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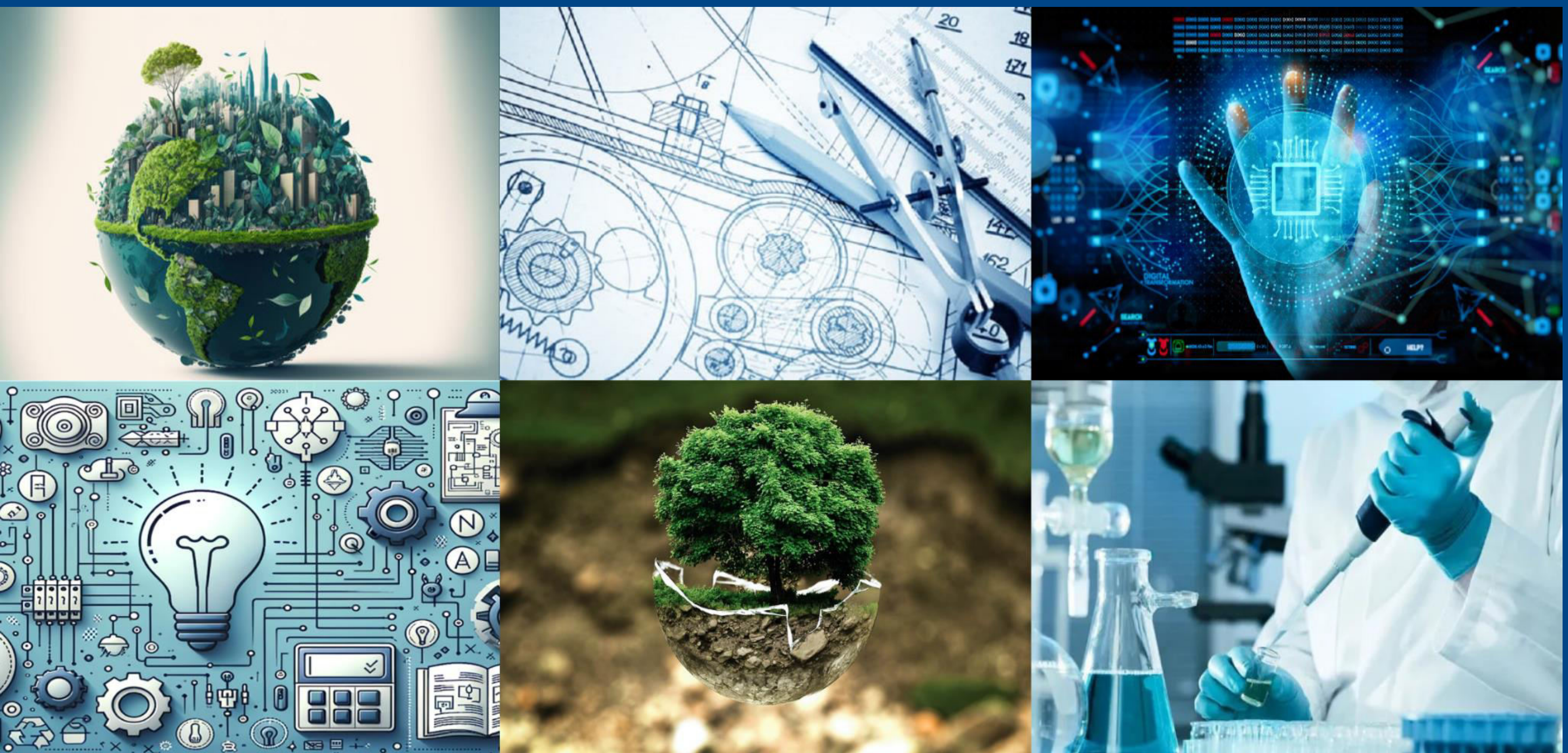

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# Review on Design and Simulation of Z Source Inverter Fed Induction Motor Drive

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**Abstract:** The use of induction motors has been increasing greatly since the day of its development. The reason for its day by day increasing reputation can be primarily attributed to its robust construction, simplicity in design and cost effectiveness. They are being used in robotics, domestic and other applications. So, for wide range of use in the industry, the machine requires an efficient drive circuit arrangement. Currently, conventional voltage source inverter (VSI) or current source inverter (CSI) is dealing as key part in the field of induction motor drive circuit. These inverters fail to perform at our desire level due to some crucial drawbacks. In this project the drawbacks of traditional inverters are eliminated by replacing it with Z –Source inverter (ZSI). This project is mainly focused on effective control of induction motor with Z–Source inverter (ZSI).

