

Modulation and Analysis of Quasi Z-Source Inverter for Solar Photovoltaic System

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Abstract

Background/Objectives: This paper looks at the execution of Sinusoidal Pulse Width Modulation and Space Vector Pulse Width Modulation for a Quasi three phase Z-source inverter. **Methods/Statistical Analysis:** In this study, a Quasi Z-source inverter is an another method got from the customary Z-source inverter. The Quasi Z-source inverter acquires every one of the upsides of the Z- source inverter, which is used for buck/boost, conditioning power and reversal in a solitary step with an enhanced dependability. **Findings:** Likewise, the proposed Quasi Z-source inverter has the novel points of interest in a minimum part appraisals and steady dc current from the source. QZSI highlights an extensive variety of voltage addition which is applicable for photovoltaic system applications, due to the reason a photovoltaic cells yield differs broadly with temperature and sunlight based illumination. The working attributes of the proposed arrangement is examined in subtle element and contrasted with that of the SPWM and SVM. Hypothetical examination of voltage help and regulation techniques for the QZSI in PV is researched in this paper. **Applications/Improvements:** Recreation of the circuit setup for the mentioned balance techniques have been looked at in MATLAB/Simulation. Moreover, the THD investigation of both SPVM and SVM is checked.

Keywords: Photovoltaic, Sinusoidal Pulse Modulation, Space Vector Modulation, Total Harmonic Distortion

1. Introduction

As of late enthusiasm for renewable force era innovations (Such as wind turbines, photovoltaic cells and power module) is quickly expanding because of worldwide contamination issues. Among the renewable vitality sources, the overall introduced power limit indicates almost an exponential increment because of diminishing expenses and change in sun based vitality innovation. In¹ presented a model of the utilization of photovoltaic vitality as a distinct option for create power has gets to be noteworthy in the late years exam. In^{2,3} presented a PV inverter is generally used to change over the photovoltaic vitality into usable electrical vitality and reliability. Inverter assumes a critical part in everyday life.

There is an extensive interest for power which expands the requirement for inverter discussed in⁴. At first, the inverters are classified as current source inverter and voltage source inverter. By considering current source inverter the voltage increase is less and more segments are required for boosting of less voltage. This can be minimized by utilizing semi impedance source inverter. Voltage and current both can be made stable utilizing semi impedance source inverter which is discussed in⁵. Proposed Quasi Z-source inverter comprises additionally boosting of voltage and high effectiveness. The proposed framework includes the single stage change system. Both boosting up of voltage and transformation of dc happens in a solitary stage discussed in^{6,7}.

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2. Quasi-Z Source Inverter

The Quasi impedance source inverter is a solitary step power inverter got from the impedance source inverter topology. In⁸ presented an impedance system couples the source of inverter to accomplish voltage support & reversal in a single stage. The inverter consumes a consistent current from the photo voltaic exhibit and also equipped for taking care of a wide info voltage range discussed in⁹. It additionally includes lower part evaluations, decreasing changing swells to the photo voltaic cell boards, cause minimum electromagnetic interference issues & diminished stress in source contrasted with an impedance source inverter discussed in^{10,11}.

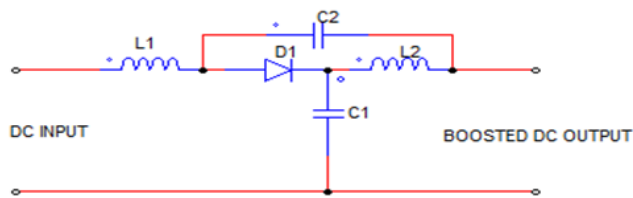


Figure 1. Quasi Impedance Source Inverter.

The figure 1 shows the basic topology of QZSI consist of two inductors L_1 and L_2 and two electrolytic capacitors C_1 and C_2 are connected to provide an impedance source. The operating principle of equivalent circuit quasi impedance source inverter is shown in figure 2. It operates in two modes, they are

- Shoot through mode
- Non-Shoot through mode
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In second mode it works as a basic voltage source inverter. Shoot through mode plays an important role. In shoot through mode, two MOSFET switches are turned on in the same leg.

