International Journal of MC Square Scientific Research Vol.13, No.4, 2021

Space Vector Modulation Control Based Induction Motor for Photovoltaic Application

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Abstract: The proposed paper is based on the Switched Inductor Quasi Z Source Inverter (SL-qZSI). The photovoltaic is the source of the proposed circuit and the SL-qZSI fed induction motor. The speed of an induction motor (IM) is controlled by space vector modulation (SVM). The proposed converter is to increase the voltage and also to regulate the dc link voltage. The proposed SL-qZSI has use the passive element in the main circuit which increases the voltage and reduces the voltage ripple. The single diode based solar photovoltaic (PV) has improved the reliability, efficient and reduce the voltage stress across the capacitor. The solar PV has employed with maximum power point traction (MPPT) algorithm to extract the maximum power from the PV system. The novel control method of proposed system is to generate more power in the output of the inverter. In order to filter the ripple and the proposed circuit implementation is verified by using MATLAB/ Simulink.

Keywords: Photovoltaic, Maximum power point traction, Switched inductor Quasi Z-source inverter, Space vector modulation and Induction motor.

1. Introduction

The solar based SL-qZSI inverter has produced as much output compared to the conventional based inverter. The single stage inverter is used in the proposed circuit method. The presented inverter increases the voltage ratio and enhances the reliability of the system. In distributed generation application the low voltage source such as PV, Fuel etc. is used as the source. The SL-qZSI has combined with the boost inverter will reduce the voltage ripple and to increase the efficiency of the network. The single diode based PV model is used because it has less cost, easy maintenance and noise less power production. A novel PV model has small error for various kindsof PV cell types for evaluation. The dynamic modeling of PV based SL-qZSI's has more efficient operation.

One of the three methods presented here for managing the speed of an induction motor is scalar control, which includes adjusting the voltage and frequency while keeping their ratio constant.The second approach is indirect field oriented control, which uses rotor flux orientation, and the last way is direct torque control, that uses motor characteristics to calculate torque and stator flux [1]. The indirect field-oriented control approach was used to apply vector control to a 3-ϕ IM. In the suggested architecture, a sliding mode controller with chattering decrease is used, with the goal of achieving good dynamic performance across a wide speed range while being resilient to load perturbations, a soft switching hyperbolic tangent function on the controllers is presented [2]. A closed-loop current amplitude input model for an IM is used to investigate fuzzy frequency control and fuzzy current amplitude control. The hybrid controller is made up of a mixture of both controllers. To solve the restrictions of field-oriented control methods, the hybrid controller controls the speed of the rotor during the acceleration and deceleration stage with a fuzzy frequency controller and the stator current magnitude during the steady-state stage with a fuzzy stator current magnitude controller [3]. A single stage converter is used in the ZSI system. The Z-source network may increase the capacitor DC voltage by modifiable the shoot-through duty cycle, which is larger than the incoming DC voltage. As a consequence, the new Z-source inverter system enhances power factor, decreases harmonics, boosts reliability, and broadens the output voltage range during voltage sags [4].

Here discusses a sensor-less indirect field-oriented control in conjunction with an intelligent approach based on fuzzy logic controllers to ensure rapid reactional so develop the dynamic performance of a3-ϕsquirrel cage IM drive [5]. To replace the usual constant gain proportional-integral-controller, a model reference adaptive system speed estimator for speed sensor-less indirect field-oriented control of an IM drive is constructed utilizing a fuzzy logic controller [6]. The solar cell model is created by combining fundamental single diode circuit equations of photovoltaic cells with temperature and sun irradiation effects. In this case, the ZSI employs an exclusive impedance network connected through the inverter circuit to accomplish the gained DC-AC alteration. Because of the interplay between the rotor winding flux and the spinning magnetic field flux, IM can self-start, producing a high rotor current as torque is raised [7]. The use of space vector modulation to novel 3-ϕtopologies as AC/DC inverters has increased the usage of SVM at 3-ϕ voltage-source inverters, AC-DC or DC-AC Current Source Voltage Source Converter, Resonant 3-ϕconverters and other similar devices [8]. The use of space vector modulation on a photovoltaic-assisted single-phase line-interactive inverter running as a power source that is uninterruptible [9]. One of the most extensively used approaches for generating sinusoidal line to line voltages and currents using a 3-ϕinverter is SVM. The sine voltage is treated as a constant amplitude vector revolving at a constant frequency in this approach. In the stationary d-q coordinate frame, a 3-ϕvoltage is converted into a vector that represents the spatial vector sum of the 3-ϕvoltage [10]. In high-performance applications, load disturbance, parameter fluctuations, and model errors all have an effect on motor speed. To keep a consistent pace, it is necessary to overcome elements that alter motor speed, which is one of the most important and difficult responsibilities [11].

