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# Single Phase Grid Tie Inverter for Reactive Power Control

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**ABSTRACT:** The focus of this work is on the control of the reactive power in single phase inverters, particularly unfolding inverters. This system has the advantages of unfolded inverters, such as decreased material, semiconductor, and reactive power injection losses. The goal is to change the shape of the waveform of the grid current while maintaining the identical zero crossing points as in a unity power outage. When the allowable deformation is attained, the current's waveform is dictated by the actual and reactive power. It's worth noting that, according to the recently released standards, reactive power supply is required for PV inverters. The idea is to change the contour of the grid waveform while preserving the same zero crossing points when the power factor is unity. Real and reactive power determine the current waveform, at the cost of tolerable deformation. The report describes the operational principles as well as the simulation results for the grid current function.

## I. INTRODUCTION

The focus of this work is on the control of the reactive power in single phase inverters, particularly unfolding inverters. This system has the advantages of unfolded inverters, such as decreased material, semiconductor, and reactive power injection losses. The goal is to change the shape of the waveform of the grid current while maintaining the identical zero crossing points as in a unity power outage. When the allowable deformation is attained, the current's waveform is dictated by the actual and reactive power. It's worth noting that, according to the recently released standards, reactive power supply is required for PV inverters. The idea is to change the contour of the grid waveform while preserving the same zero crossing points when the power factor is unity. Real and reactive power determine the current waveform, at the cost of tolerable deformation. The report describes the operational principles as well as the simulation results for the grid current function.

## II. NECESSITY OF MAXIMUM POWER POINT TRACKING

Generally the solar module's total efficiency is quite poor and it is around 13%. As a result, it is vital to run it at the crest power point in order to give the greatest power to the load regardless of constantly changing external circumstances. Because of the increased power, the solar PV module may be used more effectively. A DC/DC converter adjacent to the PV module harvests maximum power by matching the circuit's impedance to the PV module's impedance and transferring it to the load [12]. The fundamental goal of MPPT is to obtain the greatest power out of a PV module by operating it at the highest achievable voltage. MPPT looks at the PV module's output and compare it to voltage in the battery and thereby determines the maximum power about which the PV module can supply to charge the battery. It then converts that power to the best voltage to get the greatest current into the battery. It can also power a DC load that is connected directly to the battery.

## III. FUZZY LOGIC CONTROLLER

Fuzzy logic has quickly risen to the top of the list of today's most successful technologies for creating complex control systems. The quantity and variety of applications of fuzzy logic have increased dramatically during the last few years. Many decision-making and problem-solving activities are too complicated to be understood numerically, but humans achieve by employing imperfect information rather than accurate knowledge.

Rather of using mathematical equations, fuzzy logic articulated operational laws in verbal terms. Several systems are too complicated to correctly represent, even with advanced mathematical equations, making traditional techniques ineffective. The fuzzy logic's linguistic concepts offer a viable technique for specifying the system's



operational features. It is a type of symbolic controller. The three main components of the fuzzy controller are fuzzification, fuzzy inference, defuzzification.

**Fuzzification**

- Several measured inputs must initially be translated into a fuzzy membership function, which is referred to as fuzzification.
- Accomplishes a scale mapping, which converts the collection of input variable values into appropriate discourse universes.
- Performs the fuzzification task, which turns input records into linguistic values which will be used as labels for fuzzy sets.

