# DUAL VOLTAGE SOURCE INVERTER USING HYBRID ENERGY SOURCE INVERTER

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**Abstract:** *The power system undergoes a paradigm shift as a result of technological advancement and environmental concerns, integrating more renewable energy sources through distributed generation (DG). A microgrid is made up of these DG units and coordinated local generating and storage facilities. In this paper we develop a hybrid energy source inverter with novel active power optimizer control that will create a controller that will increase the solar system's power production. The simulation results demonstrate that the proposed voltage optimizer active power control approach is superior to the standard phase locked loop control for the system. Additionally, by combining it with the wind system and creating a hybrid power source, the system was made more efficient.*

**Keywords:** *Multilevel, distributed generation, Power quality improvement, DVSI, AVSI, MVSI.*

## I. INTRODUCTION

The power system undergoes a paradigm shift as a result of technological advancement and environmental concerns, integrating more renewable energy sources through distributed generation (DG). A microgrid is made up of these DG units and coordinated local generating and storage facilities [1]. Power electronic converters are used in microgrids to interface power from various renewable energy sources, such as fuel cells, photovoltaic (PV) systems, and wind energy systems, with the grid and loads. In order to transfer energy from the microgrid to the grid and the linked loads, a grid interactive inverter is necessary [2], [3]. When operating in grid injecting mode, this microgrid inverter injects electricity into the local grid while supplying a portion of the local load. The power quality in the power distribution network has been deteriorated by the growth of power electronics devices and electrical loads with unbalanced nonlinear currents. Additionally, the propagation of these harmonic currents causes the voltage at the point of common coupling to be distorted if the distribution systems have a significant amount of feeder impedance (PCC). Simultaneously, industry automation has advanced to a point of great sophistication where facilities like auto factories, chemical plants, and semiconductor factories require clean power. It is crucial to correct for nonlinear and imbalanced load currents in these applications [4]. The use of grid interactive inverters for load correction and power injection in microgrids has been discussed in the literature [5], [6]. We examine a single inverter system with improved power quality. The primary goal of this work is to implement dual functions into an inverter so that it may both inject active power from a solar PV system and act as an active power filter, compensating for imbalances and the reactive power needed by other loads connected to the system. For a wind energy system (WES), a voltage regulation and power flow control method is put out in [7], [8]. A distribution static compensator (DSTATCOM) is used for both active power injection and voltage regulation. Using sliding mode control, the control strategy keeps the power balance at the grid terminal during wind changes. [9] provides a description of a multifunctional power electronic converter for the DG power system. This plan can serve as both a harmonic balancer and an injector of power produced by WES. The majority of the available research in this field discusses the topologies and control algorithms needed to combine active power injection with load compensation in a single inverter. The amount of inverter capacity that can be employed to accomplish the second goal depends on the instantaneous microgrid real power available when a grid-connected inverter is used for active power injection as well as load correction [10]. When a PV inverter is linked to the grid, its capacity to produce reactive electricity decreases during the times when solar insolation is at its highest [11]. The reactive power to control the PCC voltage is simultaneously crucial during this time [11]. It shows that having many functions in a single inverter either reduces the ability to inject real power or improve load compensation.

## II. RELATED WORK

Varzaneh et al.[1] proposed a novel design for high voltage gain dual-input single-output three-phase inverters based on impedance source inverters to increase efficiency, decrease cost, and lighten the overall structure. Aghazadeh et al.[2] proposed a dual two-level voltage-source inverter (DTL VSI) to integrate two dc sources into the MIACDC power architecture of fully integrated power and energy systems (FIPESs). This study compares the DTL VSI with the traditional current-controlled, grid-connected two-level VSIs using mathematical calculations. Lee et al.[3] propose a dual-T-type five-level CMI to increase voltage gain and maintain cascaded extensions. Hasan et al.[4] propose a novel DSDM method for a DVR based on a current source inverter to generate switching pulses for the power electronic switches in the CSI. To validate the proposed DSDM technique, different types of fault-induced voltage sags are simulated in a radial distribution system. Ishwarao et al.[5] proposed a model to forecast the least dc voltage ripple yield switching sequence for VSIs due to reduced load current dependence. Gupta et al. [6] This paper suggests a stability blind-area-free control design approach to reduce the blind area and increase the system's resilience to changes in grid impedance in grid-connected mode. Kumar al.[13] proposed a sensorless control method for the dual-PMSM system, combining traits of the conventional modulation strategy and a novel duty cycle modification FL-VSI approach. It has good dynamic and steady-state performance and can predict the positions of the two motors accurately. Akbar et al.[8] propose a family of high-gain, dual-buck, single-phase split-source inverters (SSIs). They offer great reliability, increasing switching frequency and efficiency, and reducing pulsewidth modulation (PWM) dead-time. They have no shoot-through difficulties, MOSFETs can be utilised without problems with reverse recovery, dead-time can be reduced, switching frequencies can be raised, and efficiency can be boosted by external fast recovery diodes. A 300-W experimental prototype is tested at 25-35-V input voltage, 155 V peak output voltages, and 50 kHz. Zhu et al.[9] propose a single-phase boost inverter with reduced active and passive components, non-isolated with dual outputs, and a hybrid sinusoidal and constant pulsewidth modulation control technique. Simulation and experimental results confirm the characteristics. Wang et al.[10] demonstrate the effectiveness of the partial capacitor charging technique for enhancing the voltage profile of CSI fed motor drives. M.F. Roslan et al.[11] analyze MG control strategies and classifications in terms of protection, energy conversion, integration, benefits, and drawbacks. To increase renewable energy generation, maximum power monitoring methods are used, and the media gateway can operate with existing control technologies. To create MGs that are reasonable, effective, and sustainable, it is important to use the right control technologies. Ram Hridaya al. [12] The proposed control strategy is based on a Power Management Algorithm (PMA) that accounts for network charges and battery degradation, while still operating within the constraints of the SOC code[14], [15].

## III. PROPOSED METHODOLOGY

The MALAB/SIMULINK environment has been used to create the model. This is a high-level matrix/array language with features for object-oriented programming, control flow statements, functions, data structures, input/output, and input/output. The following are its main attributes:

- High-level language for computing in science and engineering
- Desktop environment optimised for iterative creation, exploration, and problem-solving Data visualisation tools and graphics
- Apps for a variety of activities, including signal analysis, control system tuning, data classification, and curve fitting
- Toolboxes for a variety of technical and scientific applications as add-ons
- Resources for creating apps with unique user interfaces Possibilities for royalty-free deployment of MATLAB programs to end users.

It is done to model the dual voltage inverter system. The load may be powered by solar or wind resources depending on their availability, which increases the system's dependability.

The modelling of various system components has been studied in more detail. In order to operate as efficiently as possible, the synchronous permanent magnet generator (PMSG) attached to the wind turbine and the photovoltaic system were both modelled using MPPT technology.

A hybrid system is created by combining a solar power system, which powers the Dual Voltage Source Inverter (DVSI), with a wind turbine. The DVSI standard was also used to model the DC storage capacitor system. These provide an uneven and non-linear load through their connection to the network at the PCC. The distributed power source's power is made available to the network through the VSI (DER). The DER can be a DC source or an AC source connected to a DC connection by a rectifier.

**PV Module modeling:**

The maximum output power is produced by the solar cells at a single operational point where the values of the cell's current (I) and voltage (V) are equal. These numbers represent a specific resistance that is equivalent to V / I. An easy PV cell comparable diagram.

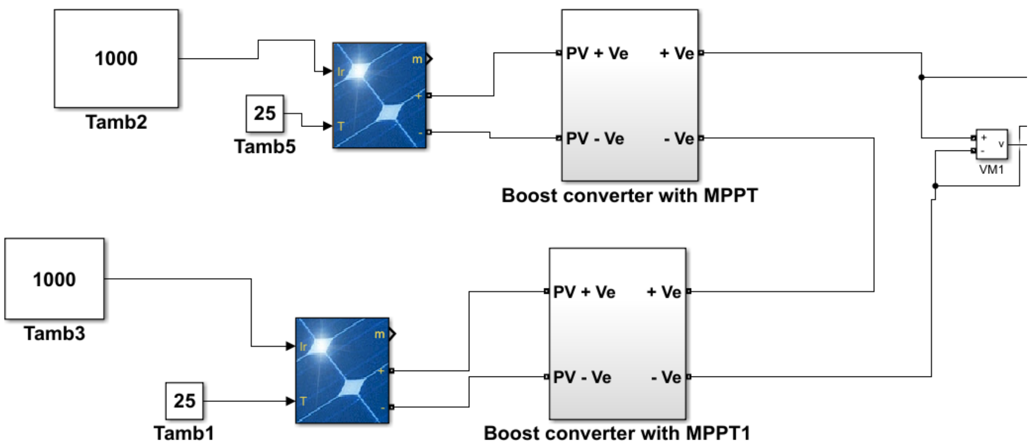


**Figure 1:Modeled Solar System**

**Table 1:Solar System Parameters**

| S. No. | Solar System Parameters | |
|---|---|---|
| 1 | Maximum PV power | 300 W |
| 2 | Maximum power point voltage | 40 V |
| 3 | Maximum power point current | 7.5 A |
| 4 | Open circuit voltage | 44.5V |
| 5 | Short-circuit current | 8.5 A |
| 6 | Nominal utility frequency | 50 Hz |