A SVM technique for quasi-Z-source 3LT2I is presented here to lower the amplitude then slew rate of common-mode voltage. The shoot-through states are inserted within the zero vector by carefully setting the shoot-through phase, so they do not impact the active states or output voltage. The CMV generated by the quasi-Z-source 3LT2I is limited to 1/6thof the dc-link voltage, allowing voltage boosting and CMV decrease to occur concurrently. Furthermore, a high dc-link voltage usage may be maintained [12]. To decrease ripple, a novel SVM control technique is developed that does not need increasing the switching frequency or inductance. The space vector is separated into twelve sectors where the ideal vector sequence may significantly minimize the dc-link current ripple [13]. It has been demonstrated how to manage a grid-connected PV converter using reactive power compensation. The converter switching frequency is kept constant by applying SVM and a simple direct power management technique. Decoupled control of active and reactive power is done without the need of a decoupling network or organize transformation to the d-q, which are both required in open circuit voltage. The controller is stable throughout a wide variety of operating circumstances and has a quick dynamic response. Under all situations, the dc voltage is maintained at a constant value [14]. The SL-qZSI offers continuous input current, a common ground with the dc source, less voltage stress on capacitors, a lower passive component count, less current stress on inductors and diodes and less shoot-through current [15]. This paper presents the system configuration, methodology, results and discussion and conclusion is following below.

2. Methodology

Here we proposed two techniques such as SL-qZSI and SVM. The SL-qZSI is used to converter the DC to AC without the use of converter. Also, the voltage level of the inverter is gained which is able to provide the required amount of power to the motor. Then the motor gets run and the proposed SVM control can used to regulate the motor speed.

3.1 System Configuration: The proposed system can be based on the switched inductor quasi Z source inverter, which has the photovoltaic (PV) as the source of the proposed circuit and the SL-qZSI fed induction motor. The induction motor is controlled by SVM. Figure 1. presents the proposed system's block diagram, which has the solar PV source. To extract maximum power by employed with maximum power point traction (MPPT) algorithm.

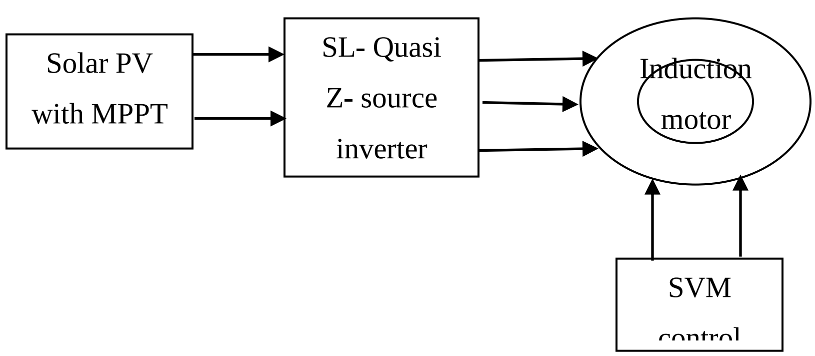


Figure 1: Block diagram of the proposed system.

Then the solar PV is connect to the SL-qZSI. The proposed SL-qZSIis a designed impedance-type power inverter. To improve voltage adjustability, the suggested inverter adopts the SL impedance network to connect the main circuit and the power supply. After that, the proposed inverter is connect to the induction motor. The inverter can provide the enough amount of power which is required by the induction motor. An induction motor is a motor that only has amortisseur windings. In the majority of circumstances, an induction motor is the simplest basic electrical equipment in terms of structure. The induction motor operates on the induction principle, in which an electromagnetic field is induced into the rotor when the stator's revolving magnetic field cuts the stationary rotor. By far the most popular form of motor utilized in an industrial, commercial, or home application. Then the induction motor is controlled by SVM.