**KEYWORDS:** Voltage source converter CSI, Z- Source,

## I. INTRODUCTION

Conventional converter topologies such as voltage source inverter (VSI) and current source inverter (CSI) are commonly used as power electronics circuits for power conversion purposes. The VSI produces an ac output (after filtering it) which is limited below the dc input voltage, which means that VSI is buck type converter. The buck operation nature of the VSI limits its operation to power conversion applications and ac drive circuits. An additional dc-dc unit is connected to the dc input of the converter in order to further increase the dc input voltage, which leads to an increase in the ac output voltage. As a result, the additional dc-dc boost converter increases the system cost, control complexity and reduces the efficiency. Further, animism-gating of the inverter bridge switches cause short circuit and destroys the power switching devices. For that, a dead-time is set between the upper and the lower switching devices of the same leg in order to avoid short circuit occurrences. The idea of impedance-source converter (ZSI) was originally developed due to the limitation in VSIs and CSIs. The conceptual and theoretical limitations in the conventional converters types reduce their application and complicate their control methods. While the ZSI great advantage can be seen as: it can operate as VSI inverter (buck type) or as CSI inverter (boost type) depending on the application. The output voltage can ideally ranges from zero to infinity. Since the invention of the ZSI inverter, there are number of research works on this interesting topology, and this project presents its basic operation and control. The limitations of traditional converter are:

- The capability of traditional converter is only used as buck converter or boost converter.
- Efficiency lower down where over drive is required
- No two thyristors can be gated ON in the same leg
- Only 8 switching states are available in traditional converter.
- Either capacitor or inductor available for energy storage and suppress ripples.

The Z-source inverter mainly used the shoot-through states to boost the dc bus voltage for the turning ON two thyristors of the upper and lower phase same leg. As a result the Z-source inverter can buck and boost voltage to a wanted output voltage that is more than dc bus voltage. Therefore improve the reliability of an inverter, the shoot-through cannot occurs to burnout the circuit. The advantages of ZSI has a low-cost, reliable and highly efficient single-stage structure for boost and buck power conversion. The main structure circuit of the Z-source inverter is presented in Fig.1. The maximum constant boost control can greatly reduce the L and C requirements of the Z-source impedance network.

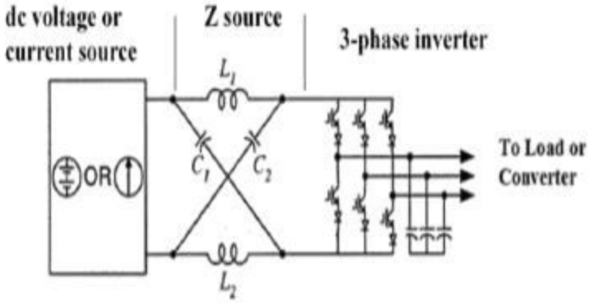


Fig. 1.Structure of ZSI

The purpose of this work is to investigate modelling and simulation of a single phase Z-source inverter and its control strategy for implementation dc-to-ac power conversion. The research motivation for this thesis also comes from the necessity of maximum power point tracking (MPPT) for the solar PV panels. The Z-source inverter and its control system should be capable of tracking individual maximum power point of the solar panels and ensures the maximum capture of energy on DC side. The ZSI impedance network has a unique LC network which is connect with dc link and controller to provide optimal output ac voltage. Also, a comparative performance analysis of a ZSI and VSI which is fed by a DC source is carried out using characteristics and torque.

the efficiency of gas system drive. Two types of indirect DC-link voltage control techniques were examined in order to estimate operation effectiveness of control system in dynamic modes. For that purpose, simulation model of ZSI fed by induction motor, based on state space averaged modelling method, has been developed utilizing MATLAB/Simulink environment. The simulation results of dynamic performance of the ZSI with single-loop and dual-loop capacitor voltage control techniques during input voltage changes and steady state operations are presented and analyzed