A cell series resistance (Rs) is coupled in series with a parallel combination of a shunt resistance (Rsh), an exponential diode (D), and a cell photocurrent (Iph). I pv and Vpv are the current and voltage of the cell, respectively. It can be said to be

$$I_{pv} = I_{ph} - I_s\left(e^{q(V_{pv}+I_{pv}*R_s)/nKT} - 1\right) - (V_{pv} + I_{pv} * R_s)/R_{sh}$$

Where:

$I_{ph}$- Solar-induced current

$I_S$ - Diode saturation current

$q$ - Electron charge (l.6e$^{-l9}$C)

$K$ - Boltzmann constant (l.38e$^{-23}$J/K)

$n$ - Ideality factor (l~2)

$T$ - Temperature $^0$K

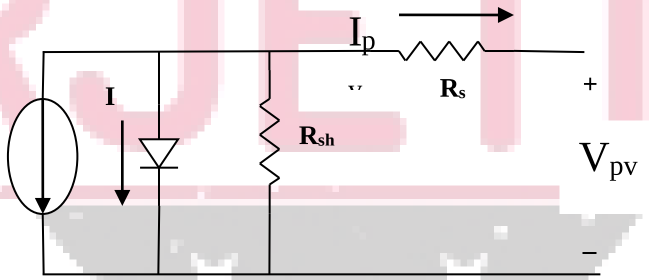


**Figure 2: Equivalent Circuit of Solar PV Cell**

You may explain how the solar PV cell's solar induced current varies with solar irradiation level and working temperature as follows:

$$I_{ph} = I_{sc} - k_i(T_c - T_r) * \frac{I_r}{1000}$$

Where:

$I_{SC}$Short-circuit current of cell at STC

$k_i$Cell short-circuit current/temperature coefficient(A/K)

$I_r$ Irradiance in w/m$^2$

$T_C$ ,$T_r$ Cell working and reference temperature at STC

In a PV cell, current and voltage have an exponential relationship, and the maximum power point (MPP) occurs at the knee of the curve as depicted in the Fig 4.4.

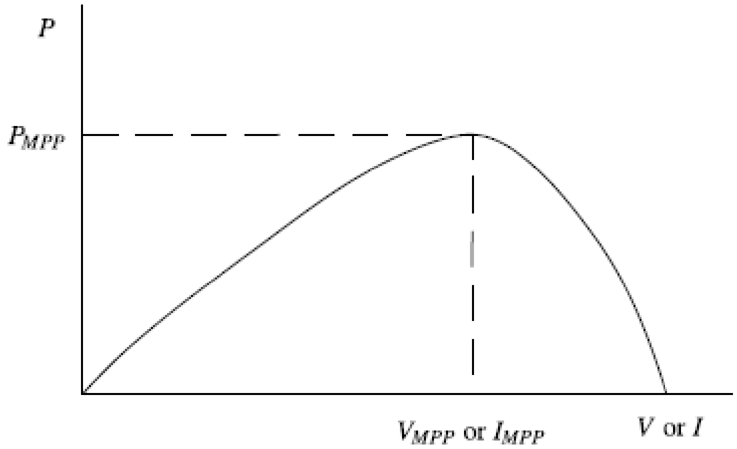


**Figure 3: Characteristic PV Array Power Curve**

The maximum power needed to run the DCMG system is monitored by the P&O algorithm. According to the theories used to develop the model, the PV behaviour can serve as a representation of the ideal current source. Additionally, all converters run in continuous conduction mode (CCM), which ignores even harmonics.

## IV. RESULT AND DISCUSSION

**Implementation Details**

The suggested algorithm for the analysis of the sentiment of a performance buffer is described analytically and numerically in this chapter. The performance of the proposed algorithm is obtained through simulation.

The suggested approach is simulated in the following configuration in order to gauge how well it performs:

Operating System with a Pentium Core I5-2430M CPU clocked at 2.40 GHz and 4GB of RAM

Microsoft Platform

**Simulation Environment**

MATLAB is the acronym of MATrix Laboratory, a programming package designed exclusively for logical calculations and easy and fast input / output. In reality, it includes various toolboxes tailored for particular analytical fields, hundreds of integrated functions for a wide range of calculations, statistics, optimizations, partial differential equation solutions, and analysis.

The MATLAB platform is utilised in this study to show how the implemented method is implemented or how its performance is simulated. There are built-in graphical features and measurement toolkits employed. The MATLAB routines are used to produce the simulation results and to compare the performance of the developed model with certain other models.

**Model Description**

An integrated solar system model and the supply of a non-linear load were used to build the initial model. In the first model, the voltage curve was examined in MATLAB while the inverter was modelled using a locked-in-phase loop control. Additionally, a modified active voltage regulator for the inverter was used in this study to optimise the voltage profile. To increase the installation's effectiveness and dependability, the second model was also combined with the wind turbine. In the case that the solar system is not maintained or operates improperly, this guarantees continuity. To compare the two models, the voltage profile of the system output signal has been re-analyzed.

This section discusses the modeling of the systems in following two cases:

**Output of Capacitor system having basic PLL control.**

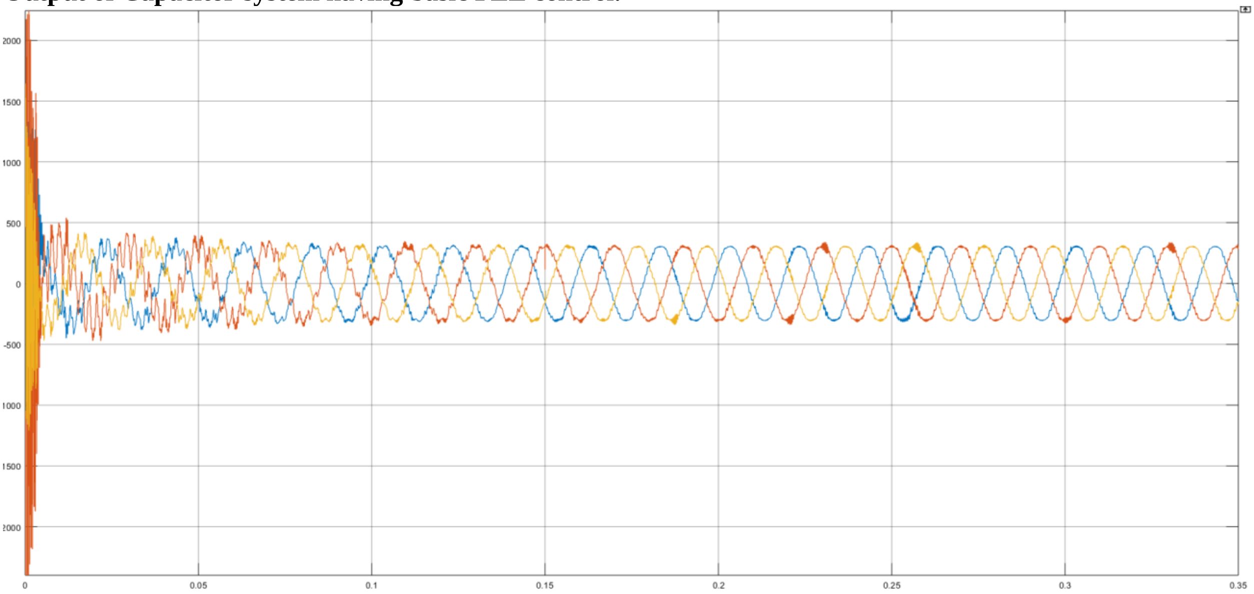

**Figure 4: Voltage Output from the Split Capacitor System**

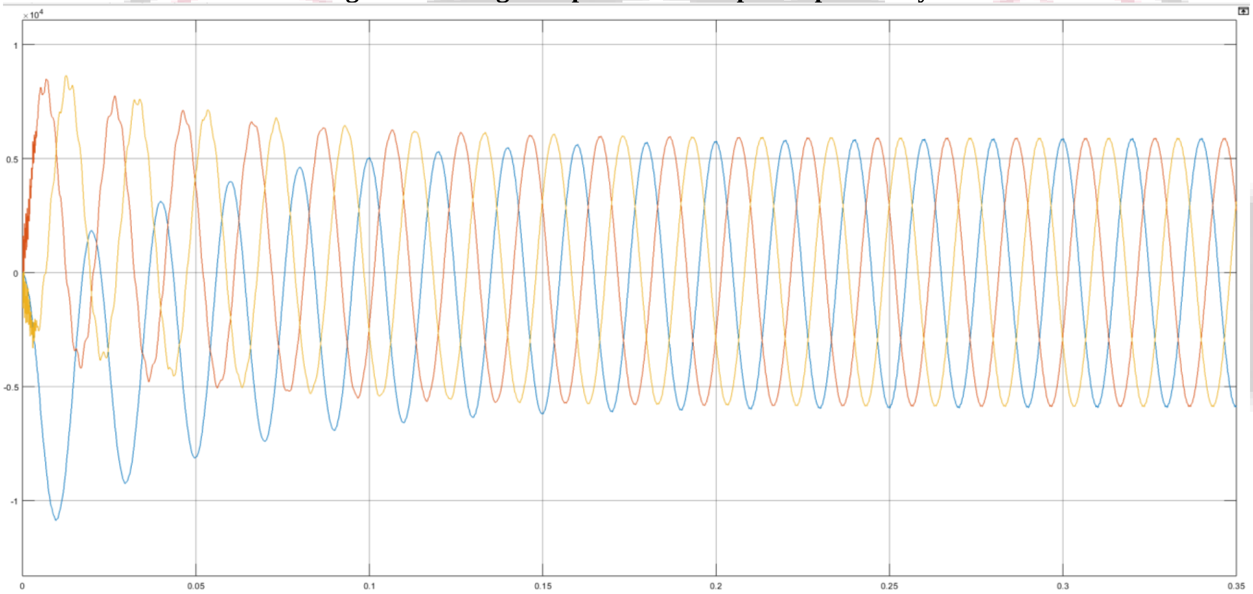

**Figure 5: Current Output from the Split Capacitor System**

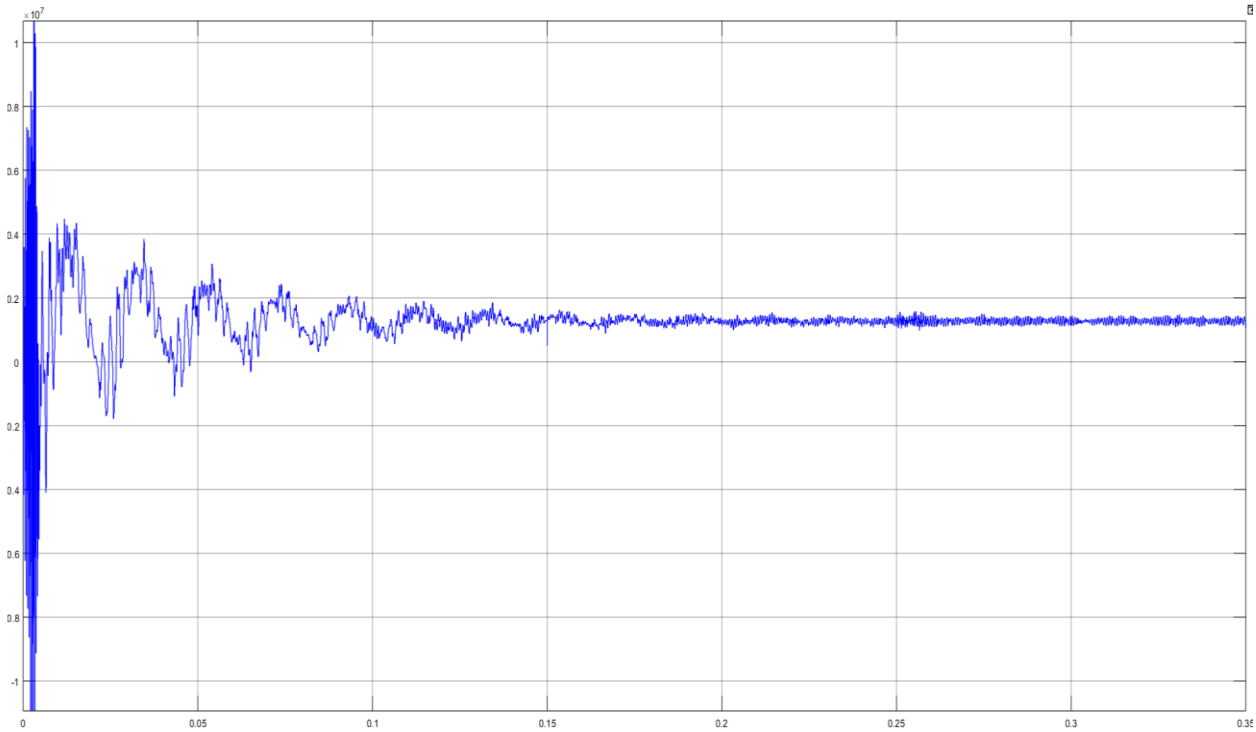

**Figure 6: Active Power output from the split capacitor system**

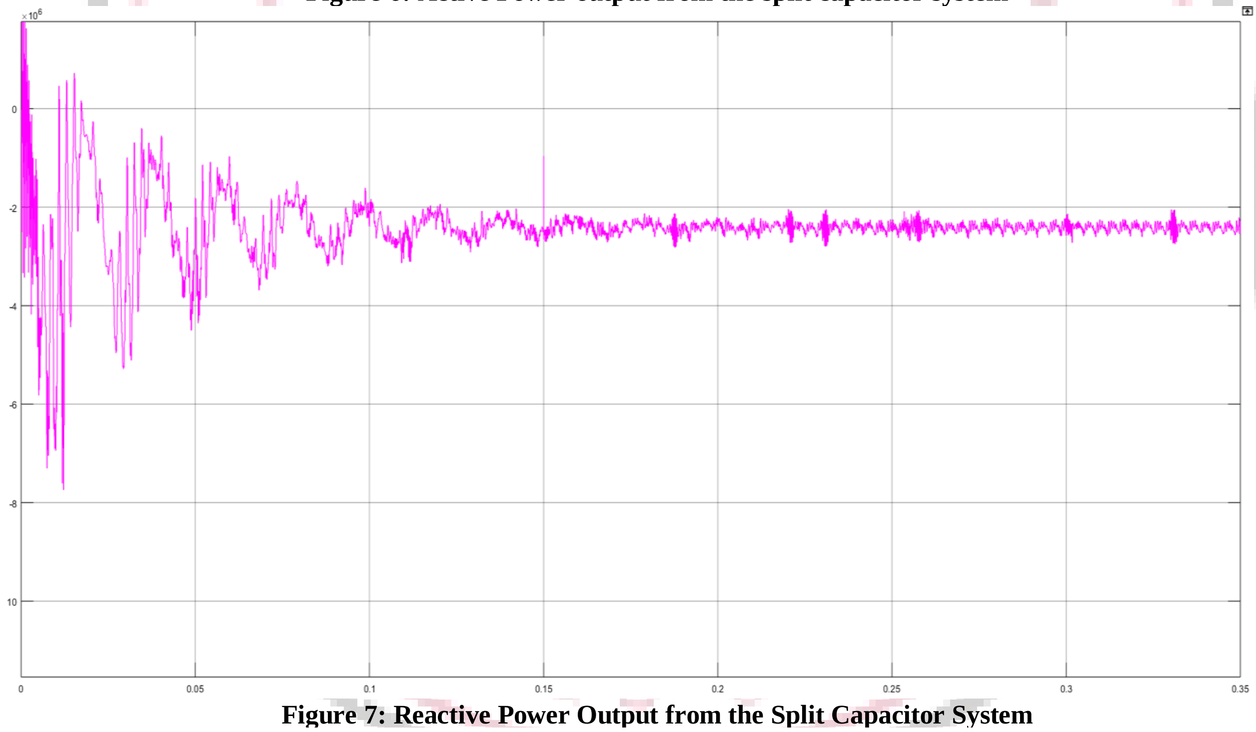

**Figure 7: Reactive Power Output from the Split Capacitor System**

The voltage output from the plate capacitor system is calculated 400 volt which is in accordance with the grid voltage. The active power output is approximately 2 megawatts.

