar PV cell can be determined using the model as a function of temperature and solar radiation. Additionally, this paper describes how PV modules and PV arrays function. An experimental test bench was constructed to validate the generated model, and the findings showed significant agreement with those from simulations.

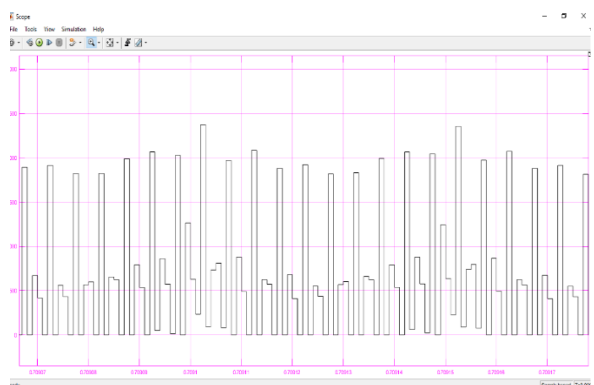
4.4 MPPT VOLTAGE



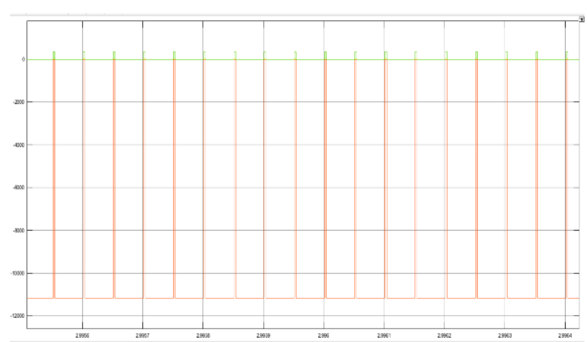
The maximum power point (MPP) designates the location on an I-V curve where a solar photovoltaic device produces the most output, or the location where the product of current intensity (I) and voltage (V) is greatest. The MPP may alter according to environmental factors including temperature, lighting, and device construction. Maximum power output trackers (MPPT) may be used to control the device's resistance in order to assure a solar PV device's maximum power output (Pmax) in light of these external influences.

4.5 Linear Transformer Voltages

The saturation characteristic is the same as that of the Saturable Transformer block when it is turned on. The initial values are automatically changed to start the simulation in a steady state if the fluxes are not given. Based on the nominal power Pn of the transformer and the nominal voltage of the winding (V1, V2, or V3), the leakage inductances and resistance of each winding are provided in pu. Refer to the Linear Transformer and the Saturable Transformer for an explanation of per units.

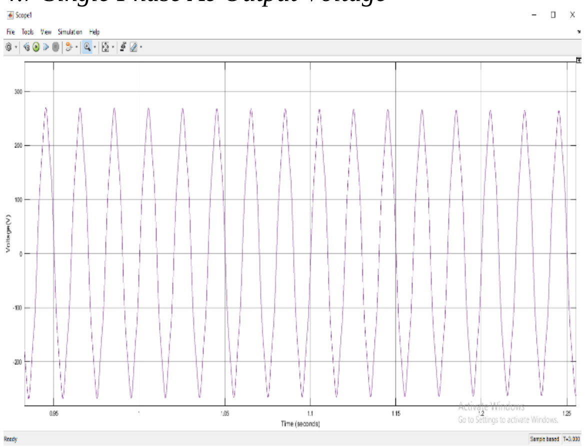


4.6 Inverter Output voltage



The system consists of two independent circuits illustrating single-phase PWM voltage-sourced inverters. The converter block are modeling simplified model of an IGBT/Diode pair where the forward voltages of the forced-commutated device and diode are ignored

4.7 Single Phase Ac Output Voltage



The fly-back unit serves as a DC-DC converter, isolating transformer, and tracking device for the maximum power of the PV panel that is connected to it. It has primary and secondary windings. Through a switching device, the fly-back transformer's primary will receive the output from the PV panel, and the secondary will produce the required output. The size of the core, the volume of primary and secondary turns, the air gap, and other variables all affect the fly-back transformer's output. The impact of these factors on the result is explained in the section that follows.

