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FOPID Controlled SLQZSI fed IM Drive with Enhanced Response

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Abstract: This effort recommends a enhanced response of fractional order PID Controlled SLQZSI fed Induction Motor. A closed control loop SLQZSI fed IM with FOPID controller is suggested to improve rise time, peak time, settling time and to reduce Steady state error. The speed of three phase Induction motor is varied dependent on the difference among SLQZSI output voltage and reference voltage to enhance its response. The Simulation results of fractional order PID controlled SLQZSI fed induction motor drive has lessened rise time, peak time, settling time and also decreased Steady state error with closed control loop SLQZSI fed IM with PI controller. The outcomes show that the reaction of SL-QZSI fed induction-motor drive with FOPID is speedier than that of PI controlled- SL-QZSI fed induction-motor drive setup.

Keywords: FOPID, Peak time, Rise time, Settling time**,** switched inductor quasi z source inverter, Steady state error, Induction motor drives.

1. INTRODUCTION

High-performance voltage and current source inverters (VSI and CSI) are extensively used in various industrial applications such as AC Motor Drives, Uninterruptible Power Supplies, Hybrid Electric Vehicles and Distributed Power Systems. However, conventional VSI and CSI have key drawbacks. High-voltage boost impedance source inverter called an exchanged coupled inductor QZSI was proposed, which coordinates an exchanged capacitor and a three-winding exchanged coupled inductor into a regular QZSI [1]-[2].

Upgraded boost QZSI with double-switched impedance-networks for topologies is exhibited for the improved boost QZSI, to be specific consistent into current design and irregular information current arrangement of enhanced boost QZSI with exchanged impedance frameworks. Like upgraded boost ZSI's, these proposed inverter topologies have exceptionally high boost voltage reversal at low shoot through duty proportion and high regulation yields an improved quality of voltage [3].

An energy stored quasi z-source cascade MLI hinged PV power generation frameworks utilizing quasi Z-source CMI presents numerous preferences over regular CMI when connected in PV power frameworks. For instance, the QZS-CMI gives the balanced dc-link voltage and voltage boost-capacity, spares 33% modules, and so on. In any case, the QZS-CMI still can't defeat the discontinuous and stochastic vacillation of sun-oriented power infused to the grid [4].

The properties of a solitary phase semi Z-source inverter (QZSI) and a solitary stage semi exchanged boost inverter (QSBI), the two of which are single phase buck-boost inverters, are explored and thought about. For the equivalent working conditions, QSBI has the accompanying favorable circumstances over QZSI are three capacitors are spared, the current rating on both of the switches and diodes is lower, its boost-factor is higher with a proportionate-parasitic-impact, and its proficiency is higher. Be that as it may, QSBI has one more dynamic switch and one more diode than Z-source/QZSIs [5].

DC-interface voltage balance control procedure dependent on multidimensional regulation strategy for QZS-CMLI PV power framework. The QZS-CHB PV framework for the most part utilizes PI- controllers built closed control-loop control techniques to adjust dc-link voltages, consolidating with distributed MPPT and grid tie control. These crave huge control calculations and equipment assets for numerous modules hinged QZS-CHB framework. The proposed MD-PWM for the QZS-CHB inverter performs shoot-through conduct dependent on geometric portrayal of the yield voltage scopes of every H-bridge in facilitate axes [6].

Switching misfortune decrease in the three phase QZSI using changed space vector regulation procedures among them a few single-phase topologies have been presented Besides, unique regulation systems, using numerous reference signals, have been created as well [7]. QZSI with a T-type converter in normal and failure mode introduces a three-phase multilevel QZSI topology working in ordinary and fault tolerant task mode. This structure is created by two symmetrical semi Z-source systems and a three stage T-type inverter. Other than the characteristic favorable circumstances of staggered voltage source inverters, the proposed structure is likewise described by their semiconductor adaptation to internal failure ability [8].

An energy stored QZSI for application to PV power system, QZSI with battery task can adjust the stochastic fluctuations of PV power infused to the framework/load, yet its current topology has a power confinement because of the wide scope of discontinuous-conduction mode amid battery release. This explains another arrangement of the energy stored QZSI to conquer the drawback [9]. Exchanging loss reduction in the three Phase QZSI utilizing modified space vector modulation approaches is unique adjustment methodologies, using numerous reference signals, have been created as well [10].

Enhanced boost QZSI with an active switched Z network was contrasted with improved boost QZSI with two exchanged impedance networks, this recommended-inverter has a similar

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elevated boost factor while utilizing two less LC sets and one less diode and just includes one exchanging gadget. Likewise, current stress over switches is decreased considerably, which prompts critical decrease in the conduction loss of switches and meliorates proficiency of the general inverter [11].