**Output of from grid system**

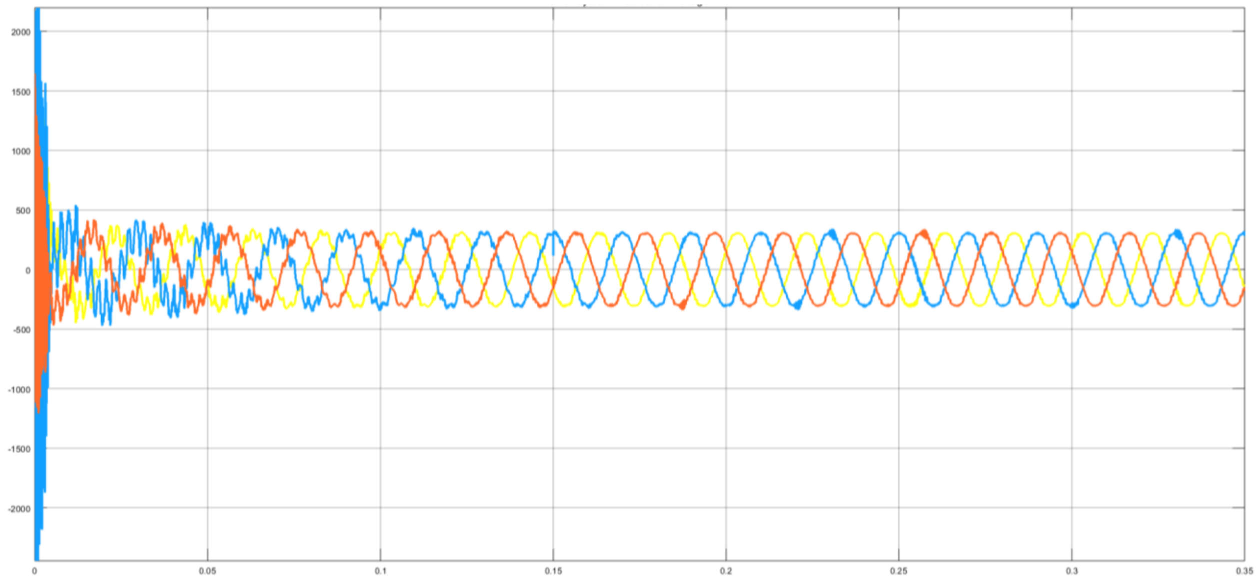

**Figure 8: Voltage Output from the Grid**

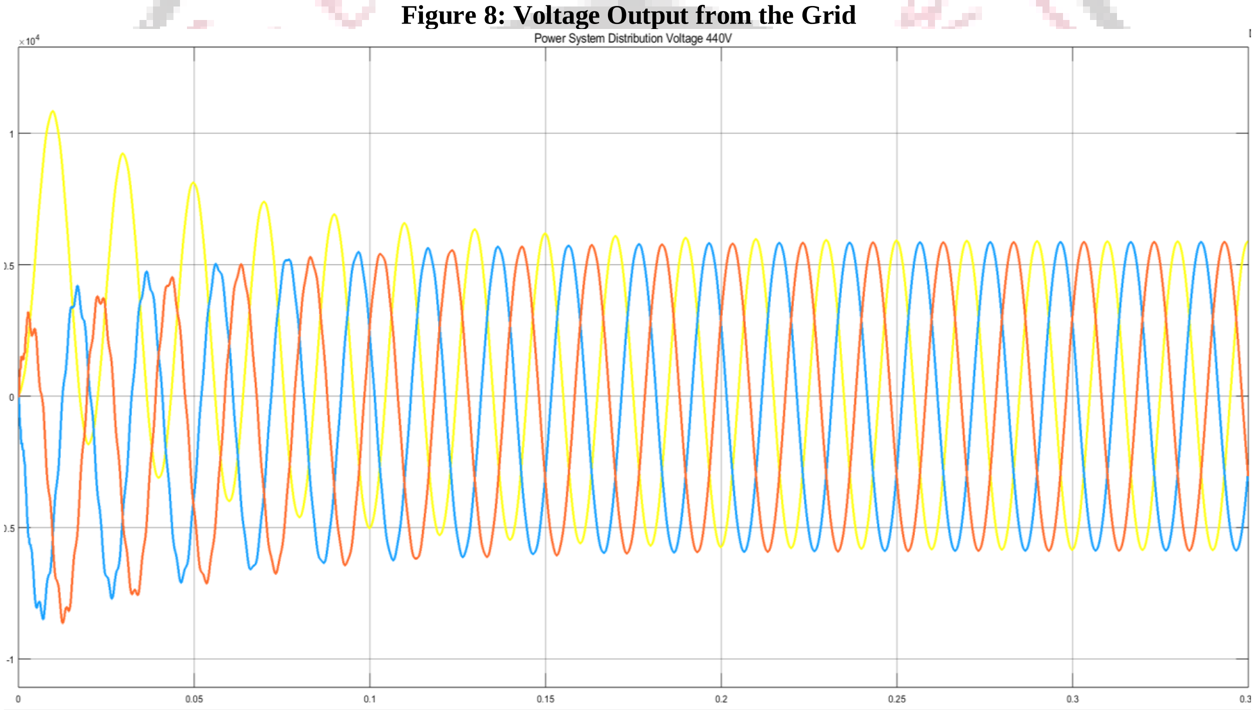


**Figure 9: Current Output from the Grid**

The voltage output from the grid system is calculated 400 volts with the current being drawn according to the load connected to the grid.

**Output of at the load terminal**

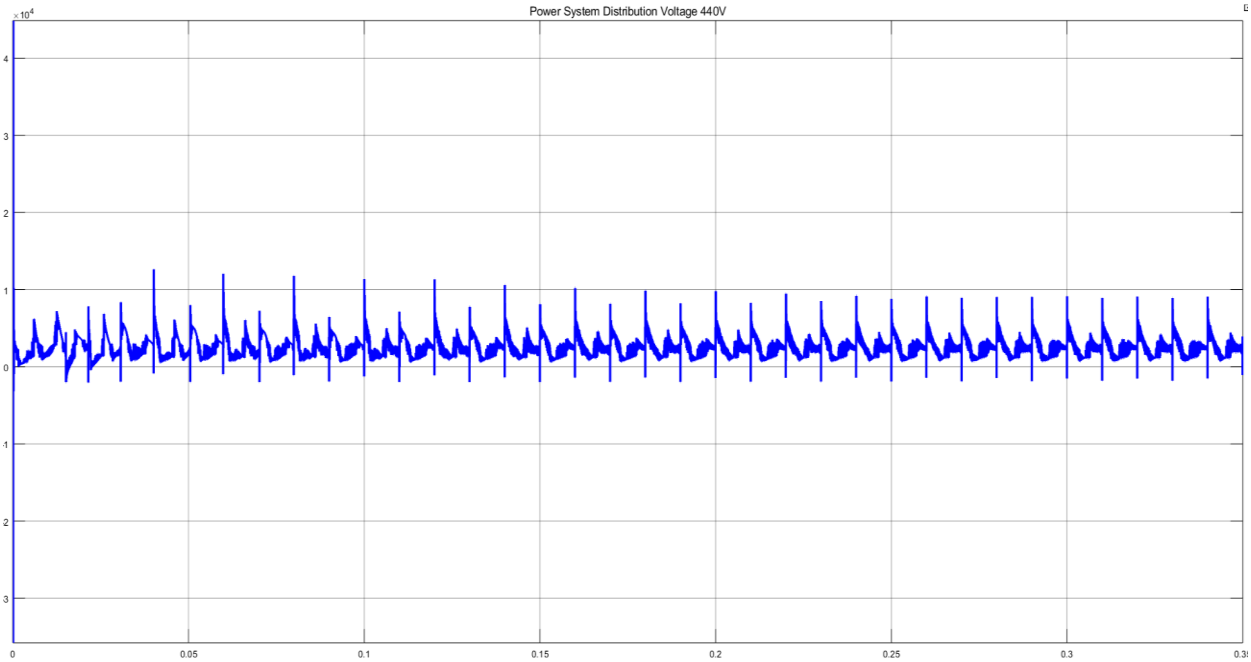


**Figure 10: Active Power Output at Load Terminal**

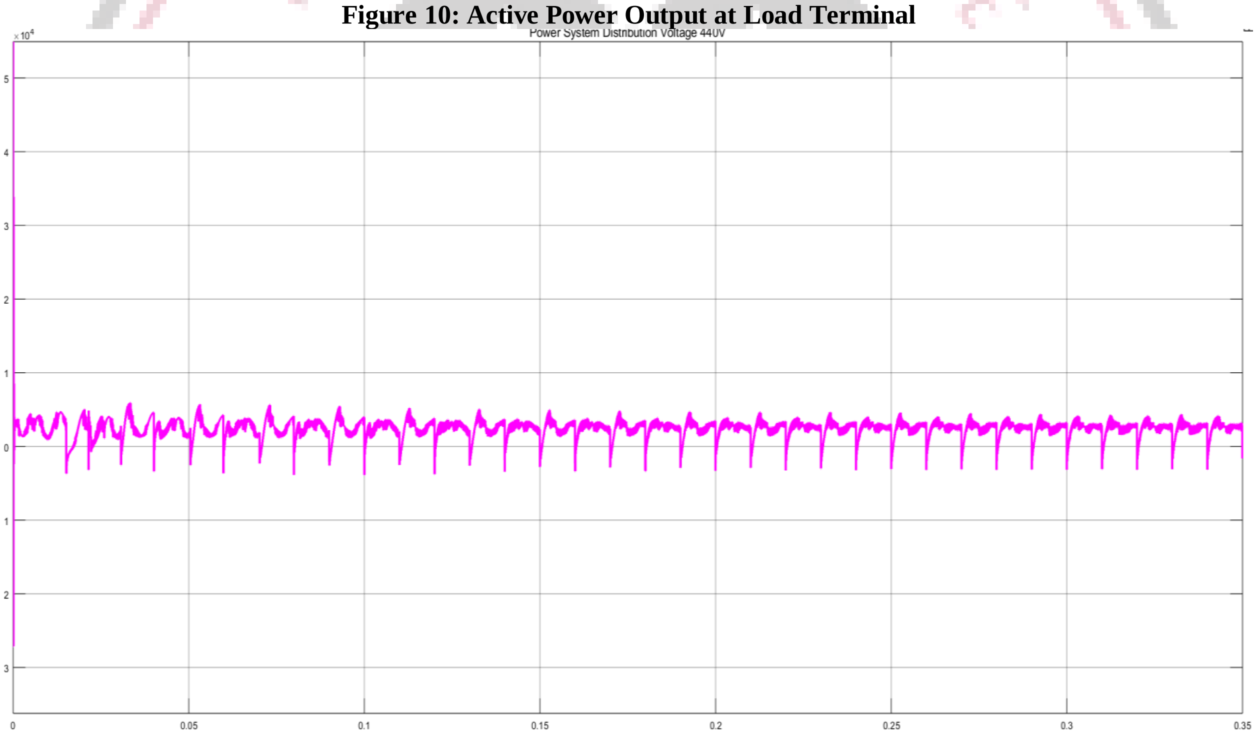


**Figure 11: Reactive Power Output at Load Terminal**

In line with the system voltage, the voltage output at the load terminal is 400 volts as well. The active power consumption ranges between 10 and 15 kilowatts. 5 KVar of reactive power is drawn.