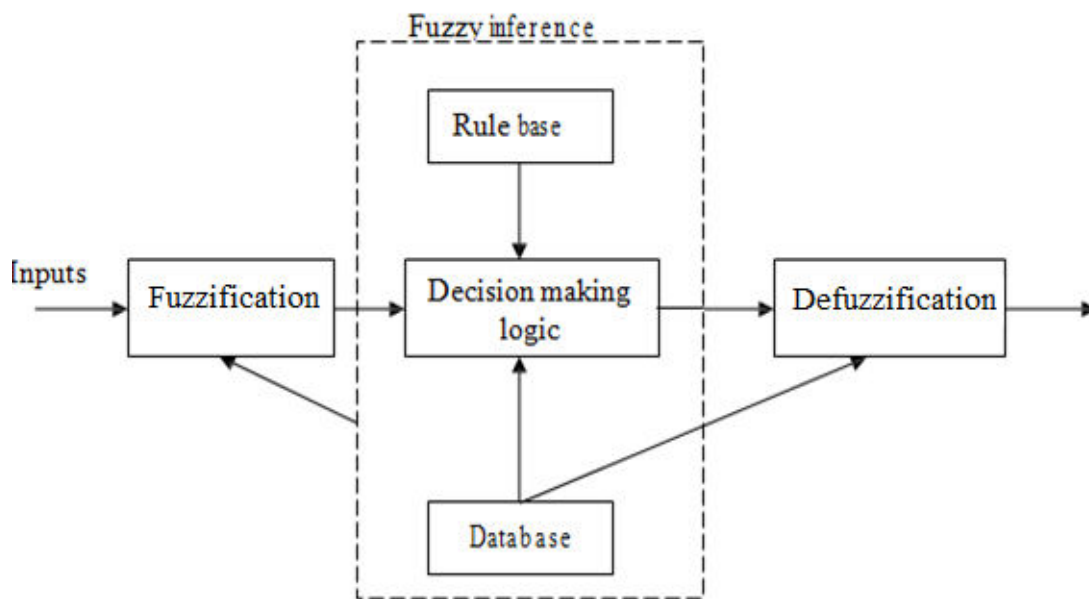


Fig. 1 Fuzzy logic control

Logic implication, such as if-then rules, is frequently used to represent fuzzy logic in language terms. Fuzzy membership functions are defined by these principles as a set of values. The fuzzy membership function can be triangular, trapezoidal, bell-shaped, or any other acceptable shape. The fuzzy controller's inputs are stated at different linguist levels.

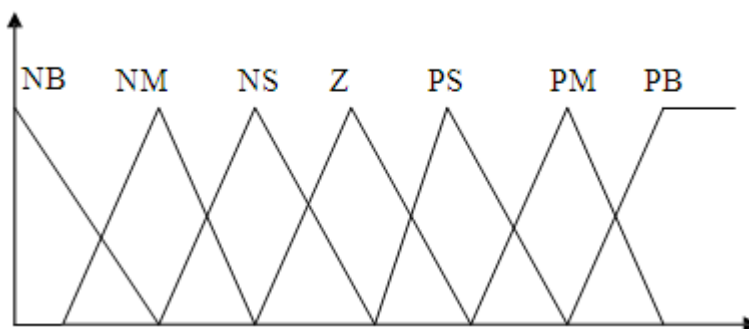


Fig. 2 Membership function



**Fuzzy inference**

Fuzzy inference is the process of applying fuzzy logic to produce a mapping from a given input to an output. The mapping can then be used to make decisions or spot trends. Mamdani-type and Sugeno-type fuzzy inference systems are supported by the Fuzzy Logic Toolbox. The results of these two types of inference systems varied slightly. The fuzzy controller's second phase is fuzzy inference, which contains both the knowledge base and decision-making logic. The rule and data bases of the knowledge base in the database, the input and output variables is described.

**Defuzzification**

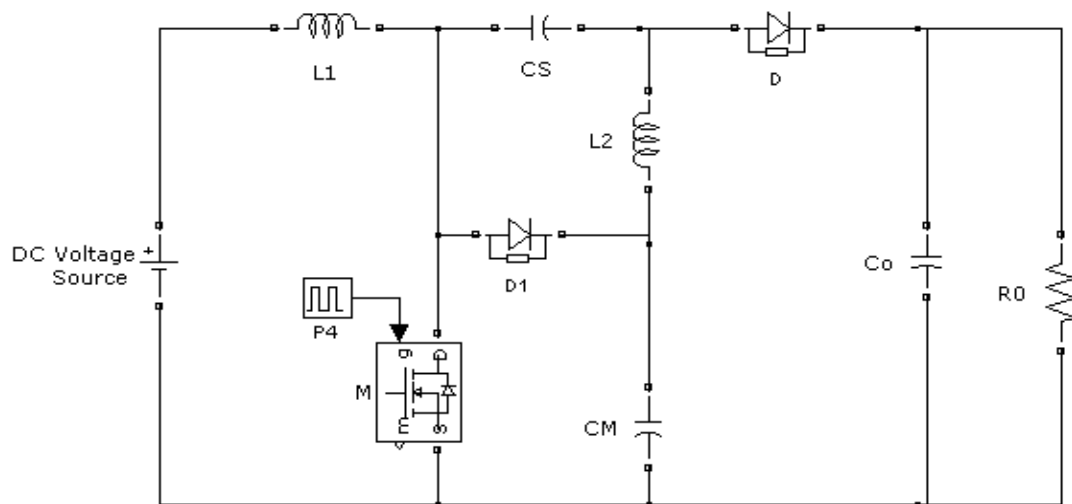
The fuzzy output variables are the inference output mechanism. So that the real system may use these variables, the fuzzy logic controller must transform its internal fuzzy output variables into crisp values. This task can be accomplished in a variety of ways. The max criterion approach, height method, centroid method and center of area method are all regularly used control defuzzification procedures.