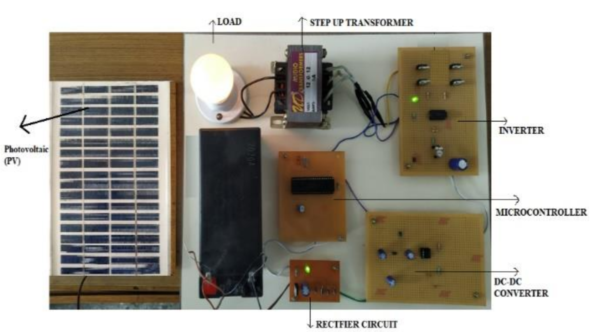


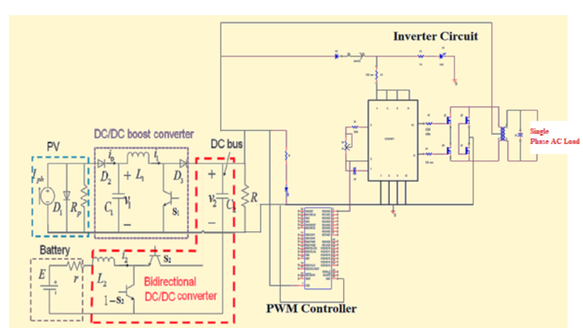
Figure 9 Proposed Hardware Output

- Design of controllers and optimization of gains at both converter stations according to transmission of active and reactive power flow in either direction is also part of the scope.
- Detailed studies has to carry out regarding independent control of active and reactive power at sending and receiving ends which can be achieved.
- Voltage of the converter varies with several parameters such as change in input voltage changes output voltage of the converter and as the load demand changes then also the output voltage changes.
- So output voltage has to be controlled for efficient operation of the network.

Table 1: Hardware Specification

Hardware	*Specification*	*Input Ranges*	*Output Ranges*
Power generation	Solar Power	Maximum Power (p-max)- 10.0 W	Power produced 12-15V
Power generation and Back up storage	Battery	-	12V, 1.3AH Battery
Converter	DC-DC Converter	12V input source	up-to 24 V input source
Transformer	Step down	230v	110V
Microcontroller	PIC (16F877A)	5V DC	5V DC
Rectifier	Input power	110V AC	230V DC
Inverter	Output power	24 DC	Up to 110V AC
Transformer	step-up	110v AC	230v AC
Load	Load	230V AC	4A

4.8 Circuit Diagram Of Proposed For Hardware



- The power supply circuit consists of step down transformer which is 230V step down to 12V.
- In this circuit 4diodes are used to form bridge rectifier which delivers pulsating dc voltage and then fed to capacitor filter the output voltage from rectifier is fed to filter, this 5V DC is used to supply power to the controller.
- Solar DC output is converted to an AC using a DC AC inverter after bucked or increased demand.
- An inverter function must change the DC input voltage as desired voltage and voltage as an asymmetric AC output voltage.
- The best inverter's output voltage should be the sine curve for waveforms. However, practical inverters have a non-wavelength signal and some synchronization.

5. CONCLUSION

The Maximum Power Point Tracking (MPPT) algorithm is a widely used control technique that varies the electrical operating point to extract the maximum power available from the solar cell of the photovoltaic (PV) module. A novel high step-up quasi-Z-source DC–DC converter with a single switched-capacitor circuit. By using the same or similar passive and active components as another high boost DC–DC converters, the proposed converter can provide higher output voltage gain, lower Harmonic distortion across the switches, and lower voltage stress across the output diodes. As a result, the converter's efficiency and reliability can be improved, and the topological derivation, operating principle, parameter selection, and comparison with other DC–DC converters are all discussed. The high performance of the proposed control technique was validated through stringent results in *Hardware Protype* under different operation conditions.

REFERENCES

[1] M. A. Hasan and S. K. Parida, “Referring PV source dynamics on AC side of a three phase solar PV fed inverter”, IEEE International Conference on Computing, Power and Communication Technologies (GUCON), pp. 773-777, 2020.

[2] Rahman, S., Saha, S., Islam, S. N., Arif, M. T., Mosadeghy, M., Haque, M. E., and Oo, A. M. T. “Analysis of power grid voltage stability with high penetration of solar PV systems”. IEEE Transactions on Industry Applications, 57(3), 2245–2257.

[3] Jain, V, and Singh, B. “Power quality improvement in PV system tied to weak grid”. IEEE Transactions on Industry Applications, 57(2), 1265–1273, 2021.

[4] K. Lumei, “Design and analysis of a three-phase grid-connected solar PV inverter with proportional-integral controller”, IEEE International Conference for Innovation in Technology (INOCON), pp. 1-5, 2020.

[5] V. K. Mahawar and S. Tiwari, “An improved inverter control for grid-connected PV System”, International Conference on Communication and Electronics Systems (ICCES), pp. 547-551, 2019.

[6] Y. Jia and R. Wu, “Voltage source grid-connected PV inverters based on MPPT and droop control”, IEEE 2nd Annual Southern Power Electronics Conference (SPEC), pp. 1-6, 2016.

[7] S. Jain and V. Agarwal, “An integrated hybrid power supply for distributed generation applications fed by nonconventional energy sources”, IEEE Transactions on Energy Conversion, vol. 22 [2], June 2018.

[8] S. Mukherjee, S. Mazumder, S. Sharma, T. Sarkar, S. Dey, and S. Adhikary, “Performance of grid-connected inverter fed from PV array”, International Conference on Energy Management for Green Environment (UEMGREEN), 2019, pp. 1-5.

[9] Mahmoud Et Al., “A simple approach to modeling and simulation of photovoltaic modules”, IEEE Transactions on Sustainable Energy, Vol. 3 [1], January 2019.

[10] S. S. Dhokare and P. K. Katti, “Fuzzy based switched boost inverter for solar PV application”, International Conference on Power Energy, Environment and Intelligent Control (PEEIC), pp. 387-391, 2018.