Direct MPC procedure of QZSI was exhibits a direct MPC technique for QZSI's. A discrete-time demonstrates is determined that precisely catches every single working method of the converter [12]. In new generation of progressively electric flying devices, dc bus voltage is variable because of the variable speed generator. This infers obliges to structure the actuator for the most reduced dc voltage esteem. In the event of PMSM starter provided by an ordinary power topography (LC input channel voltage source inverter), the torque steady ought to be low enough to guarantee the controllability of the phase flows.

This prompts increment evaluated current thus to outsize the inverter heat sink. In this, an ideal structure strategy for a QZSI with coupled inductors was displayed for a PMSM starter appliance. This topography permits boosting the inverter input voltage at high speeds [13]-[18]. An epic group of PWM techniques are for single phase QSBI. By consolidating shoot through (ST) mode in the inverter's switches and the turning on condition of an extra switch, the QSBI delivered a high voltage gain without including any latent parts.

The overhead literature does not pact with SLQZSI fed induction motor drive. This investigation suggests SLQZSI amongst semi-converter and IMD. The above leaflet review does not report the comparison of PI and FOPID controlled SLQZSIIM systems. The point of this task is to redress enhancement of time response of SLQZSIIM system using FOPID controller.

2. SL-QZSI TOPOLOGY

The proposed SL-QZSI topology is shown in Fig. 1, it has three inductors (L_1, L_2, and L_3), two capacitors (C_1 and C_2), and four diodes (D_{1n}, D_1, D_2, and D_3). The combination of L_2–L_3– D_1–D_2–D_3 acts as a SL cell.

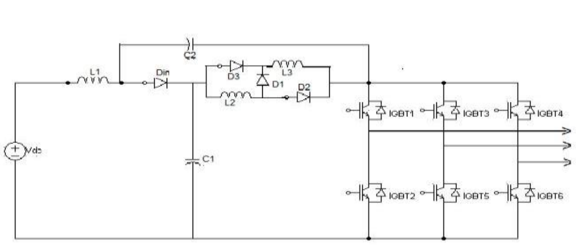

Fig. 1. SL-QZSI topology

However at start up resonance is provided by source impedance of inductor and capacitors and here no current flows to the main power circuit. Hence, the proposed topology is suppressing the in rush current. The proposed inverter increases factor of boost from 1/(1−2D) to (1+D)/(1−2D −D2) by adding three diodes and one inductor to the topology.

A. Circuit Analysis

The proposed SL-QZSI has traditional six active, two zero states and extra shoot-through zero states like conventional ZSI. Thus, the operating principles of both proposed inverter and the classical ZSIs are similar. The operating states of proposed SL-QZSI are classified into shoot-through and non-shoot- through states.

Non- shoot- through state:

During the non-shoot-through state the proposed inverter has six active states and two zero states. In this state, D_{in} and D_1 are on, while diodes D_2 and D_3 are off. Inductors L_2 and L_3 are connected in series. The capacitors C_1 and C_2 are charged, while the inductors L_1, L_2, and L_3 transfer energy from the dc input source to the main power circuit. V_{L2}_non and V $_{L3}$_non-are the corresponding voltages across L_2 and L_3 respectively. Fig. 2(a) and Fig 2(b) show the non- shoot -through operating state and reduced equivalent circuit of SL-QZSI under non-shoot-through state.

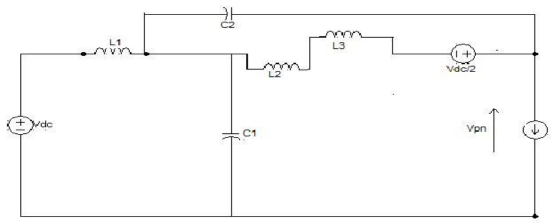

Fig. 2(a). Non- shoot-through operating state

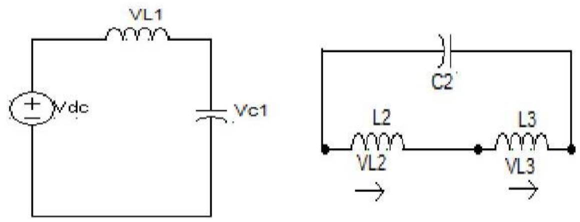

Fig. 2(b). Reduced Equivalent circuit of SL-QZSI under non-shoot-through state

$$VL1 = VC1 = Vdc \quad (1)$$

$$VL2 = VL2\_non = VC2 - VL3\_non \quad (2)$$

$$VL3 = VL3\_non = VC2 - VL2\_non \quad (3)$$

$$VPN = VC1 + VC \quad (4)$$

$$VL1 = -VC2 - Vdc \quad (5)$$

$$VL2 = VL3 = -VC1 \quad (6)$$

Shoot- through state:

This state occurs when both the upper and lower switching references. The shoot- through state repeats periodically every devices of any phase leg of the inverter is shorted. The shoot- through operating state and reduced equivalent circuit of SL-QZSI under shoot-through state is shown in Fig. 3(a) and Fig.3(b). During shoot- through state, D_{in} and D_1 are off, while D_2 and D_3 are on. The inductors L_2

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and L_3 are connected in parallel and the capacitors C1 and C2 are discharged, while inductors L_1, L_2, and L_3 store the energy.