**IV. LUO CONVERTER**

The control transistor's duty cycle regulates the LUO's output, enabling output voltage to be larger, less, or equal to that at its input. LUOs are beneficial in situations when the battery voltage is both above and below the regulator's specified output voltage. Fig. 3 depicts the power circuit of a traditional LUO converter. For applications with a large input voltage range, the LUO converter's step-up and step-down static gain is an intriguing operation characteristic. This configuration is not utilized for a universal input HPF rectifier since the switch voltage equals the sum of the input and output voltages. The LUO converter is used to adjust the voltage multiplier approach. With the insertion of the diode  $D_m$  and the capacitor  $C_m$ , the LUO converter is modified.

The suggested improvement changes a number of operating aspects of the traditional LUO converter. The capacitor  $C_m$  receives the output voltage of the typical boost converter. As a result, during the conduction of the power switch (S), the voltage provided to the  $L_2$  inductor is higher than in a standard LUO, resulting in a higher static gain. The converter proposed inverts the polarity of the voltage stored in the capacitor  $C_s$  and the theoretical analysis presents equations for the capacitor voltages and other operation parameters.

The energy stored in the input inductor  $L_1$  is sent to the output via the  $C_s$  capacitor and output diode  $D_o$ , as well as to the  $C_m$  capacitor via the diode  $D_m$ , when switch S is turned off at time  $t_1$ . As a result, the switch voltage is the same as the  $C_m$  capacitor voltage. The energy stored in the inductor  $L_2$  is supplied to the output via the diode.



In the second phase, the input voltage is delivered to  $L_1$ , and the voltage  $V_{cs}-V_{cm}$  is applied to  $L_2$ .  $V_{cm}$  is more than  $V_{cs}$ . The  $C_m$  capacitor voltage is equal to the voltage in all diodes and the power switch. The sum of the  $C_s$



and  $C_m$  capacitors' voltages is the output voltage. The input current is equal to the average current in  $L1$  inductor and the output current is equal to the average  $L2$  inductor current.

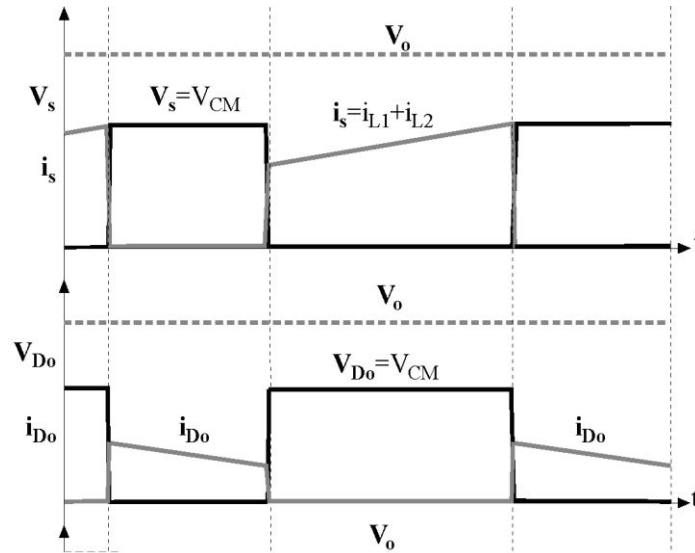


Fig. 4 Input waveforms

This session covers the key equations and theoretical analysis of the proposed converter. The theoretical analysis' findings are contrasted to those of a traditional boost converter to demonstrate the suggested converter's benefits and drawbacks. Because the suggested topology is derived from this converter, a comparison with the classical LUO converter is also made. The inductances and capacitances of this converter are determined using the equations provided by the theoretical analysis. LUO converter is used in this work since the voltage may be stepped up and down.