## II. PREVIOUS WORK

[1] D. I. Ivanchenko, R. A. Salov and E. V. Yakovleva, "Analysis of Z-source inverter control system for asynchronous drive for gas compressor," 2018 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (EIConRus), 2018, pp. 636-640, doi: 10.1109/EIConRus.2018.8317177.
The article deals with the comparison of Z-source inverter based control systems for the asynchronous drive of gas compressor that is used in oil and gas industry. The relevance of the task is highlighted by the fact that choice of control system determines the reliability and.

[2] V. Sharma, M. J. Hossain, S. M. N. Ali, M. Kashif and E. Fernandez, "Design and Implementation of Trans-Z-Source Inverter-Fed Induction Motor Drive with Fault-Tolerant Capability," 2020 IEEE Applied Power Electronics Conference and Exposition (APEC), 2020, pp. 690-695, doi: 10.1109/APEC39645.2020.9124323.

The traditional Z-source inverter suffers from large voltage stress across the switches, and discontinuous source current, which is not appropriate for the electric motor drives applications. This paper presents a design and thorough analysis of a trans-Z-source (transformer-based Z-source) with higher boost capability and negligible leakage inductance which overcomes the drawbacks of traditional Z-source inverters (ZSI). Additionally, the fault-tolerant capability of the proposed trans-ZSI is investigated for open-circuit and short-circuit faults occurring in the power semiconductor switches of the inverter module. It proposes a highly efficient faulty leg identification method which is independent of the temperature rise occurring due to high current in the faulty mode.

The proposed fault-tolerant scheme is characterized by low cost, fast fault diagnosis irrespective of load, and maintaining post-fault speed characteristics of motor identical to pre-fault characteristics. The experimental results are presented to validate the effectiveness of the proposed method for induction motor drives. Also, a comparative study with similar fault diagnosis strategies is tabulated to validate the potential of the proposed fault-tolerant strategy.

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[3] S. Rahman, K. Rahman, M. A. Ali, M. Meraj and A. Iqbal, "Quasi Z Source Inverter Fed V/f Controlled Five Phase Induction Motor Drive Powered," 2019 International Conference on Electrical, Electronics and Computer Engineering (UPCON), 2019, pp. 1-6, doi: 10.1109/UPCON47278.2019.8980073.

Impedance Source Inverters are extremely popular these days. They offer simultaneous boosting of input voltage applied as well as inversion operation. The converter achieves this by means of a specially designed impedance network along with H - Bridge. Unlike conventional H - Bridge (HB) inverters, impedance source inverters can boost the supply voltage thereby achieving boost operation. Utilizing this feature, voltage transient due to grid side disturbance, improved control and enhanced fault tolerance capability can be achieved. There are two types of impedance source-based inverters namely Z Source Inverters (ZSI) and quasi Z Source Inverters (qZSI). In this paper, five phase qZSI fed five phase induction motor drive is discussed. V/f control is implemented to induction motor in synchronism with closed loop voltage control of quasi network output voltage. Constraints in the integrated performance are discussed and taken into consideration for development of control algorithm. Simulation results are presented for the system when subjected to different load transients thereby validating the integrated control.

[4] O.B. Shonin, R.A. Salov, “Improvement in energy efficiency, reliability and environmental safety of power plants based on associated petroleum gas”, Journal of Ecological Engineering, vol. 18, i. 3, 2017, pp. 91–96. DOI: 10.12911/22998993/69357The article deals with the comparison of Z-source inverter based control systems for the asynchronous drive of gas compressor that is used in oil and gas industry. The relevance of the task is highlighted by the fact that choice of control system determines the reliability and the efficiency of gas system drive. Two types of indirect DC-link voltage control techniques were examined in order to estimate operation effectiveness of control system in dynamic modes. For that purpose simulation model of ZSI fed by induction motor, based on state space averaged modeling method, has been developed utilizing MATLAB/Simulink environment. The simulation results of dynamic performance of the ZSI with single-loop and dual-loop capacitor voltage control techniques during input voltage changes and steady state operations are presented and analyzed.