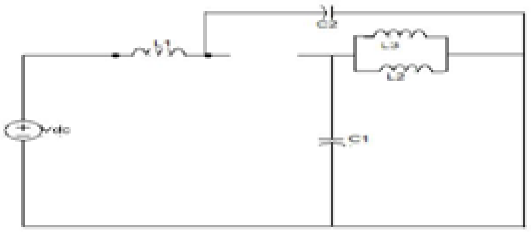

Fig. 3(a). Shoot-through operating state

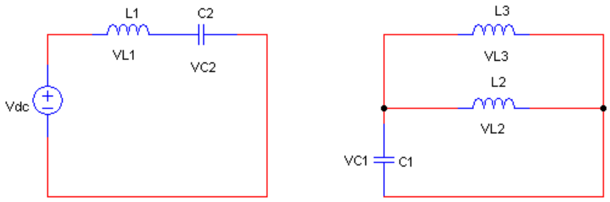

Fig. 3(b). Reduced Equivalent circuit of SL-QZSI under shoot-through state

3. SL-QZSI FED INDUCTION MOTOR WITH FOPID CONTROLLER

DC from the yield of semi-converter is applied to SL-Network. The DC yield of the SL network is connected to the inverter. The VSI is used to have power over the speed of the drive for fluctuating AC voltage. The DC voltage of the semi-converter is controlled by utilizing (FOPID) to lessen the settling-time. The block diagram of open loop SLQZSI fed IM drive system is shown in Fig. 4. The block diagram of closed loop SLQZSI fed IM with PI controller is shown in Fig. 5. The block diagram of proposed closed loop SLQZSI fed IM drive with FOPID-controller is shown in Fig. 6.

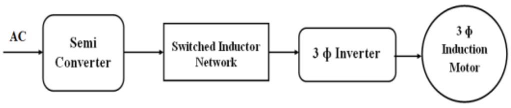

Fig. 4. Block diagram of open loop SLQZSI fed IM

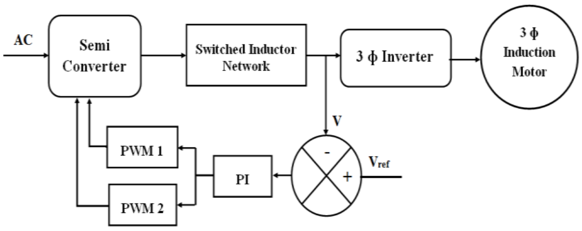

Fig. 5. Block diagram of Closed loop SLQZSI-IM with PI controller

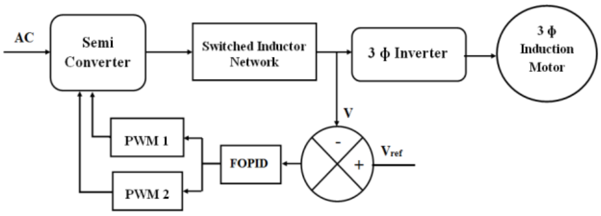

Fig. 6. Block diagram of closed loop SLQZSI-IM with FOPID controller

4. SIMULATION RESULTS

A. Open loop SLQZSI fed induction motor with disturbance

Open loop SLQZSI fed IM with disturbance is modeled and simulated using Matlab is displayed in Fig. 7. The AC input voltage of 110V (peak amplitude), 50Hz are applied to SLQZSI fed IM with disturbance is laid out in Fig. 8. Voltage across SLQZSI is displayed in Fig. 9 Output voltage 130V of inverter in SLQZSI fed induction motor is displayed in Fig. 10. Fig. 11 demonstrates the current through inverter of SLQZSI fed induction motor. Motor speed of 900 rpm and torque of 2.5 N-m of SLQZSI fed induction motor is laid out in Fig. 12 and Fig. 13 respectively.