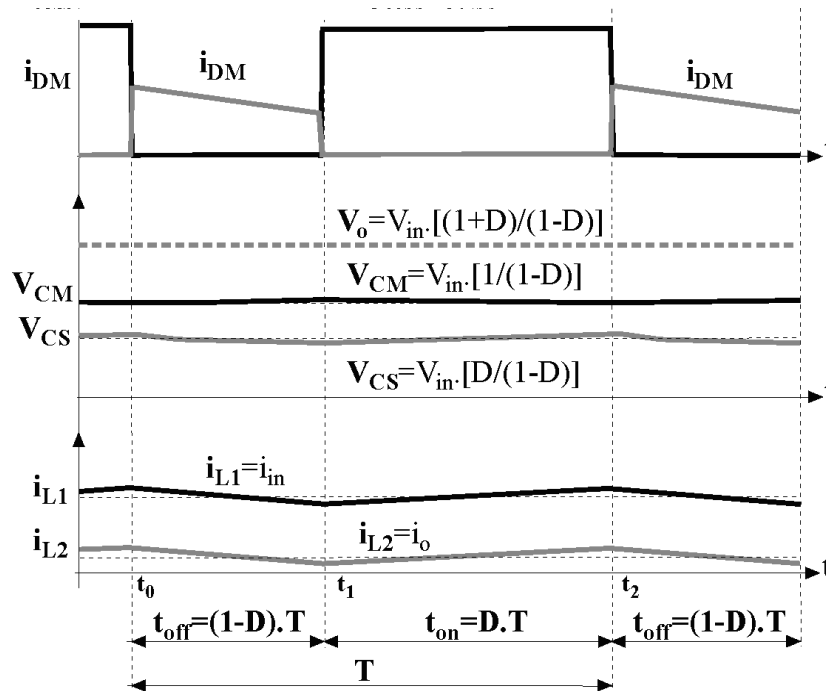


Fig 5 Output waveform



**Operation**

LUO converter receives the voltage from the solar panels. The LUO converter allows you to modify a wide variety of DC voltages while maintaining a consistent voltage output. Dc-dc converters work by rapidly turning an IGBT on and off, usually with a high frequency pulse. When the output is too low, the feedback loop in the controller must capable of increasing the duty cycle to increase it, and reduce it when the output is high. In order to accomplish so, the output must be compared to a constant reference voltage regardless of the input. The difference in voltage between the output and the reference voltage is amplified and added to a bias voltage.

The amplified error grows when the output is too low, causing the control voltage to rise. The duty cycle increases when the control voltage is increased until the output is right. A DC-DC converter's output voltage is fed into the inverter's input. When using the Sinusoidal Pulse width Modulation (SPWM) approach, the output voltage of an inverter might be greater or lower than the input voltage, depending on the modulation index. When the output is too low, the duty cycle of the PI controller feedback loop is increased, and when the output is too high, it should be decreased.

To do so, the output must be compared to a constant reference voltage that does not vary while the input varies. The difference between the reference and output voltages is then amplified and added to the bias voltage. The output voltage is then utilized as the SPWM control voltage. The amplified error grows when the output is too low, causing the control voltage to rise. The duty cycle increases when the control voltage is increased until the output is right. For reactive power correction, the inverter output is directly linked to the stand-alone load without the use of a transformer. A measurement block measures the active and reactive power of the load, and the measurement block output is sent to the PI controller.

A PI controller's goal is to reduce the error associated with the carrier signal utilized to create the inverter's pulse. In this system, the major goal of the inverter is to create an AC output current that is equal to and in phase with the reference current. The PV grid-connected system converts PV electricity to line power. A closed loop control is achieved by using a PI controller. The voltage and current obtained from the grid are the PI controller's inputs. A PI controller is used to regulate the inverter gate pulse. The output voltage of the inverter is directly linked to the load and a smooth sinusoidal voltage is obtained using a smooth reactor. These voltages are linked to the load directly.

**V. RESULTS&DISCUSSION**

The proposed system is developed using MATLAB environment. The goal of this control technique is to inject reactive power while keeping total harmonic distortion to a minimum. Many phase control applications employ the property of sinusoids, which results in a quasi-sinusoidal resonant edge. The suggested control strategy aims to maintain the same grid current and voltage zero crossing points while changing the first-order component of grid current to transfer reactive power. Fig. 6 and Fig. 7 shows the MATLAB simulation circuit of the system.