2.1 Shoot through Mode

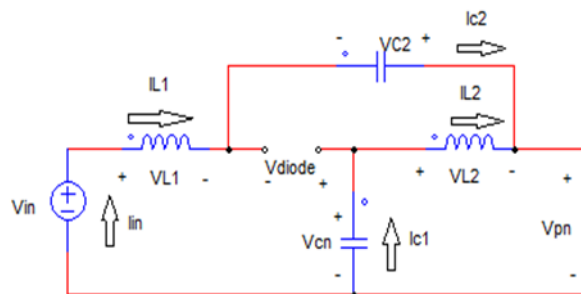


Figure 2. Equivalent Circuit of Mode 1.

In mode 1, an inverter switches are switched ON simultaneously for a short time. The source does not get short-circuited due to the presence of LC system, while boosting the yield voltage. The DC join voltage on first state helped by a support variable, which worth relies upon the shoot through obligation proportion for a given modulation index. Accepting that amid one exchanging cycle, T , the interim of the mode 1 state is T_0 ; the interim of mode 2 state is T_1 ; subsequently one has $T = T_0 + T_1$ and the shoot-through obligation proportion, $D = T_0/T_1$.

2.2 Non-Shoot through Mode

In mode 2, the exchanging design of Quasi impedance source inverter is like as voltage source inverter. The inverter from the DC side is comparable to a present source and accessible at the DC join voltage, which behaves quasi impedance source inverter is operate as voltage source inverter Assume that,

$$T_z = T_a + T_b \text{ (Switching period)} \quad (1)$$

T_a - Total duration of shoot through zero vectors.

T_b - Total duration of non-shoot through switching vectors.

V_{in} is the output voltage of fuel cell

Under normal condition, the average value of inductor switching frequency is zero. In mode 2 the exchanging design for the Quasi impedance source inverter is like as voltage source inverter. The inverter from the DC side is comparable to a present source and dc voltage is accessible as DC connection voltage information to the inverter shown in figure 3, which makes the Quasi impedance source inverter behave similar to a Voltage source inverter.

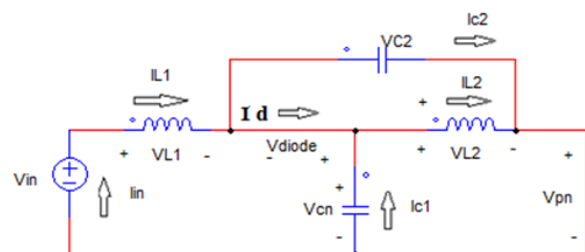


Figure 3. Equivalent Circuit of Mode 2.

Subsequently QZSI acquires every one of the upsides of the ZSI. It can buck or help a voltage with a given support component. It can deal with a shoot through state

and in this way it is more solid than the customary VSI. It is pointless to include a dead band into control plans, which diminishes the yield mutilation. Moreover, there are some novel benefits of the QZSI when contrasted with the ZSI.

3. Sinusoidal PWM

Sinusoidal pulse width modulation is a technique for controlling a voltage as a part of inverters. In this plan, the switches in the two legs of the full-connect inverter are not exchanged at the same time, as in the bi-polar plan. The QZSI outlines of six element vectors and two zero vectors are shorted, whether lower or upper three switches discussed in¹². These total eight trading states and their mixes have been created various PWM control arranges. Sinusoidal PWM is the most generally used PWM methodology as a part of the VSI. On the other hand, QZSI has additional zero vectors or shoot through trading expresses that are unthinkable in standard VSI. For a yield voltage be gotten, a shoot through state should reliably be trailed by element state. This essential may be reached by the complimentary operations of the various switches within a leg. In this unipolar plan the legs An and B of the full-connect inverter are controlled independently by contrasting transporter triangular wave v_{car} and control sinusoidal sign v_c and $-v_c$ separately. This SPWM is for the most part utilized as a part of modern applications. The quantity of heartbeats per half-cycle relies on the proportion of the recurrence of bearer sign (f_c) to the modulating sinusoidal sign. The recurrence of control sign or the balancing signal sets the inverter yield recurrence (f_o) and the top greatness of control sign controls the regulation list mama which thus controls the rms yield voltage. The region of every heartbeat relates around to the range under the sine wave between the adjoining midpoints of off periods on the gating signals.