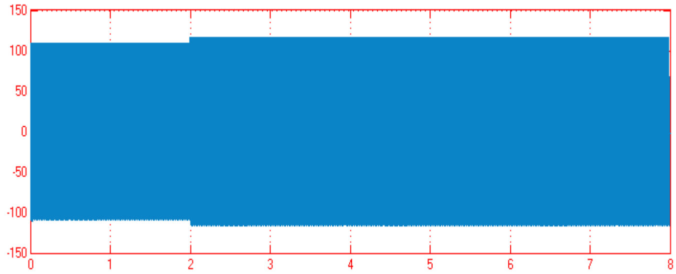

Fig. 8. AC input voltage

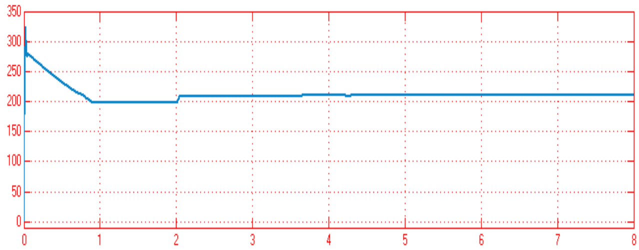

Fig. 9. Voltage across SLQZSI

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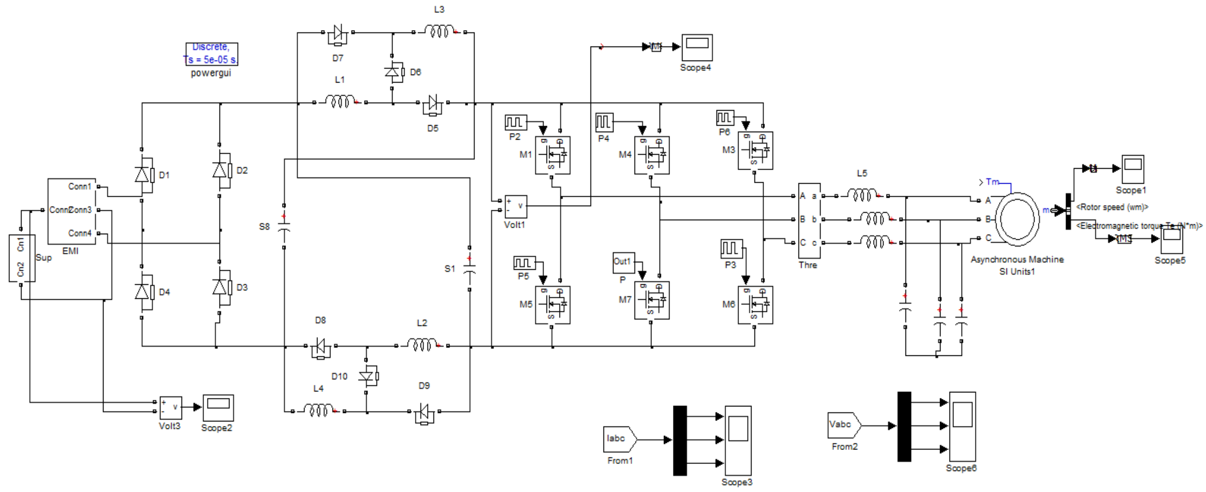