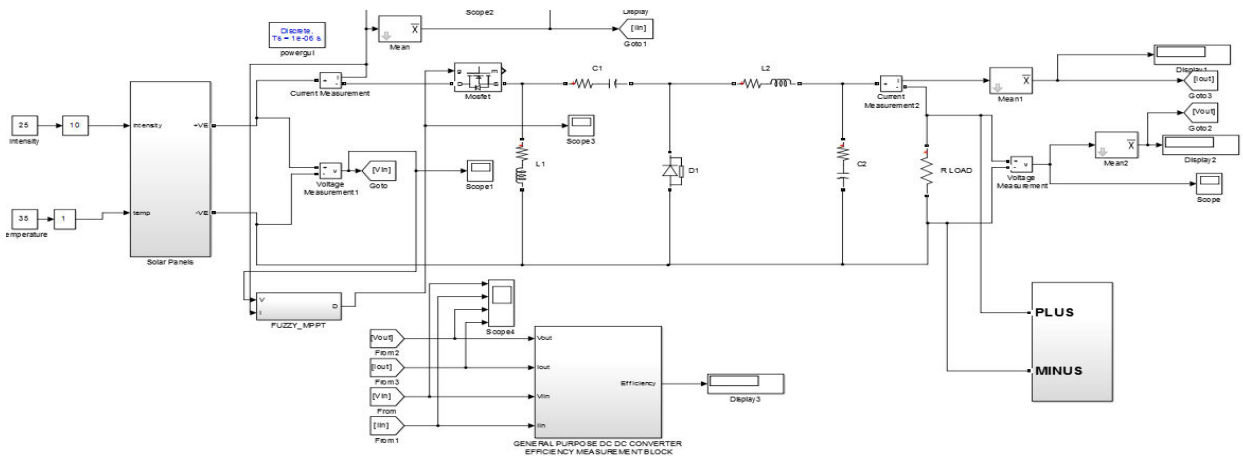


Fig.6 Circuit including Solar panel, Fuzzy controller and LUO Converter

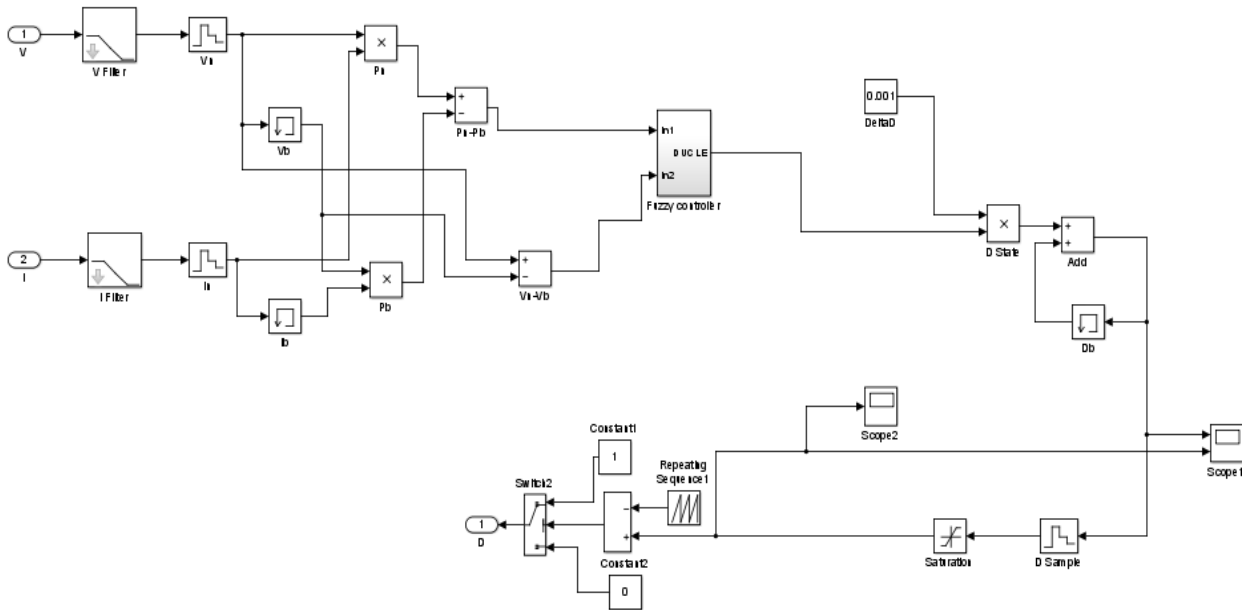


Fig .7 Matlab simulation circuit

The idea is to change the shape of the grid current waveform while retaining the same zero crossing points as when the power factor is at unity. At the cost of allowable deformation, the current waveform is determined by real and reactive power. The grid voltage and current waveforms is shown in