**CASE 1: System with modified voltage optimizer active power controller disconnected from the load.**

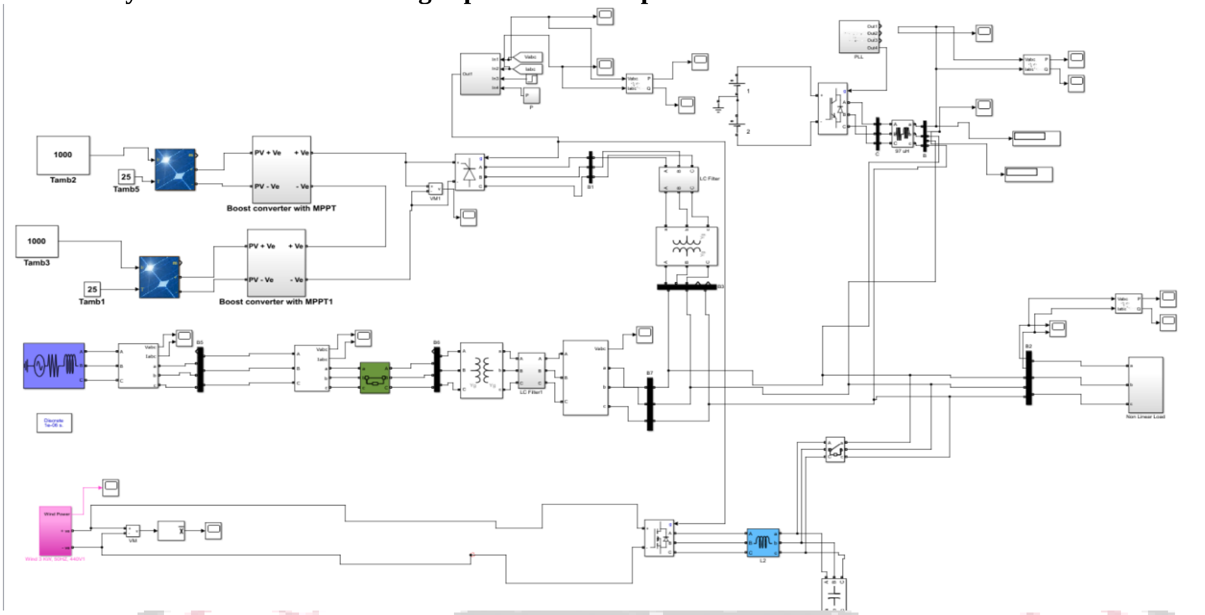


**Figure 12: MATLAB/SIMULINK model of VSI Integrated with Hybrid System with Voltage Optimizer Active Power Controller**

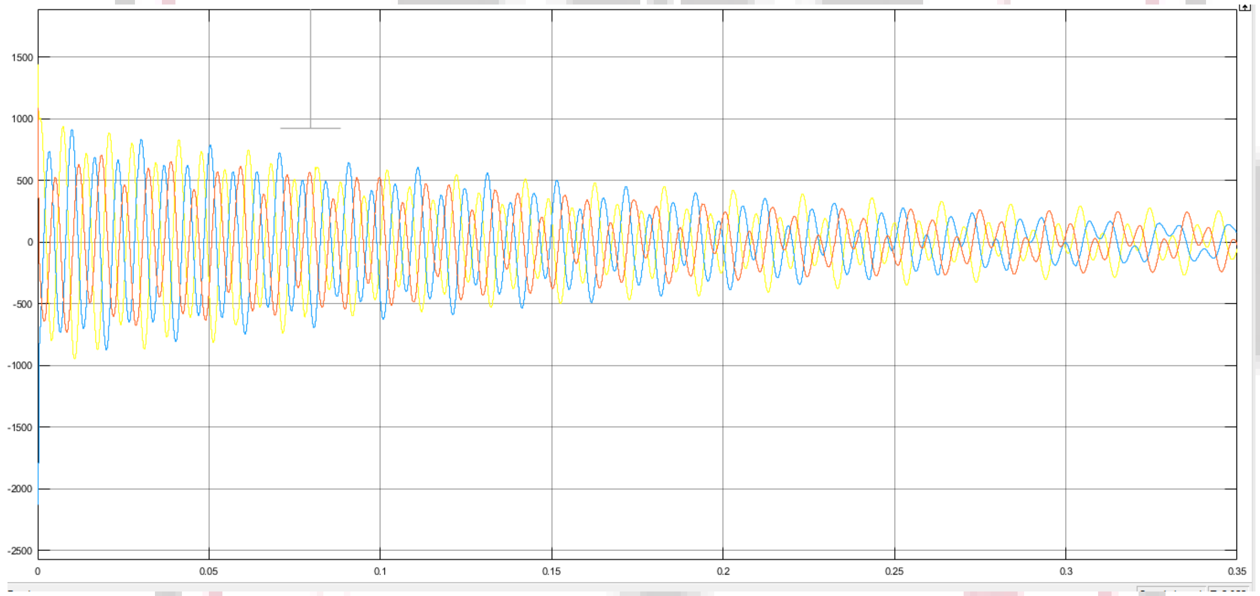


**Figure 13: Voltage output from the solar system through inverter**

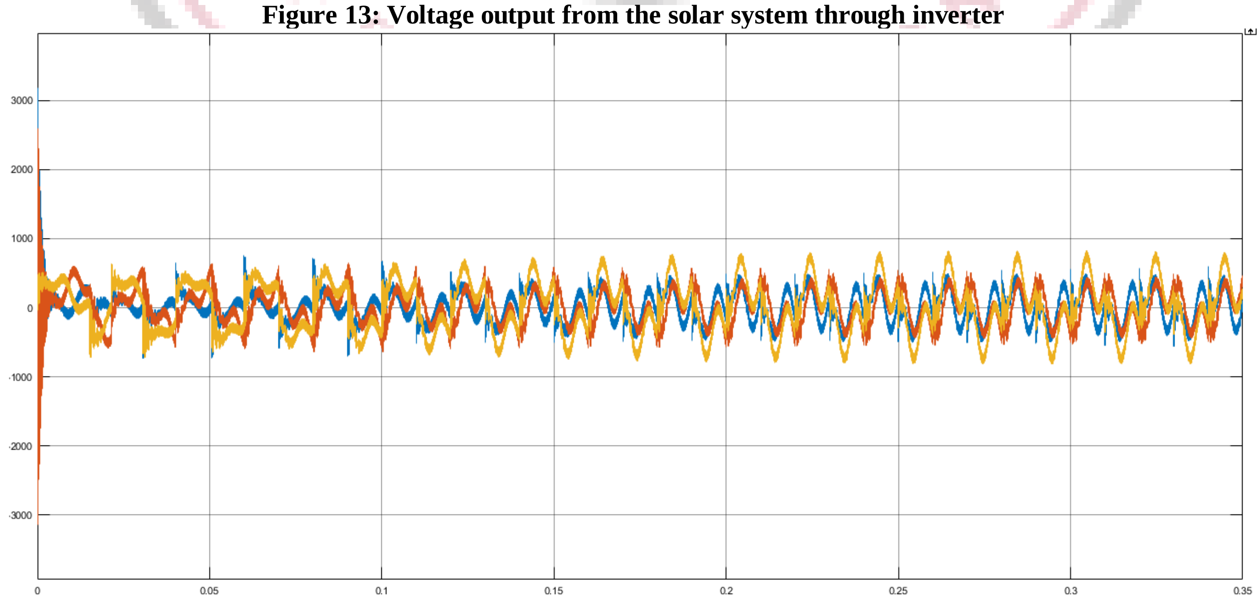