4. Space Vector Modulation

Space vector modulation (SVM) was initially created as vector way to deal with heartbeat with adjustment for three stage inverter. In¹³ presented a best method for producing sine wave that gives a higher voltage and also minimise the harmonics. In¹⁴ presented SVM strategy is a propelled

calculation escalated PWM strategy and potentially the best strategies for variable recurrence drive. The circuit model of an average three stage voltage source inverter is appeared in figure 4. M1 to M6 are the six force switches are controlled by the exchanging variables. This essential may be reached by the basic operation of the switches within a leg. Note that looking down the segments for the element trading vectors V1-6, the yield voltages shift as a beat sinusoid, with each leg offset by 120 degrees of stage edge. To execute space vector modulation, a

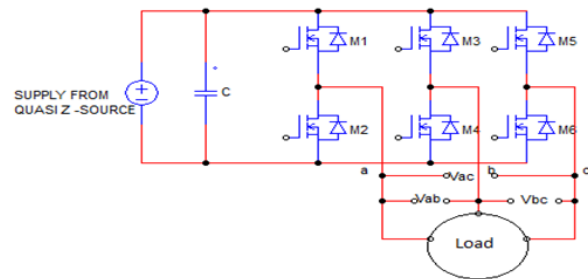


Figure 4. Three Phase Inverter.

Voltage reference signal is tested with a frequency f_s ($T_s = 1/f_s$). The voltage reference sign is delivered from three different stage references with the help of variables (α, β, γ) . The voltage reference vector is consolidated using a mix of two connecting dynamic trading vectors and the zero vectors. Procedure determination may be influence the substance and exchanging misfortunes vector PWM strategy is leverage as a result of expanded adaptability in the decision of exchanging vector for both info current and yield voltage control.

In¹⁵ Space vector modulation alludes to an unique exchanging group of three staged inverters using energy transistors. This strategy has known not lower consonant bending of yield voltages and gives more proficient utilization of the supply voltage in examination with direct sinusoidal adjustment method. Eight exchanging voltage vectors are acquired with an assistance of every leg exchanging states of variables (S_a, S_b, S_c). The figure 5 shows the voltage vectors V_1 to V_6 are called dynamic voltage vectors that create the voltages in a traditional voltage source inverter. V_0 and V_7 are zero vectors, they don't produce yield voltages yet they are utilized as a part of the technique. The figure 6 shows that eight vectors are displaced at 60 degree.

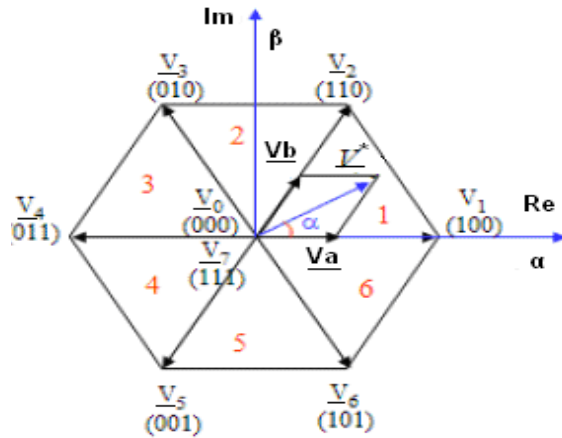


Figure 5. Space Vector Modulation.

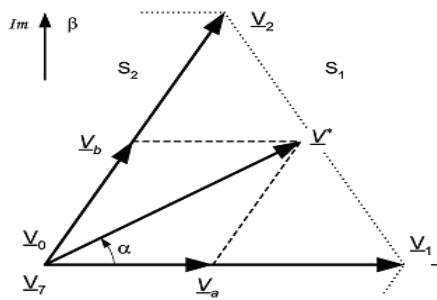


Figure 6. Space Vector Modulation Principle.