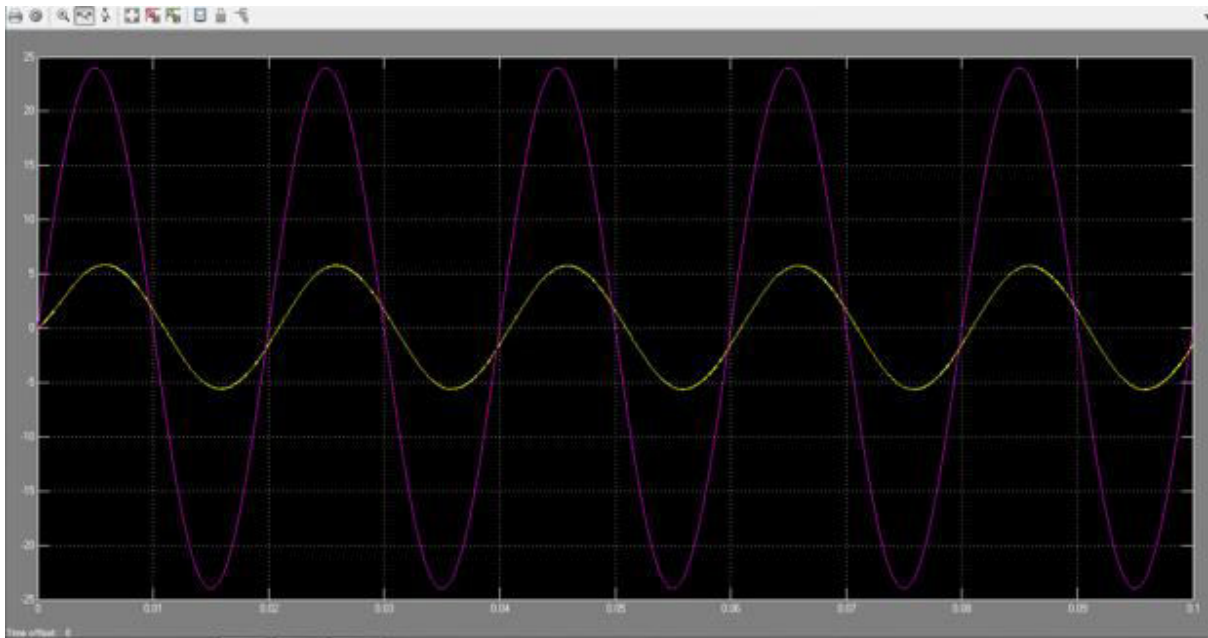


Fig.8 Grid voltage and current waveforms

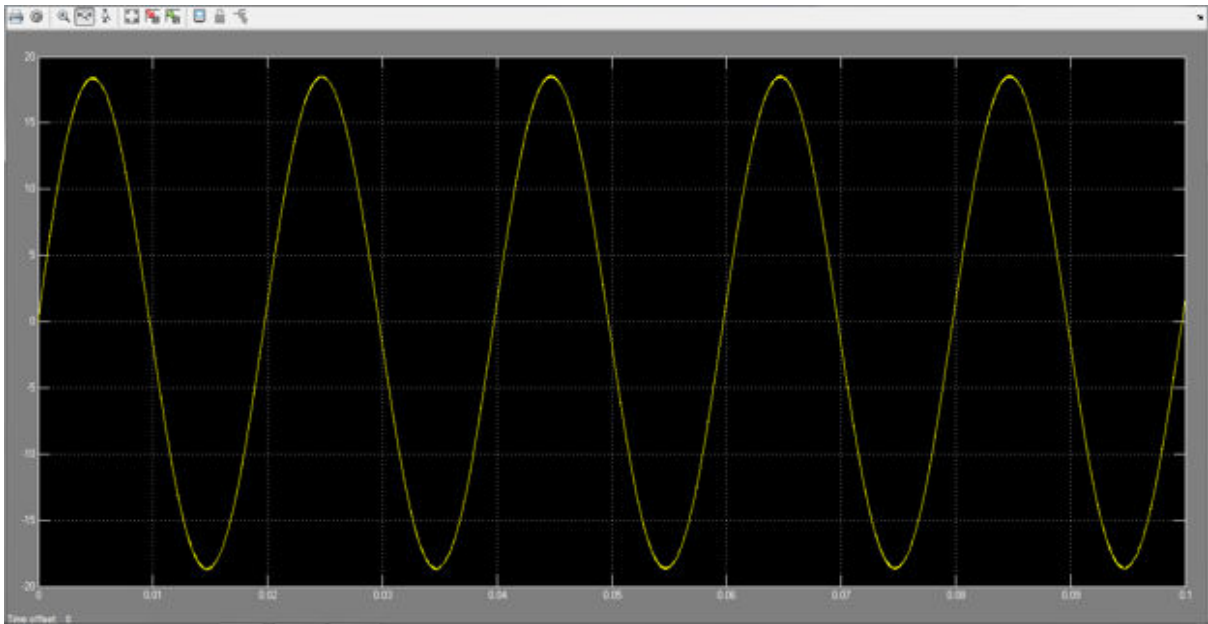


Fig.9 Inverter output voltage waveforms

The inverter output voltage and reference signal waveforms are shown in Fig. 9 and Fig. 10 respectively.