3.2 SL-qZSI: The SL-qZSI is presented in Figure 2, which is consists of 3 capacitors (C1, C2 and C3), 2 inductor (L1 and L2), 3 diodes (D1, D2 and D3), and 1 switch. Where, the V_{in} is the input voltage, V_{D1}, V_{D2} and V_{D3} are diode voltages, i_{L1} and i_{L2} are the inductor current.

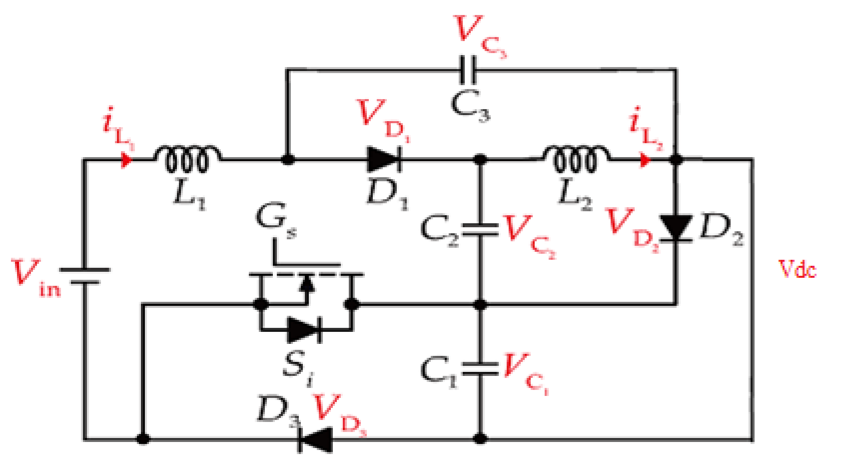
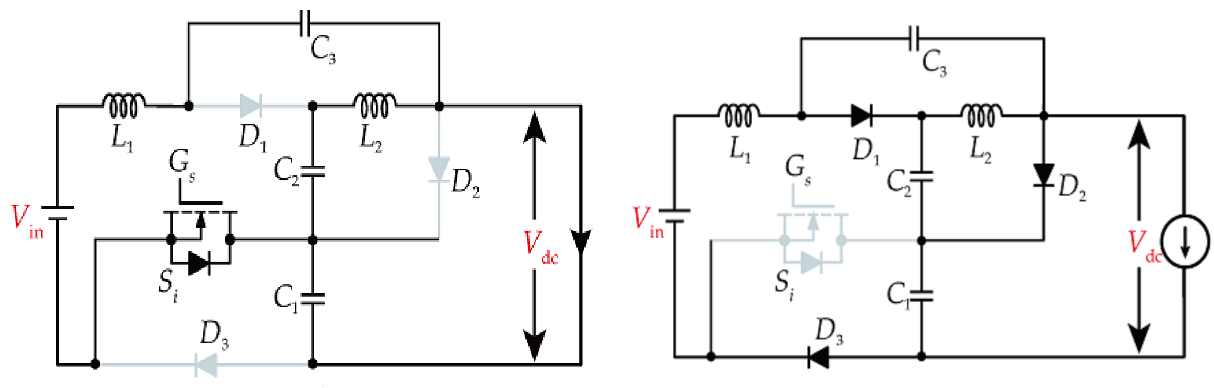


Figure 2: Proposed SL-qZSI

The presented S-qZSI can be realised by leveraging the inverter's shoot-through condition, in which the inverter leg is short-circuited by simultaneously turning on two switches. As per the proposed S-qZSI has two operation modes: shoot-through mode (STM) and non-shoot-through mode (NSTM) are shown in Figure 3 (a) (b).



(a) (b)

Figure 3: Equivalent circuit of SL-qZSI a) During STM.

b) During NSTM.

Hence, the voltages and currents between the components may be calculated using Kirchhoff's law, which is shown in Table 1.

Table 1: Voltages in shoot through state and non-shoot through state

Components	**Voltages in STM**	**Voltages in NSTM**
L_1	$V_{c1}+V_{c3}+V_{in}$	$V_{in}+V_{c3}-V_{dc}$
L_2	$V_{c1}-V_{c2}$	$-V_{c2}+V_{c3}=0$
S	0	V_{c1}
D_1	$-V_{c1}+V_{c2}-V_{c3}$	0
D_2	$-V_{c1}$	0
D_3	$-V_{c1}$	0
DC-link	0	V_{c1}

Table 1, represents that the operation of the proposed inverter in two modes STM and NSTM. Each component may operate according with voltages in both modes. Finally, the Dc-link voltage is delivering from the inverter to the motor as the input source of the induction motor.