**Figure 14: Current output from the solar system through inverter**

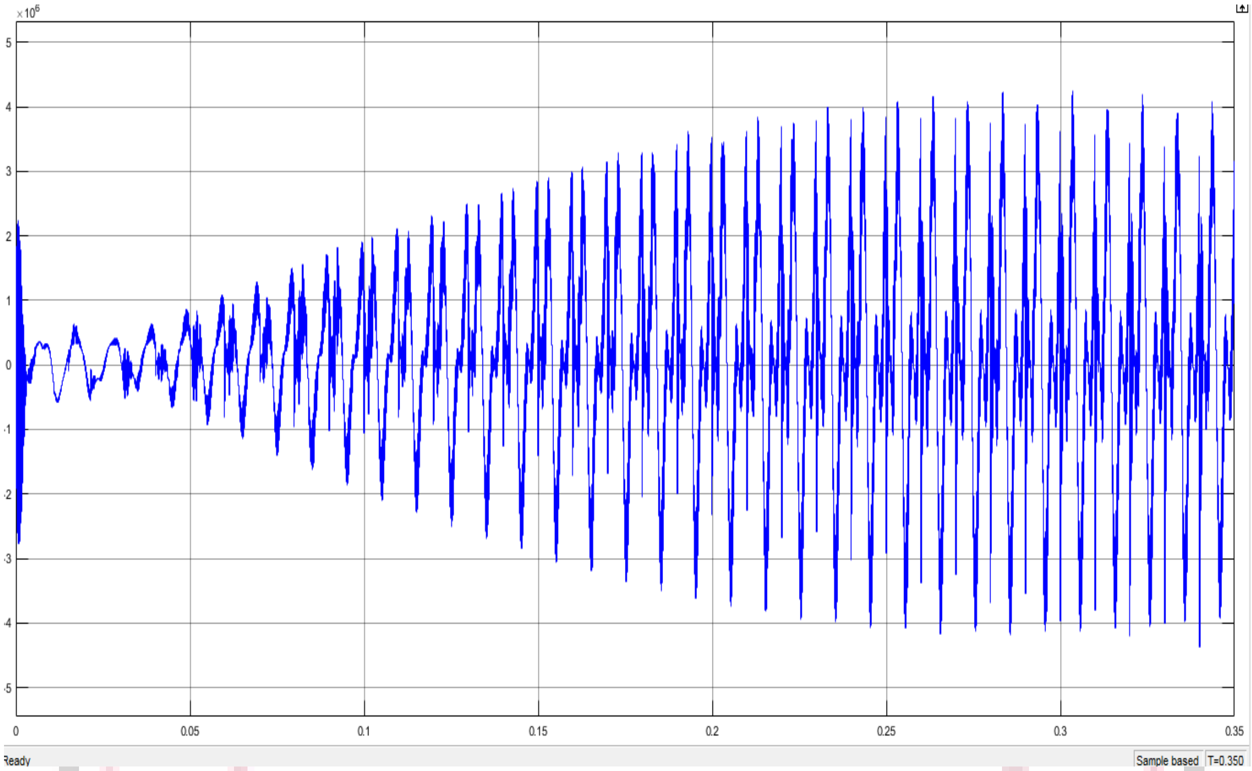


**Figure 15: Active power output from the solar system through inverter**

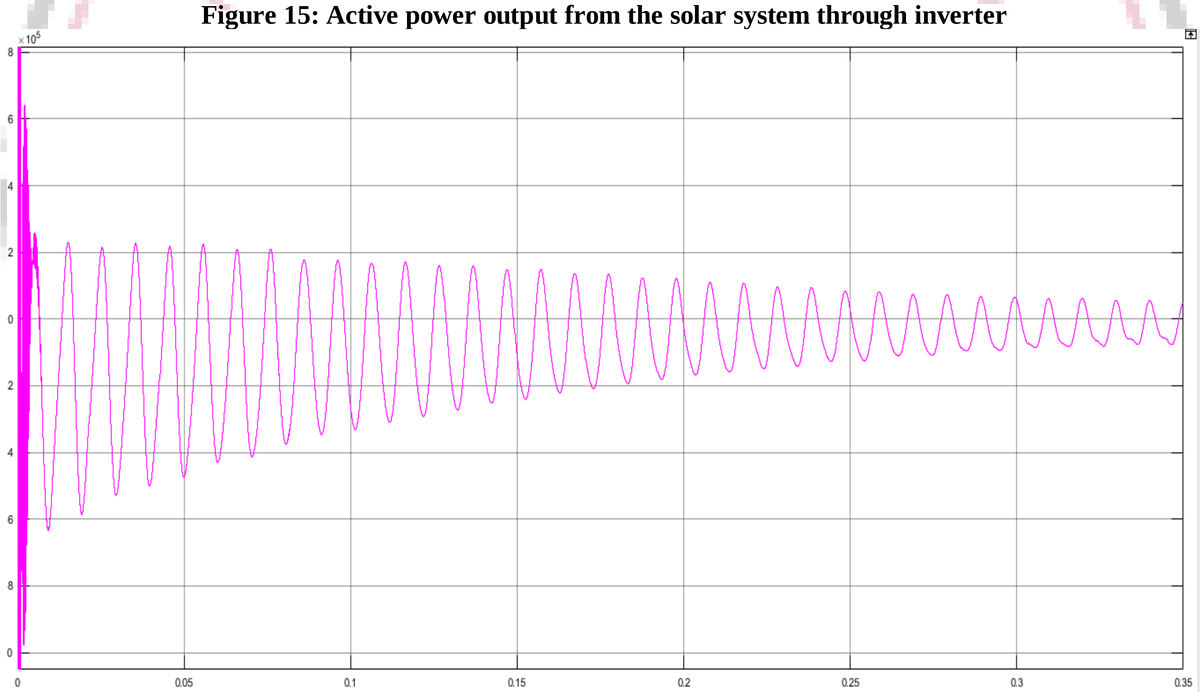


**Figure 16: Reactive power output from the solar system through inverter**

The active power output from the solar system is about 4 MW, and the voltage output is 400 volts via an inverter with a voltage optimizer active power controller.