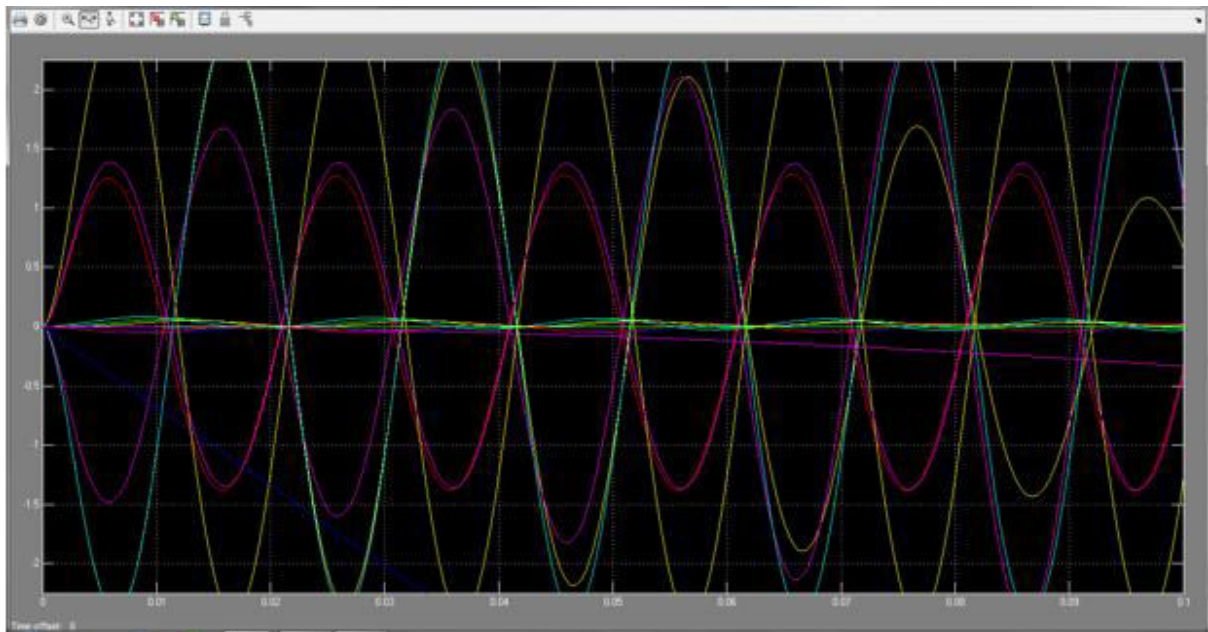


Fig.10 Reference signal waveforms

### VI. CONCLUSION

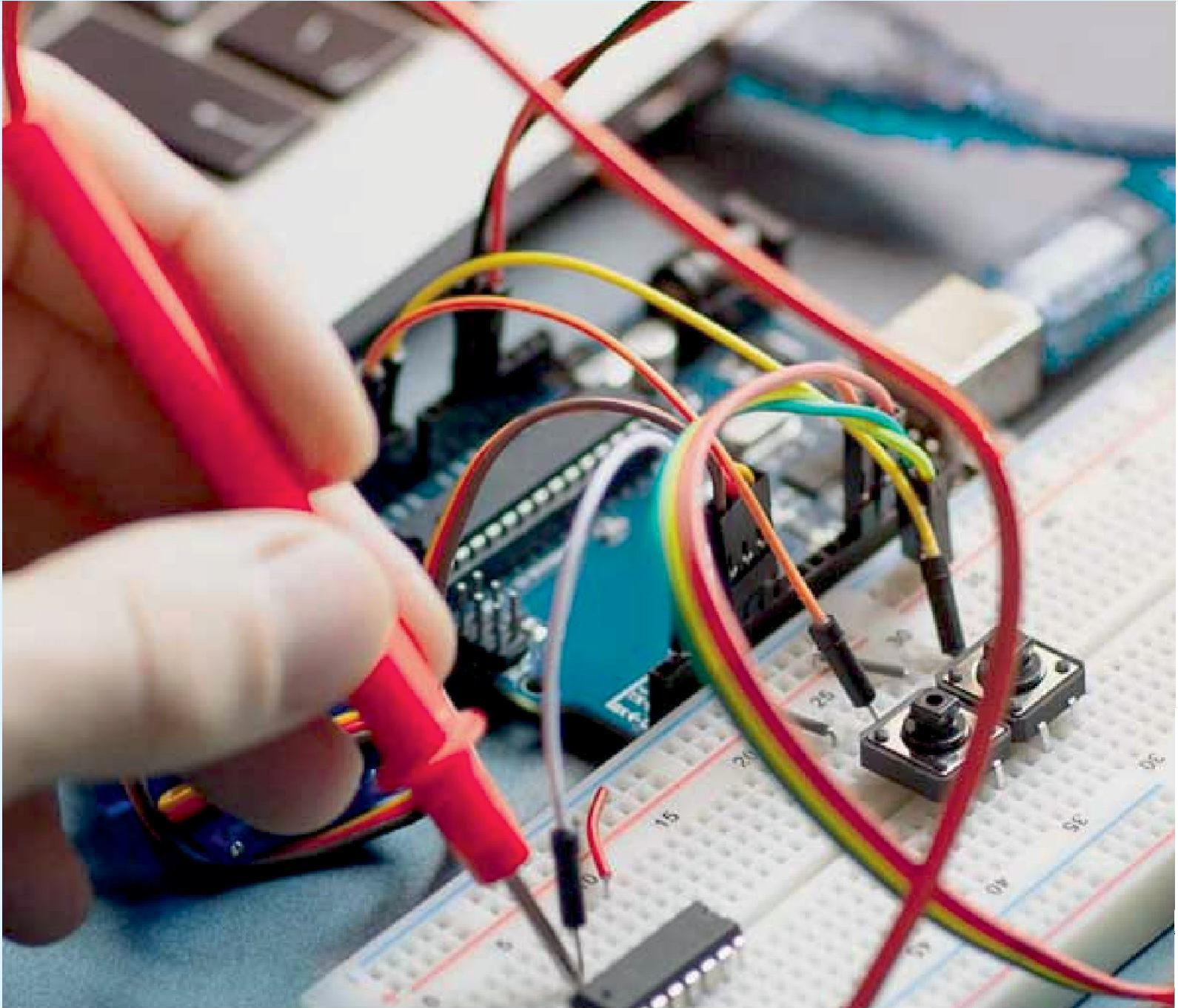
In MATLAB/SIMULINK, a closed-loop simulation of a Grid-connected transformer less PV system with reactive power adjustment is performed. The single phase LUO converter without transformer grid coupled with PV system capable of overcoming the transmission line's reactive power compensation problem was examined. In this project, a fuzzy logic controller in MATLAB/ SIMULINK is used to get the maximum power point of a solar panel. Modifying the inverter control to correct the reactive power as well as actual power without exceeding the current rating of the PV system inverter increases the system's utility. For various load circumstances, reactive power