3.3 SVM: SVM is a modulation technique which it determines the duty cycles of switches to synthesize a desired output voltage on typical without the usage of a carrier waveform.

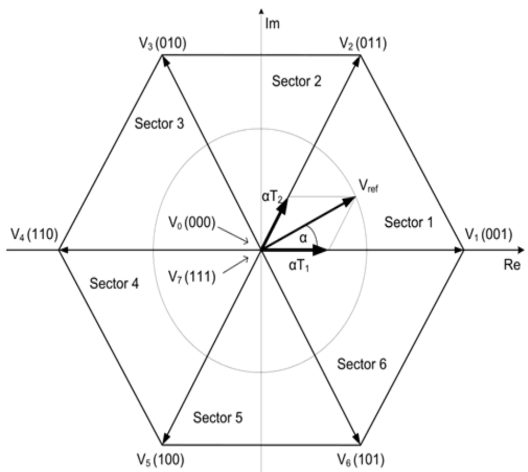


Figure 4: SVM Model

A voltage vector can be recreated on average utilizing the converter's 8 possible states by giving a reference voltage (magnitude and phase). The modernization is carried out by selecting the V_{ref}at a particular time Ts and calculatingTsto be in specific situations so that the is V_{ref}obtained on average.

3. Simulation Results and Discussion

The proposed system is designed and implementation using MATLAB/Simulink software, which is shown in Figure 5. The Design is implemented with source of solar PV which has the inbuilt model from the Simscape. In the PV system the solar arrays, modules are manually entered to get required amount of the power regarding applications. Here we considered the 1 solar cell, short circuit current is 7.34A and open circuit voltage is 3V. After that the voltage and current are provide to MPPT algorithm to track the maximum power. Because alone solar cannot provide continuous power to the load, due to atmospheric conditions. Then the power from the source can be given to the proposed inverter. The switch can be pulse and controlled with MPPT technique.

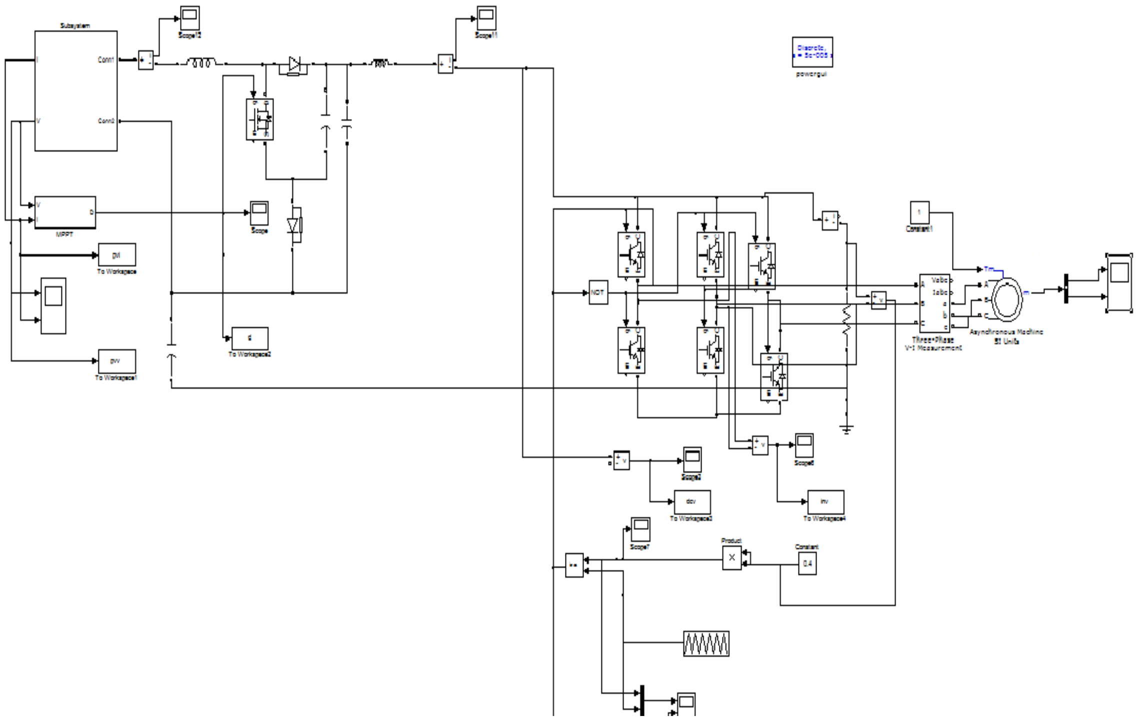


Figure 5: Simulink diagram of proposed circuit method

DC-link capacitor is used to purpose of provide the voltage to the induction motor. And the motor can run with the required amount of power from the source through DC-link capacitance. Further induction motor can be controlled by SVM technique with the rectifier switches.