**CASE 2: System with basic PLL control disconnected from the load**

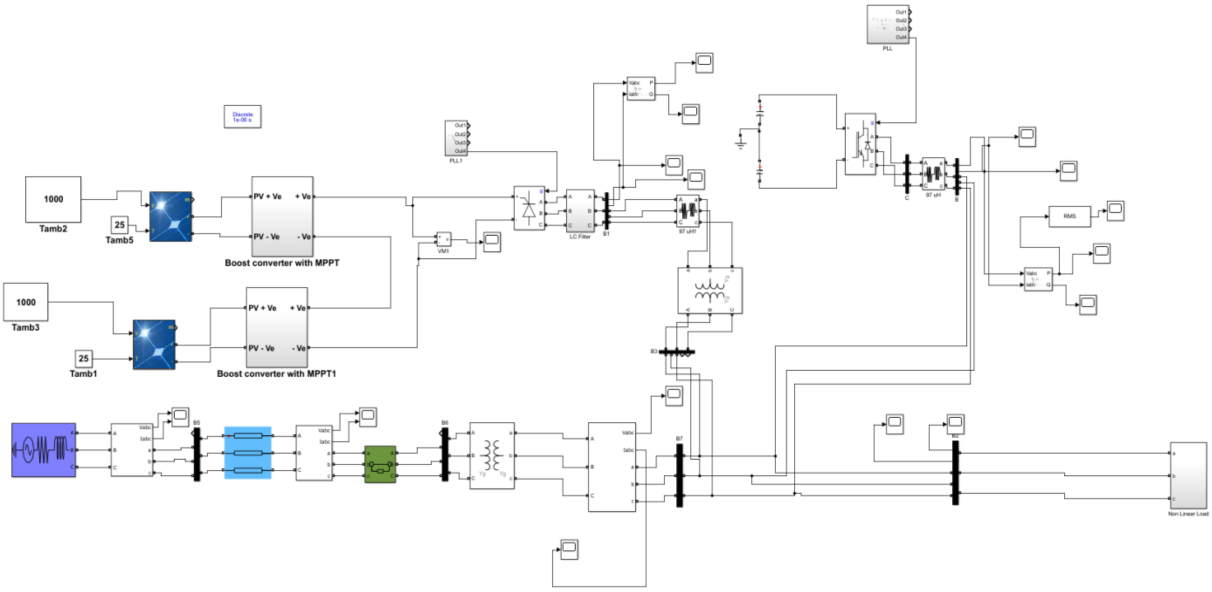


**Figure 17: MATLAB/SIMULINK model of VSI integrated with solar system with basic PLL control**

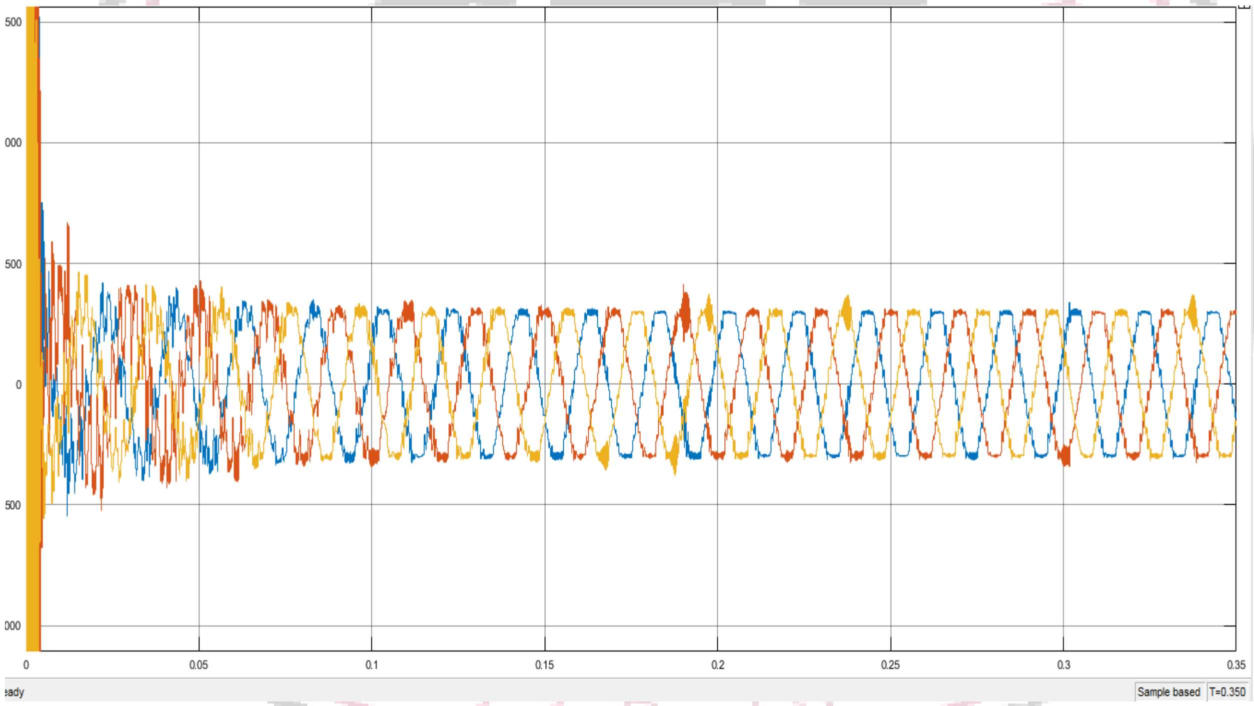

**Figure 18: Voltage output from the solar system through inverter**

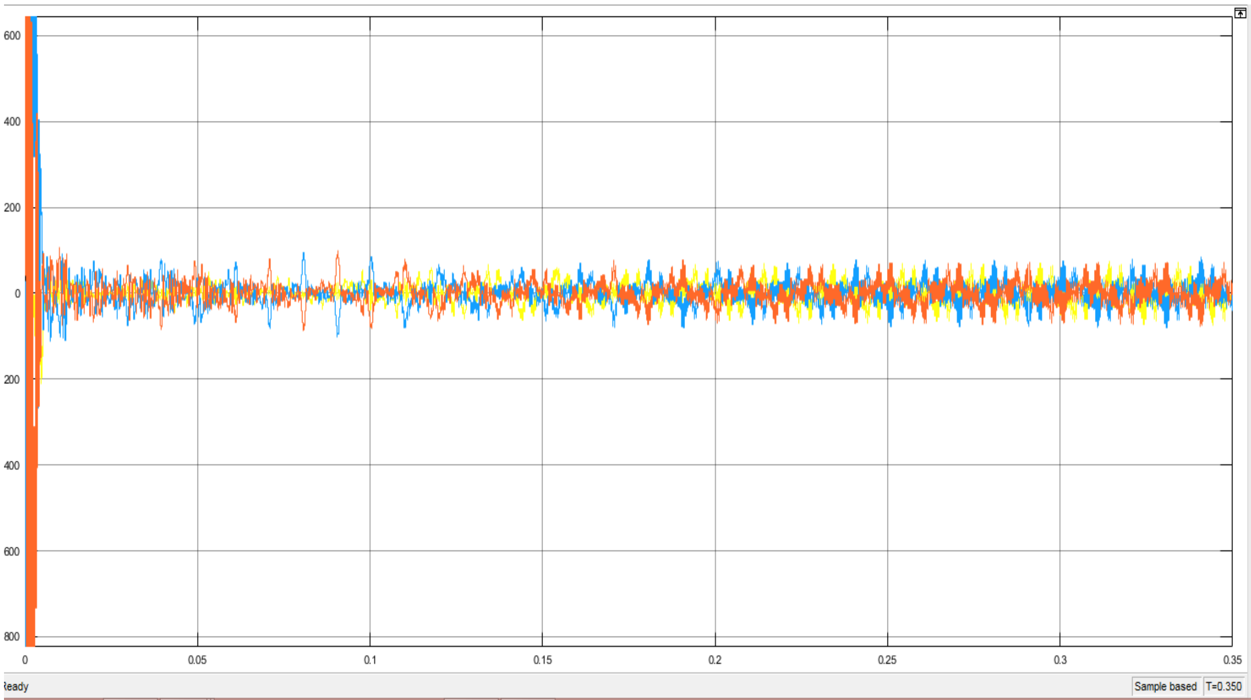


**Figure 19: Current Output from the Solar System through Inverter**

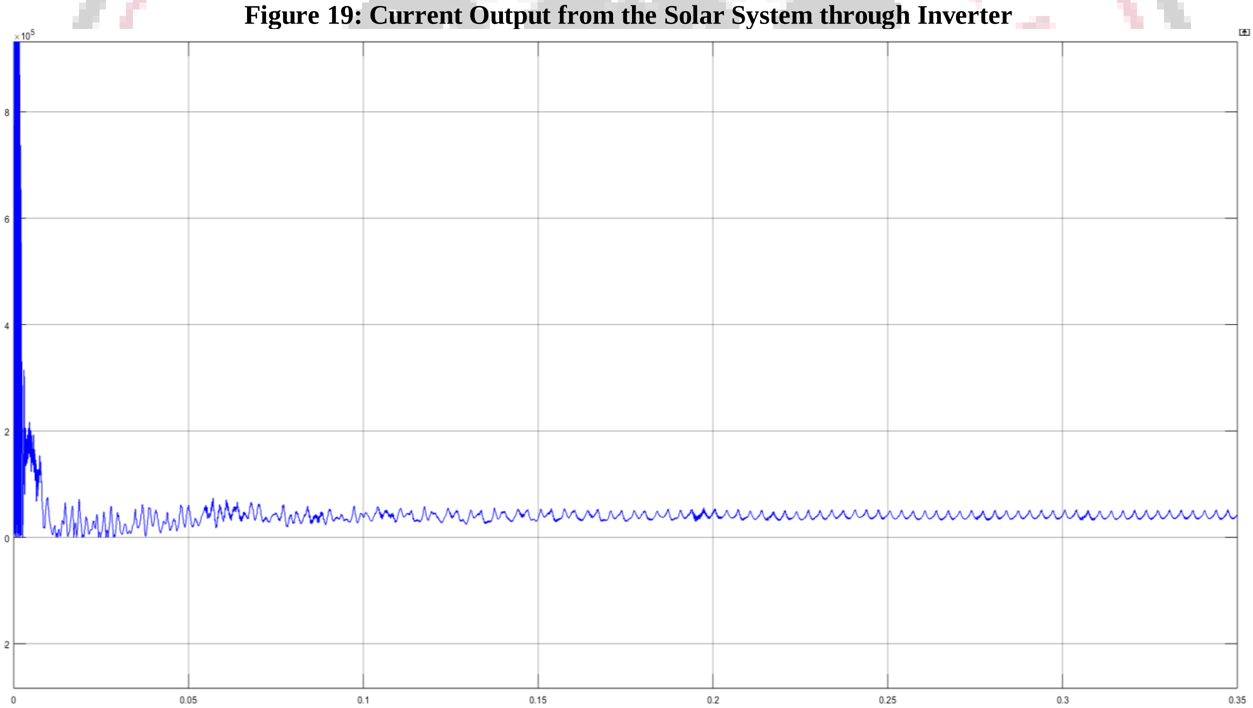


**Figure 20: Active Power output from the Solar System through Inverter**

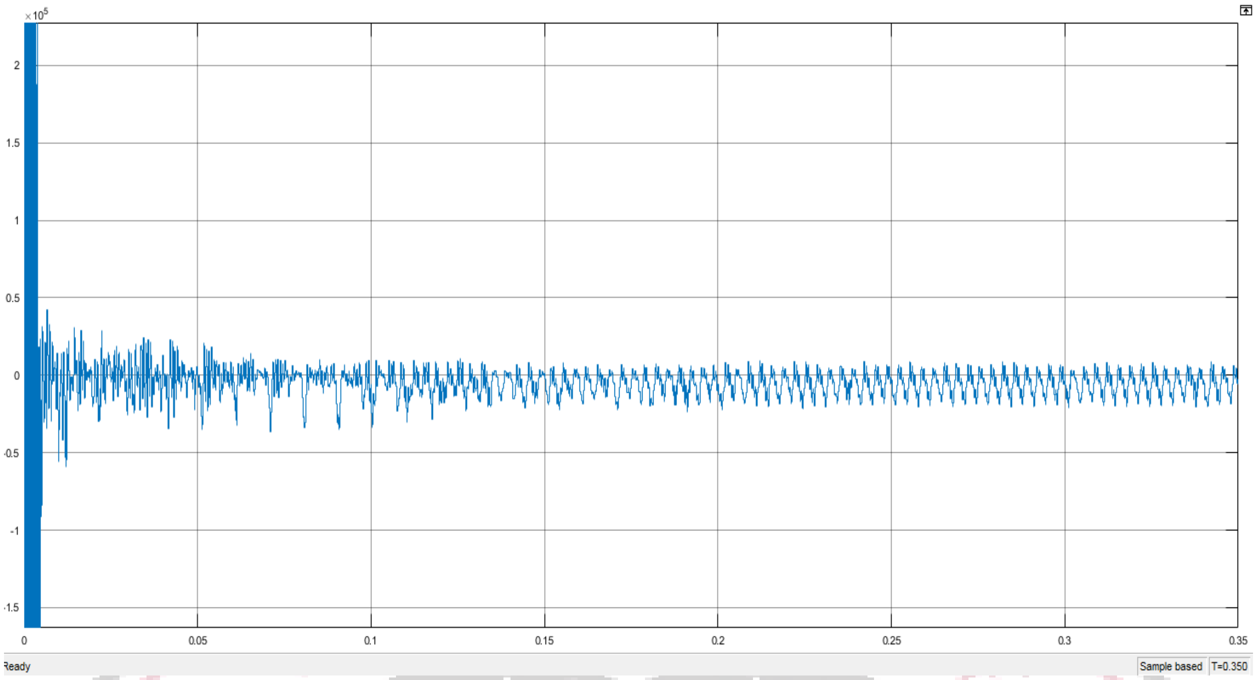

**Figure 21: Reactive Power Output from the Solar System through Inverter**

The voltage output from the solar system via inverter having PLL controller is 400 volts and active power output is approximately 0.1 MW.

## V. CONCLUSION AND FUTURE WORK

The supply of renewable energy, also known as non-conventional energy, is constantly supplied by natural processes. The best option for producing renewable energy is a hybrid system. Realistic power generation is made possible by combining solar and wind energy. Here, a converter topology that uses a controller for inverter operation is given for a dual voltage source converter with split capacitor system and solar system. Installing this hybrid solar-grid system will really be highly profitable because it would lessen reliance on the grid. On the other hand, this approach encourages green energy, which is crucial given that all energy sources are rapidly running out. It was discovered that the proposed system produces 4 MW of output, which is significantly greater than the 0.5 MW output of the system with basic PLL control, when comparing the active power outputs from the system with phase locked loop control with proposed voltage optimizer active power control.Both systems provide 400 volts of voltage as their output. Better results are obtained thanks to the proposed controller's smoothing of this voltage.In order to increase the system's dependability, the grid has been incorporated. In the event of excessive loads, power can also be supplied to the grid via a hybrid system (wind energy system). In upcoming study, a 3 phase grid integrated with nonlinear and linear loads will be constructed using an adaptive neural network-based control for improved power quality. The anticipated control strategy effectively controls system voltage and enhances power quality.

## REFERENCES


[1] M. G. Varzaneh, A. Rajaei, A. Jolfaei, and M. R. Khosravi, “A High Step-Up Dual-Source Three-Phase Inverter Topology With Decoupled and Reliable Control Algorithm,” IEEE Trans. Ind. Appl., vol. 56, no. 4, pp. 4501–4509, 2020, doi: 10.1109/TIA.2019.2956715.

[2] A. Aghazadeh, M. Davari, H. Nafisi, and F. Blaabjerg, “Grid Integration of a Dual Two-Level Voltage-Source Inverter Considering Grid Impedance and Phase-Locked Loop,” IEEE J. Emerg. Sel. Top. Power Electron., vol. 9, no. 1, pp. 401–422, 2021, doi: 10.1109/JESTPE.2019.2953522.

[3] S. S. Lee, C. S. Lim, Y. P. Siwakoti, and K.-B. Lee, “Dual-T-Type Five-Level Cascaded Multilevel Inverter With Double Voltage Boosting Gain,” IEEE Trans. Power Electron., vol. 35, no. 9, pp. 9522–9529, 2020, doi: 10.1109/TPEL.2020.2973666.