The V^* (called the reference vector) vector rotates counter clockwise with the angle α varying between 0 and 360 degrees. At each moment

$$\underline{V}^* = \underline{V}_a + \underline{V}_b \quad (2)$$

At the point when the motor is begun the size of V^* is V start. As the supply voltage is raised, the greatness of

the vector will develop in this way portraying a winding. Duty cycles for each sector are discussed in table 1.

Table 1. Duty cycles

Sector S_1	$D_1 = \mu_\alpha - \mu_\beta$	$D_2 = 2\mu_\beta$	$D_0 + D_7 = 1 - D_1 - D_2$
Sector S_2	$D_2 = \mu_\alpha + \mu_\beta$	$D_3 = \mu_\beta - \mu_\alpha$	$D_0 + D_7 = 1 - D_3 - D_2$
Sector S_3	$D_3 = 2\mu_\beta$	$D_4 = \mu_\alpha - \mu_\beta$	$D_0 + D_7 = 1 - D_3 - D_4$
Sector S_4	$D_4 = \mu_\beta - \mu_\alpha$	$D_5 = -2\mu_\beta$	$D_0 + D_7 = 1 - D_4 - D_5$
Sector S_5	$D_5 = \mu_\alpha - \mu_\beta$	$D_6 = \mu_\alpha - \mu_\beta$	$D_0 + D_7 = 1 - D_5 - D_6$
Sector S_6	$D_6 = -2\mu_\beta$	$D_1 = \mu_\alpha + \mu_\beta$	$D_0 + D_7 = 1 - D_1 - D_6$

5. Results and Discussion

The comparison results for the QZSI output voltage of SPWM and SVM are shown in figure 9 and 13. The low voltage DC of photovoltaic cell is given to the inverter through a Quasi impedance source circuit. Inverter boosts the voltage under shoot-through-mode and converts into AC voltage from DC voltage. This conversion is done with the help of the inverter based on both SVM and SPWM technique. This circuit takes the reference voltage from the three phase inverter output. The Quasi Z-source inductor and capacitors are act as a filter and they generate resonant to the switches. Output voltage obtained three phase AC which is given to the grid or to the load.

Obtaining AC contains ripples which are filtered by LC filter. The sub system of SVM technique is shown in figure 12. The figure 7 and 10 are simulated by using SIMULINK software. The comparison results of FFT analysis using SPWM and SVM technique are shown in Figure 8 & 11. Finally, the THD of SPWM and SVM is