Fig. 7. Simulation diagram of open loop SIQZSI-IM with disturbance

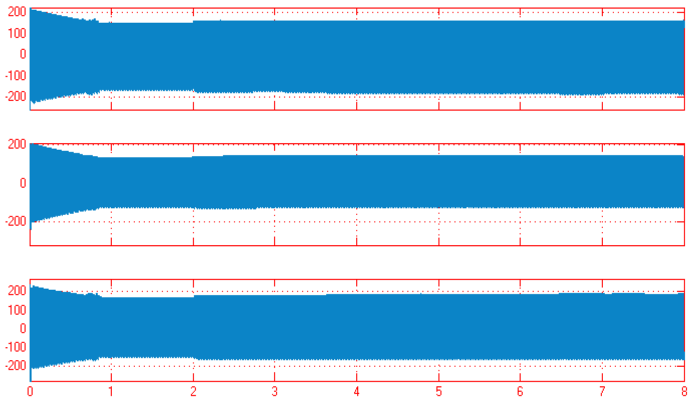

Fig. 10. Output voltage of inverter in SLQZSI fed IM

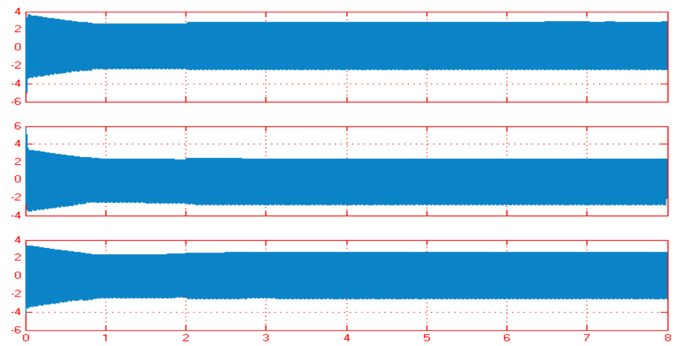

Fig. 11. Current through inverter in SIQZSI fed IM

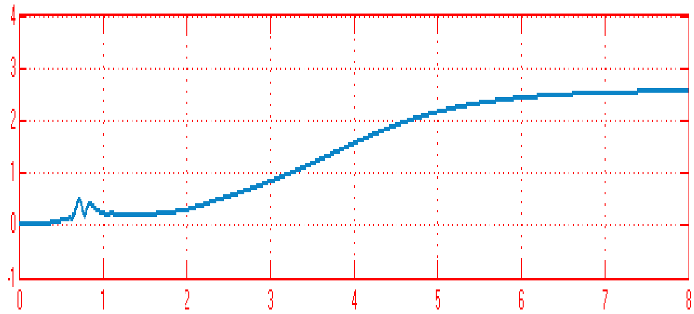

Fig. 12. Motor speed of SLQZSI fed IM

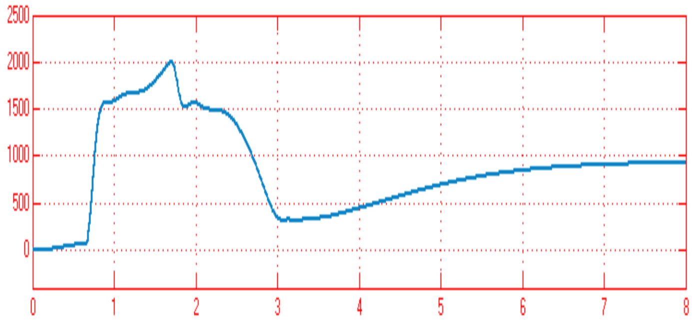

Fig. 13. Motor Torque of SIQZSI fed IM

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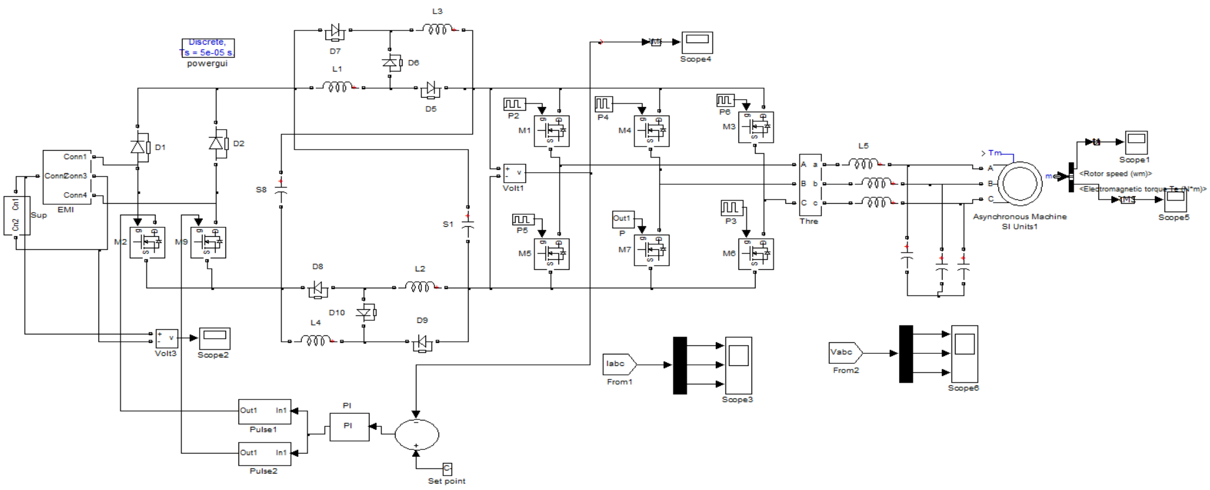

Fig. 14. Simulation diagram of Closed control loop SLQZSI fed IM with PI controller

B. **Closed loop SLQZSI fed IM with PI controller**

Closed loop SLQZSI fed IM with PI controller is modeled and resembled using Matlab is shown in Fig. 14. The AC input voltage of 110V (peak amplitude), 50Hz are applied to SLQZSI fed IM with PI controller is displayed in Fig. 15. Voltage across SLQZSI with PI controller is laid out in Fig. 16. Output voltage 200V of inverter in SLQZSI fed induction motor is laid out in Fig. 17. Fig. 18 demonstrates the current through load of SLQZSI fed induction motor with PI controller. Motor speed of 900 rpm and torque of 2.6 N-m of SLQZSI fed induction motor is displayed in Fig. 19 and Fig. 20 reciprocally.