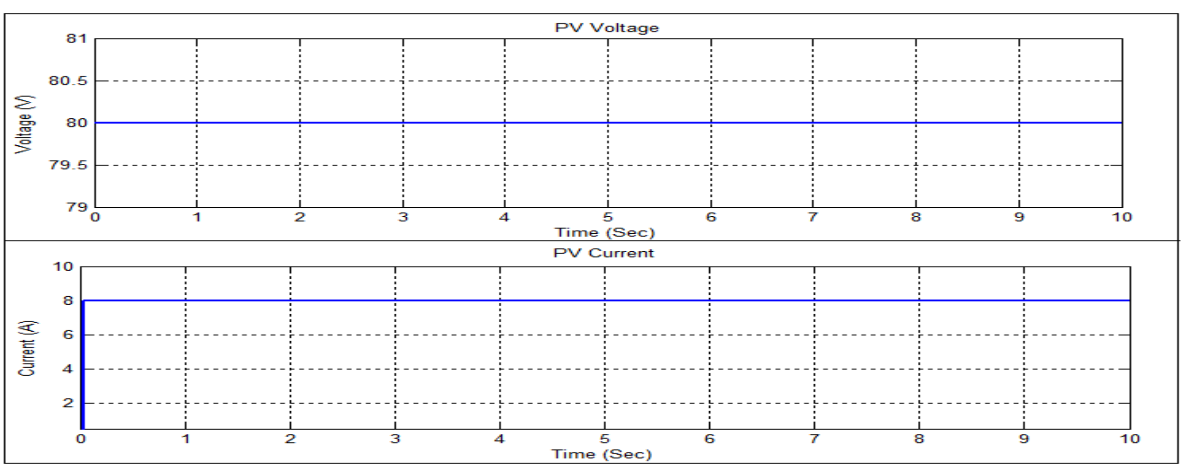


Figure 6: PV voltage and current

Figure 6 represents that the PV's output voltage and output current. The PV output voltage is 80V and PV output current is 8A. Using MPPT technique this much amount of voltage and current can be extracted, which shows that the MPPT based Solar PV performs well.

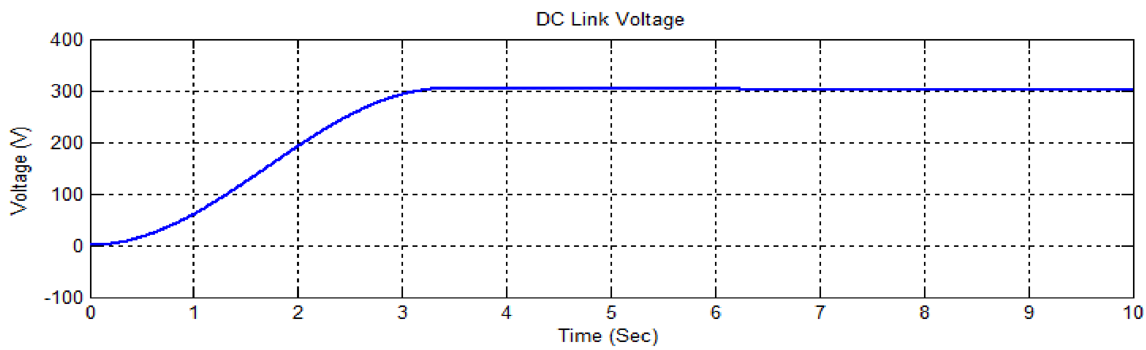


Figure 7: DC Link Capacitor across Voltage Waveform

Figure 7 shows that the DC-link capacitor voltage, which is 300V. The DC-link capacitor serves as the PFC stage output filter, absorbing switching currents and ensuring that the ripple voltage is as low as possible. The output stage might be a switched mode converter or an inverter that receives high frequency current bursts from the DC-link capacitor.