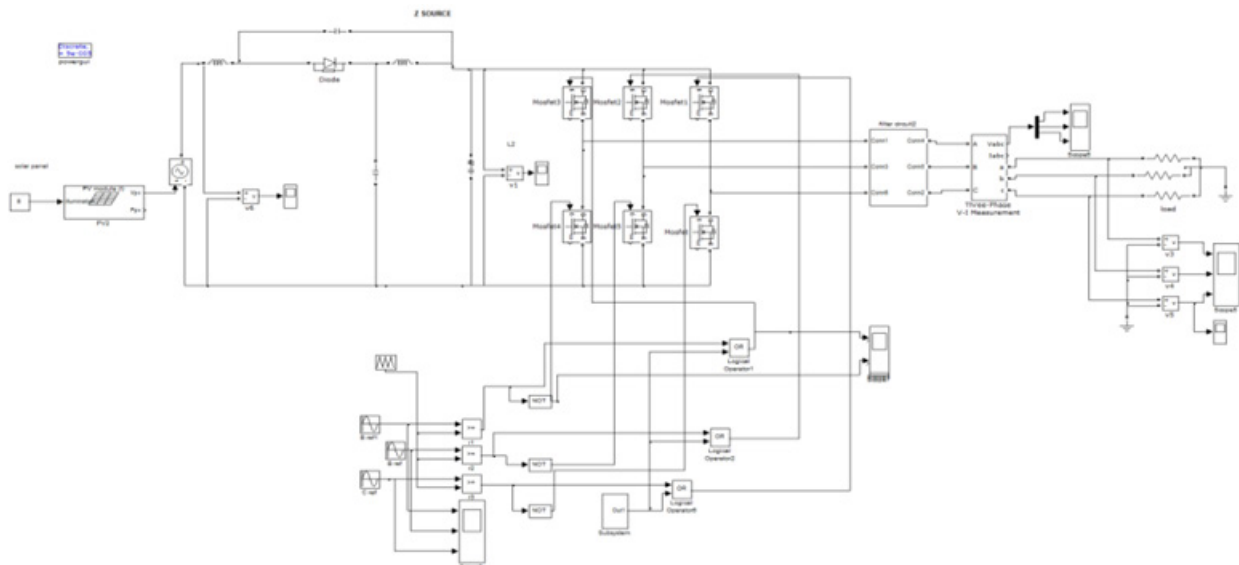


Figure 7. Quasi Z Source nverter using SPWM.

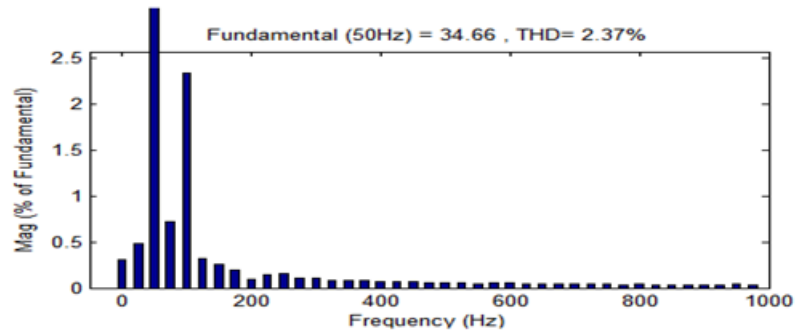


Figure 8. FFT Analysis of SPWM.

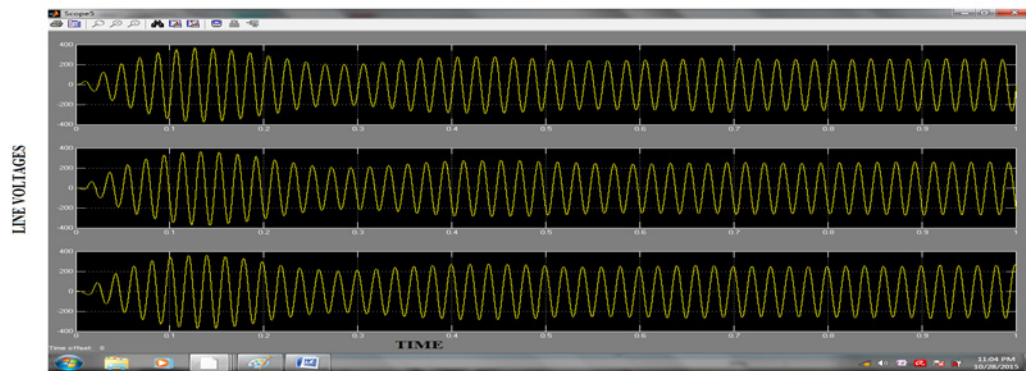


Figure 9. Output waveform of Quasi Z source Inverter for SPWM Technique.