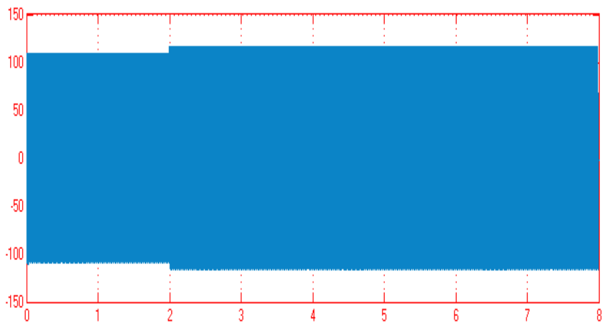

Fig. 15. AC input voltage

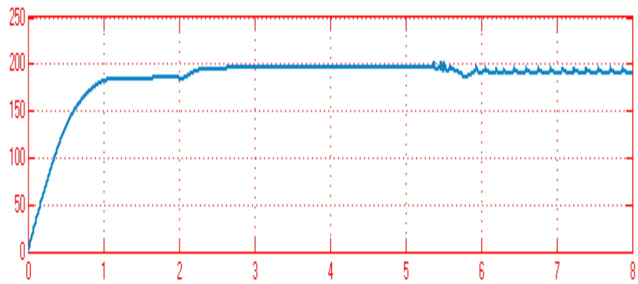

Fig. 16. Voltage across switched inductor quasi Z source of Closed loop SIQZSI fed IM with PI controller

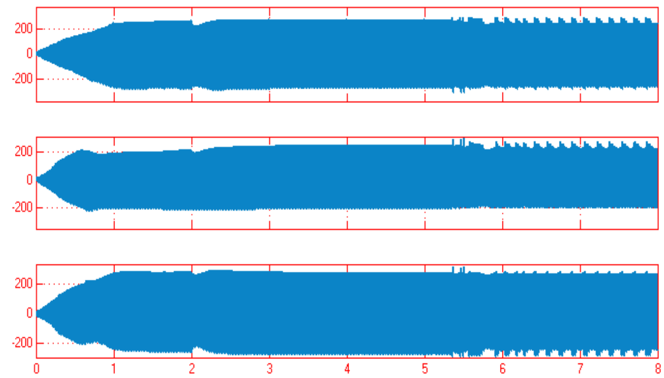

Fig. 17. Output voltage across inverter of Closed control loop SIQZSI-IM with PI controller

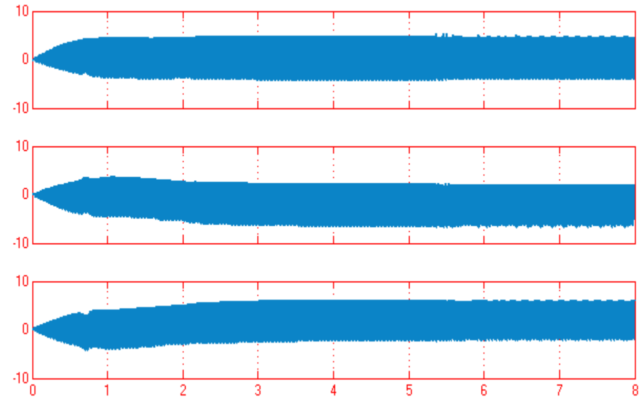

Fig. 18. Current through load of Closed loop SIQZSI fed IM with PI controller

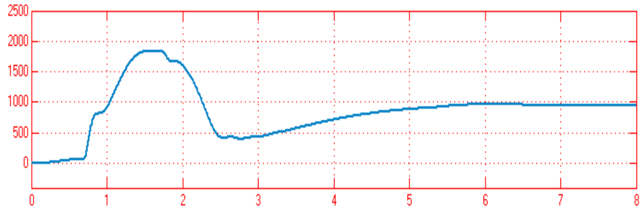

Fig.19. Motor speed of Closed control loop SLQZSI fed IM with PI controller

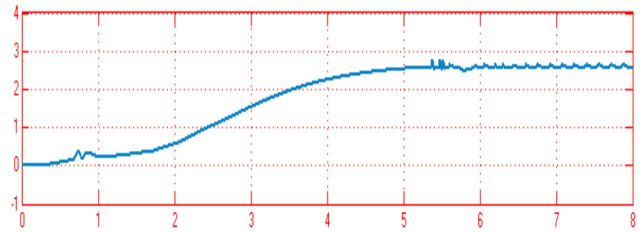

Fig. 20. Motor Torque of Closed loop SIQZSI fed IM with PI controller

C. Closed loop SLQZSI fed IM with FOPID controller

Closed control loop SLQZSI fed induction motor with FOPID controller is modeled and simulated using Matlab is displayed in Fig. 21. The AC input voltage of 110V (peak amplitude), 50Hz are applied to SLQZSI fed IM with PI controller is laid out in Fig. 22. Voltage across SLQZSI fed induction motor with FOPID controller is displayed in Fig. 23. Output voltage 300V of inverter in SLQZSI fed IM with FOPID controller is laid out in Fig. 24. Fig. 25 presents the current through load of SLQZSI fed induction motor with FOPID controller. Motor speed of 900 rpm and torque of 2.6 N-m of SLQZSI fed induction motor is displayed in Fig. 26 and Fig. 27 reciprocally.