[4] S. Hasan, K. M. Muttaqi, D. Sutanto, and M. A. Rahman, “A Novel Dual Slope Delta Modulation Technique for a Current Source Inverter Based Dynamic Voltage Restorer for Mitigation of Voltage Sags,” IEEE Trans. Ind. Appl., vol. 57, no. 5, pp. 5437–5447, 2021, doi: 10.1109/TIA.2021.3089984.

[5] A. I. Gedam and K. R. Sekhar, “Minimum DC Voltage Ripple Switching Sequence Elicitation for Dual Inverter Through AC Load Error Volt-Sec Computation,” IEEE Trans. Power Electron., vol. 37, no. 12, pp. 15654–15665, 2022, doi: 10.1109/TPEL.2022.3193886.

[6] C. Gupta and V. K. Aharwal, “Optimizing the performance of Triple Input DC-DC converter in an Integrated System,” J. Integr. Sci. Technol., vol. 10, no. 3, pp. 215–220, 2022.

[7] A. Kumar and S. Jain, “Multilevel Inverter with Predictive Control for Renewable Energy Smart Grid Applications,” Int. J. Electr. Electron. Res., vol. 10, no. 3, pp. 501–507, 2022, doi: 10.37391/IJEER.100317.

[8] P. Mahapatra and C. Gupta, “Study of Optimization in Economical Parameters for Hybrid Renewable Energy System,” Res. J. Eng. Technol. …, no. 2581, pp. 39–46, 2020, [Online]. Available: http://www.rjetm.in/RJETM/Vol03_Issue02/Study of Optimization in Economical Parameters for Hybrid Renewable Energy System.pdf.

[9] A. Kumar and S. Jain, “A Review on Cascaded Multilevel Inverter with Different Levels,” pp. 134–137, 2019.

[10] A. Kumar and S. Jain, “Predictive Switching Control for Multilevel Inverter using CNN-LSTM for Voltage Regulation,” vol. 11, pp. 1–9, 2022.

[11] A. Kumar and S. Jain, “Critical Analysis on Multilevel Inverter Designs for,” vol. 14, no. 3, 2022, doi: 10.18090/samriddhi.v14i03.22.

[12] A. Kumar and S. Jain, “Enhancement of Power Quality with Increased Levels of Multi-level Inverters in Smart Grid Applications,” vol. 14, no. 4, pp. 1–5, 2022, doi: 10.18090/samriddhi.v14i04.07.

[13] C. G. Aditya Hridaya, “International Journal of Current Trends in Engineering & Technology ISSN : 2395-3152 AN OPTIMIZATION TECHNIQUE USED FOR ANALYSIS OF A HYBRID International Journal of Current Trends in Engineering & Technology ISSN : 2395-3152,” Int. J. Curr. Trends Eng. Technol., vol. 06, no. October, pp. 136–143, 2015.

[14] V. Meena and C. Gupta, “A Review of Design , Development , Control and Applications of DC − DC Converters,” no. 2581, pp. 28–33, 2018.

[15] C. Gupta, V. K. Aharwal, and M. Pradesh, “Design of Multi Input Converter Topology for Distinct Energy Sources,” vol. 14, no. 4, pp. 1–5, 2022, doi: 10.18090/samriddhi.v14i04.09.

[16] Z. Zhou, X. Li, Y. Lu, Y. Liu, G. Shen, and X. Wu, “Stability Blind-Area-Free Control Design for Microgrid-Interfaced Voltage Source Inverters Under Dual-Mode Operation,” IEEE Trans. Power Electron., vol. 35, no. 11, pp. 12555–12569, 2020, doi: 10.1109/TPEL.2020.2988565.

[17] Q. Geng, Z. Li, M. Zhang, Z. Zhou, H. Wang, and T. Shi, “Sensorless Control Method for Dual Permanent Magnet Synchronous Motors Driven by Five-Leg Voltage Source Inverter,” IEEE J. Emerg. Sel. Top. Power Electron., vol. 10, no. 1, pp. 260–272, 2022, doi: 10.1109/JESTPE.2021.3096198.

[18] F. Akbar, H. Cha, H. F. Ahmed, and A. A. Khan, “A Family of Single-Stage High-Gain Dual-Buck Split-Source Inverters,” IEEE J. Emerg. Sel. Top. Power Electron., vol. 8, no. 2, pp. 1701–1713, 2020, doi: 10.1109/JESTPE.2019.2894384.