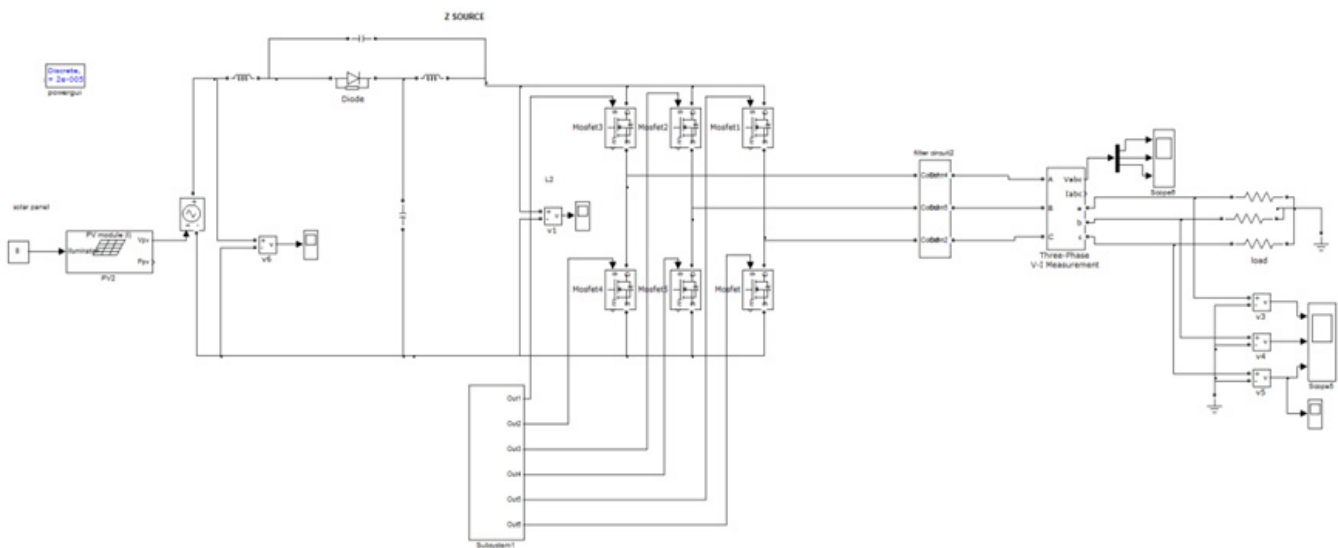


Figure 10. Quasi Z-Source Inverter using SVM.

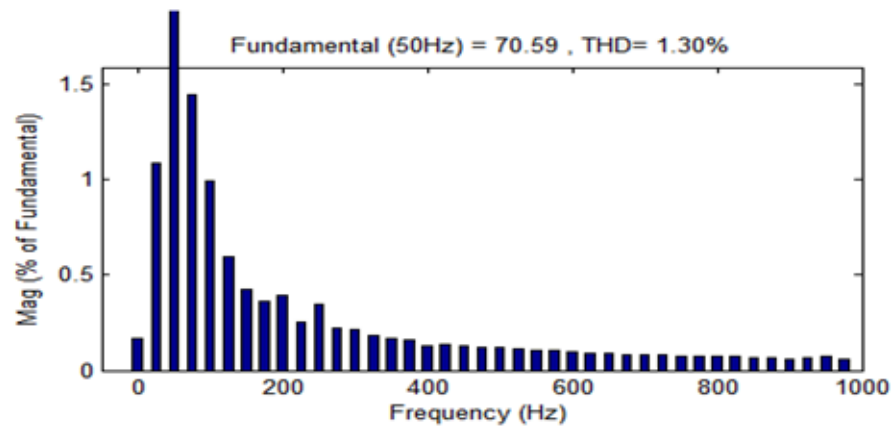


Figure 11. FFT Analysis of SVM.