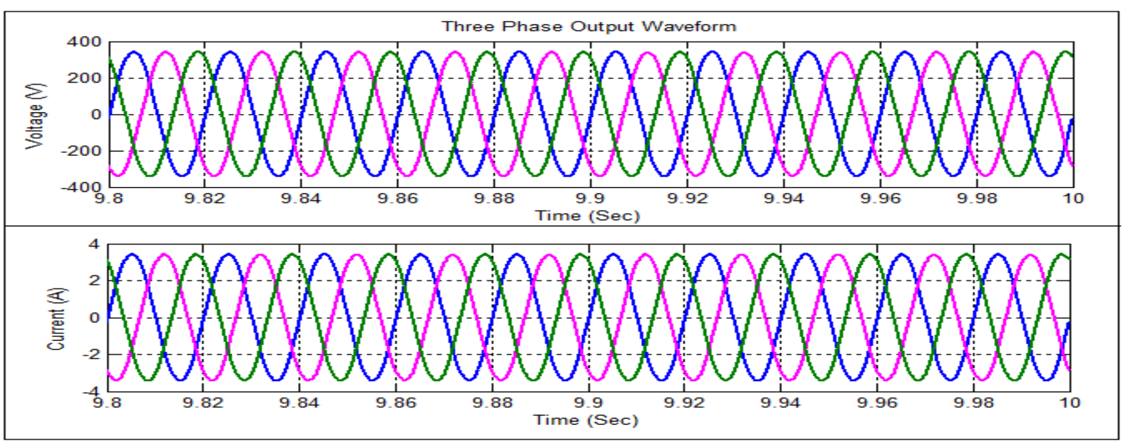


Figure 8: Three phase voltage and current waveform

Figure 8 illustrates that the 3-phase voltage and current of the proposed system. The motor can be operate at 270V and 3A. Then the speed performance of the induction motor is represents in Figure 9.

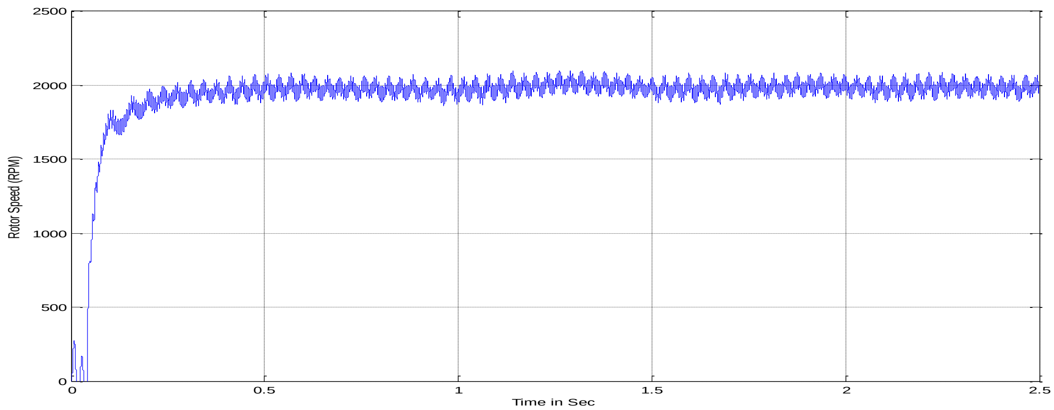


Figure 9: Speed of an Induction motor

Figure 9 represents that the speed performance of the induction motor, which has the rotating speed is 2000 rpm. In initial state, the speed of the induction motor has slightly oscillate at 0.1 sec. Then gradually increase the speed performance and stabilize at 0.25 sec.

4. Conclusion

The proposed system can be simulated, the solar PV with MPPT technique, Then the proposed Sl-qZSI can be integrate to the source. This has one main advantage, the proposed inverter need not require any converter, leads less system design's complexity, and low cost. The converter's function is to enhance the voltage also regulating the dc link voltage. Then the inverter can provide the supply to three phase induction motor, which functions increased and the dc voltage is improved by SVM. SVM is one of the most often used methods for generating sinusoidal line-to-line voltages and currents with a three-phase inverter. The proposed SVM based motor has reduce the passive element and also reduce the total harmonic distortion.This controlled signal can be provide to the inverter switches. Further, the distribution system based SL-qZSI has increases the voltage gain and the simulation is verified. The graphical representation of the proposed system shows the performance of every components.

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