adjustment is accomplished with a PI controller. The related simulated results indicate that the inverter's voltage and current to the grid are in phase, ensuring that the system's real power remains constant. As a result, the system compensates for the reactive power by keeping a constant actual power.

#### REFERENCES

- [1] S. B. Kjaer, J. K. Pedersen and F. Blaabjerg, "A review of single-phase grid-connected inverters for photovoltaic modules", *IEEE Trans. Ind. Appl.*, vol. 41, no. 5, pp. 1292-1306, Sep. 2005.
- [2] Z. Zhao, M. Xu, Q. Chen, J.-S. Lai and Y. Cho, "Derivation analysis and implementation of a boost-buck converter-based high-efficiency PV inverter", *IEEE Trans. Power Electron.*, vol. 27, no. 3, pp. 1304-1313, Mar. 2012.
- [3] T. K. S. Freddy; J. H. Lee; H. C. Moon; K. B. Lee; N. Abd Rahim, "Modulation Technique for Single-Phase Transformerless Photovoltaic Inverters with Reactive Power Capability," in *IEEE Transactions on Industrial Electronics*, 2017.
- [4] D. Li, C. Ho, L. Liu, and G. Escobar, "Reactive Power Control for Single phase Grid-tie Inverters using Quasi Sinusoidal Waveform," *IEEE IECON16*, Nov. 2016.
- [5] O. Khan and W. Xiao, "An Efficient Modeling Technique to Simulate and Control Submodule-Integrated PV System for Single-Phase Grid Connection," *IEEE Transactions on Sustainable Energy*, vol. 7, no. 1, pp. 96-107, Jan. 2016.
- [6] L. Zhou, F. Gao and T. Xu, "Implementation of active NPC circuits in transformer-less single-phase inverter with low leakage current", *IEEE Trans. Ind. Appl.*, vol. 53, no. 6, pp. 5658-5667, Nov. 2017.
- [7] H. V. Nguyen, D.-H. Park and D.-C. Lee, "Single-phase transformer less PV power conditioning systems with low leakage current and active power decoupling capability", *J. Power Electron.*, vol. 18, no. 4, pp. 997-1006, Jul. 2018.
- [8] N. Vosoughi, S. H. Hosseini and M. Sabahi, "Single-phase common-grounded transformer-less grid-tied inverter for PV application", *IET Power Electronics*, vol. 13, no. 1, pp. 157-167, 2019.
- [9] Y. P. Siwakoti and F. Blaabjerg, "Common-ground-type transformer less inverters for single-phase solar photovoltaic systems", *IEEE Trans. Ind. Electron.*, vol. 65, no. 3, pp. 2100-2111, Mar. 2018.
- [10] N. Vosoughi, S. H. Hosseini and M. Sabahi, "A New Single-Phase Transformerless Grid-Connected Inverter With Boosting Ability and Common Ground Feature," in *IEEE Transactions on Industrial Electronics*, vol. 67, no. 11, pp. 9313-9325, Nov. 2020.
- [11] Asmita M. Gaikwad, Shailendra K. Mittal, "A Single-Phase Transformer-less Grid Connected Photovoltaic Inverter", *Inventive Systems and Control (ICISC) 2020 Fourth International Conference on*, pp. 619-625, 2020.
- [12] Ali Sarikhani, Mohammad Hassan Ghaderi, Mohsen Hamzeh, "A Common-Ground Quazi-Z-Source Single-Phase Inverter Suitable for Photovoltaic Applications", *Energy Conversion IEEE Transactions on*, vol. 36, no. 2, pp. 594-601, 2021.



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