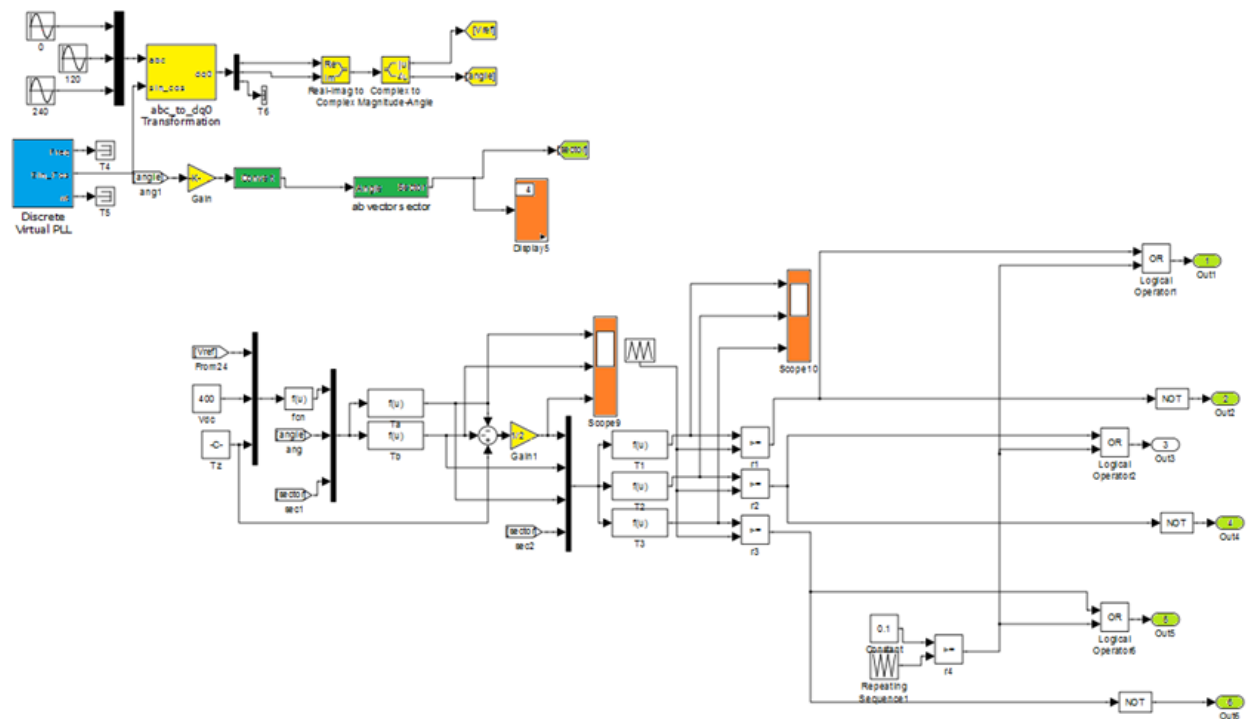


Figure 12. Sub system of SVM.

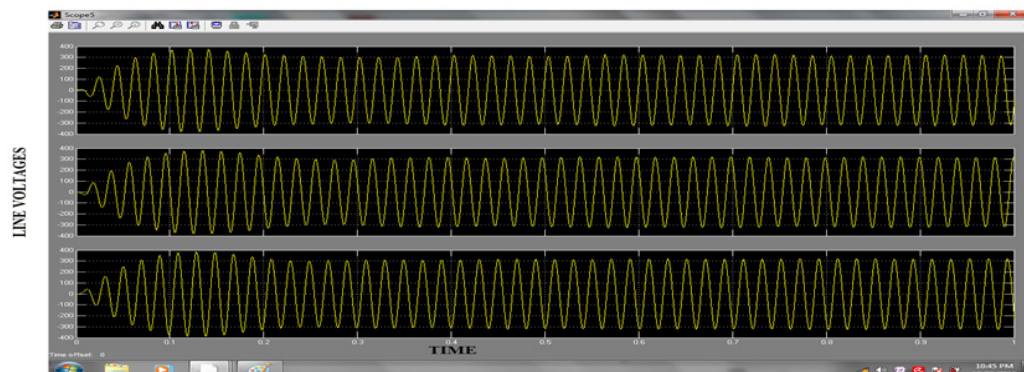


Figure 13. Output waveform of Quasi Z source Inverter for SVM Technique.

compared in Table 2.

Table 2. Comparison of Modulation

Modulation	THD
SPWM	2.37%
SVM	1.30%

6. Conclusion

This paper thought about the execution of Quasi Z source inverter by utilizing SPWM and SVM strategy. The aggregate consonant mutilation in the yield voltage is observed to be decreased utilizing Space vector modulation system. The hypothetical examination, reproduction results introduced in this work obviously exhibit the proposed QZSI inverter with SVM method. The QZSI is equipped for taking care of extensive variety of info voltage changes. It gives the improved single stage force change topology and higher dependability. QZSI is most appropriate interface for sun based photovoltaic framework and could turn out to be very effective, when executed with the enhanced control systems proposed.

7. References

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