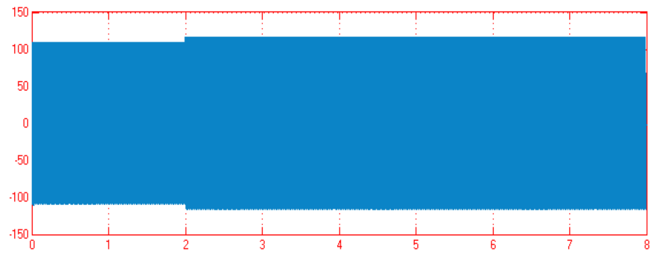

Fig. 22. AC input voltage

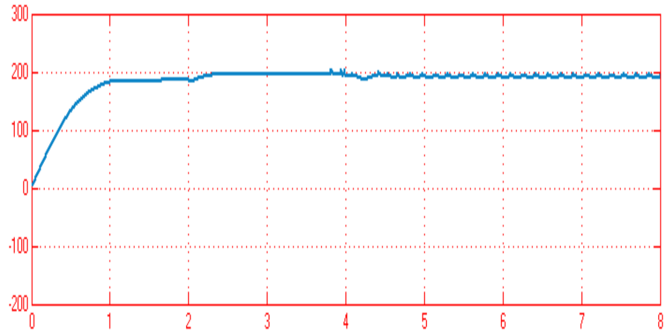

Fig. 23 .Output voltage of switched inductor Z source of SLQZSI fed IM with FOPID controller

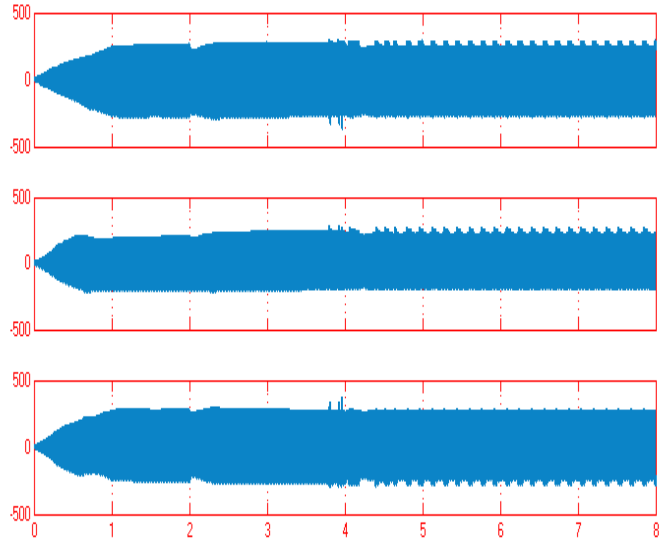

Fig. 24. Voltage across load of SLQZSI fed IM with FOPID controller

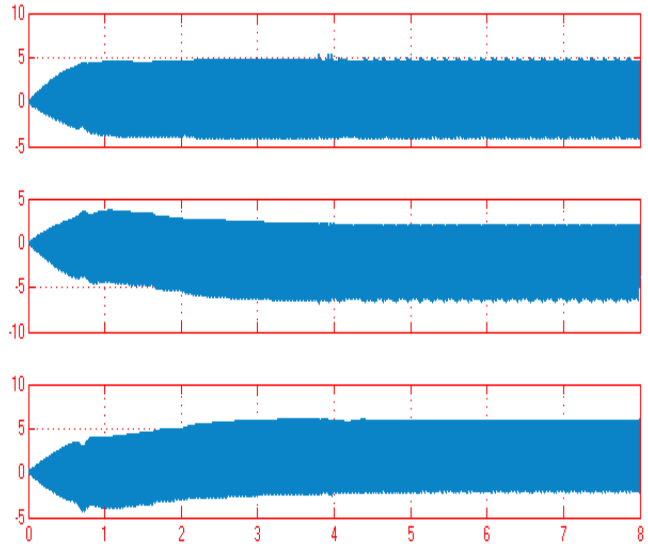

Fig. 25. Current through inverter of SLQZSI fed IM with FOPID controller

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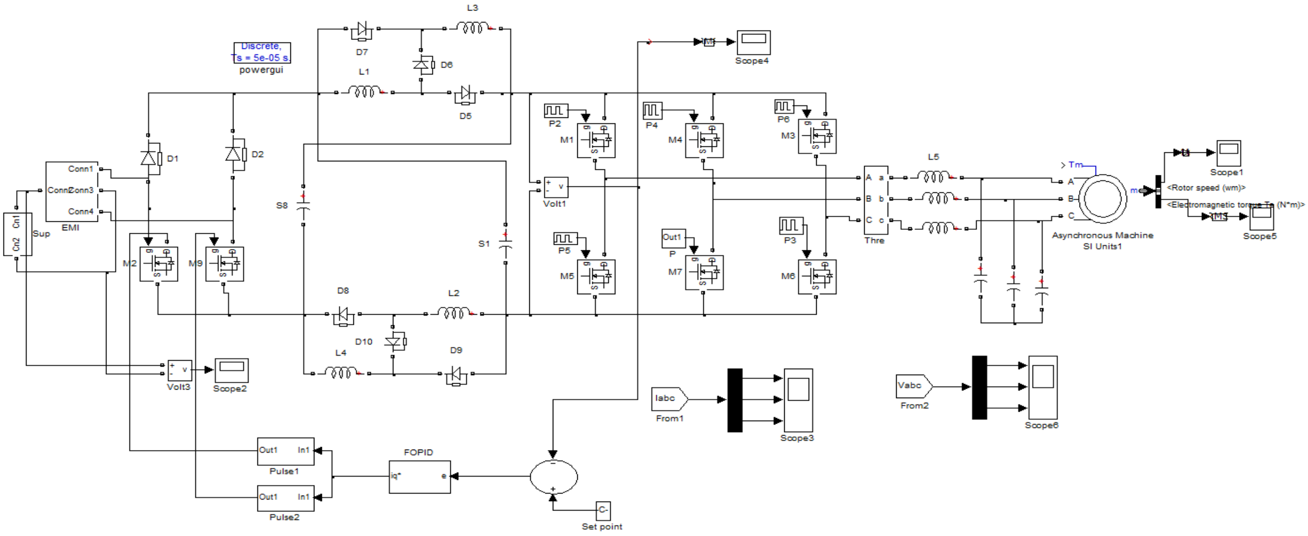

Fig. 21.Simulation diagram of Closed control loop SIQZSI-IM with FOPID controller

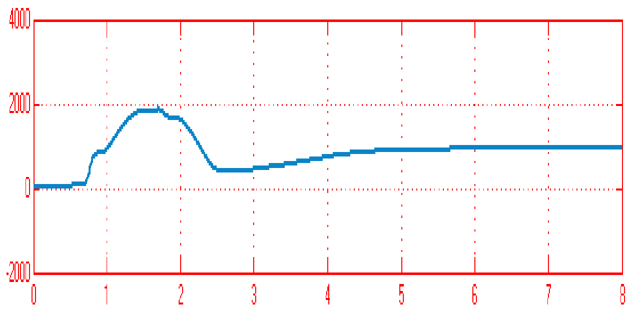

Fig. 26. Motor speed of SIQZSI fed IM with FOPID controller

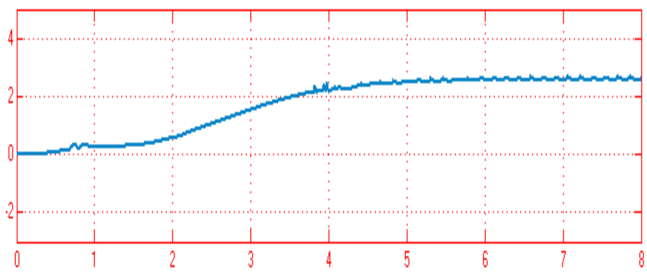

Fig. 27. Motor Torque of SIQZSI fed IM with FOPID controller

A comparison of time-domain parameters using PI and FOPID is provided in Table-1. By adopting FOPID, rise-time is lessened from 2.23 sec to 2.22 sec, peak-time is lessened from 5.2 Sec to 3.6Sec, settling-time is lessened from 6.0 sec to 4.3 sec and steady-state error is lessened from 8.3V to 5.6V.

Table -1

Comparison of time domain parameters SLQZSI fed IM using PI and FOPID

Controller	Rise time	Peak time	Settling time	Steady state error
PI	2.23	5.2	6.0	8.3
FOPID	2.22	3.6	4.3	5.6

5. CONCLUSION

"Open-loop and Closed-loop-SLQZSI with PI and FOPID controller"are replicated by exercising Matlab simulink. By adopting FOPID, settling-time is reduced from 6.0 Sec to 4.3Sec& steady-state-error is decreased from 8.3V to 5.6V. Hence, 'FOPID-controlled- SLQZSI is superior to PI-controlled- closed-loop-SLQZSI'. The benefits of SLQZSI – IM are lessened switch count and improved time response. The drawback of SLQZSI – IM is increased number of passive components. The Current-article pacts with the comparison of PI and FOPID-controlled-closed-loop-SLQZSI. Hysteresis-controlled-closed-loop-SLQZSI can be done in succeeding work.

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