[5] O. Ellabban, J.V. Mierlo, P. Lataire, “Capacitor Voltage Control Techniques of the Z-source Inverter: A Comparative Study”, EPE Journal, Vol. 21, no. 4, 2011, pp. 13-24. DOI:10.1080/09398368.2011.11463806.The Z-source inverter (ZSI) is a recently proposed single-stage power conversion topology. It adds voltage boost capability for complementing the usual voltage buck operation of a traditional voltage source inverter (VSI) with improved reliability. In this paper, a single-loop and dual-loop capacitor voltage control techniques for the ZSI are digitally designed based on a third order small signal model of the ZSI, implemented using a digital signal processor (DSP) and compared. Simulation and experimental results of a 30 kW ZSI during input voltage changes, load disturbances and steady state operations are presented and compared. The results show that the dual-loop capacitor voltage control technique achieves better steady state and transient performance and enlarge the stability margins of the ZSI compared to the single-loop capacitor voltage control technique.

## III. TRADITIONAL VOLTAGE SOURCE INVERTER

Fig. 2 shows the traditional single-phase voltage-source converter (abbreviated as V-source converter) structure. A dc voltage source supported by a relatively large capacitor feeds the main converter circuit, a single-phase bridge. The dc voltage source can be a battery, fuel-cell stack, diode rectifier, and/or capacitor. Four switches are used in the main circuit; each is traditionally composed of a power transistor and an antiparallel (or freewheeling) diode to provide bidirectional current flow and unidirectional voltage blocking capability.

Fig. 3.4.1 Traditional Voltage Source Inverter

It, however, has the following conceptual and theoretical barriers and limitations. The ac output voltage is limited below and cannot exceed the dc-rail voltage or the dc-rail voltage has to be greater than the ac input voltage. Therefore, the voltage source inverter is a buck (step-down) inverter for dc-to-ac power conversion and the voltage source converter is a boost (step-up) rectifier (or boost converter) for ac-to-dc power conversion. For applications wherever drive is desirable and the available dc voltage is limited, an additional dc-dc boost converter is needed to obtain a desired ac output .The additional power converter stage increases system cost and lowers efficiency. The upper and

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lower devices of each phase leg cannot be gated on simultaneously either by purpose or by EMI noise. Otherwise, a shoot-through would occur and
destroy the devices. The shoot-through problem by electromagnetic interference (EMI) noises mis-gating-on is a major killer to the converter's reliability. Dead time to block both upper and lower devices has to be provided in the voltage source converter, which causes waveform distortion, etc. An output LC filter is needed for providing a sinusoidal voltage compared with the current-source inverter, which causes additional power loss and control complexity.

## IV. TRADITIONAL CURRENT SOURCE INVERTER

Fig. 4.6 shows the traditional single-phase current-source converter (abbreviated as I-source converter) structure. A dc current source feeds the main converter circuit, a single-phase bridge. The dc current source can be a relatively large dc inductor fed by a voltage source such as a battery, fuel-cell stack, diode rectifier, or thyristors converter. Four switches are used in the main circuit; each is traditionally composed of a semiconductor switching device with reverse block capability such as a gate-turn-off thyristors (GTO) and Silicon Controlled Rectifier (SCR) or a power transistor with a series diode to provide unidirectional current flow and bidirectional voltage blocking

Fig. 3.5.1 Traditional Current Source Inverter However, the Current source converter has the following conceptual and theoretical barriers and limitations. The ac output voltage has to be greater than the original dc voltage that feeds the dc inductor or the dc voltage produced is always smaller than the ac input voltage. Therefore, the current source inverter is a boost inverter for dc-to-ac power conversion and the current source converter is a buck rectifier (or buck converter) for ac-to-dc power conversion. For applications where a wide voltage range is desirable, an additional dc–dc buck (or boost) converter is needed. The additional power conversion stage increases system cost and lowers efficiency. At least one of the upper devices and one of the lower devices have to be gated ON and maintained ON at any time. Otherwise, an open circuit of the dc inductor would occur and destroy the devices. The open-circuit problem by EMI noise's mis-gating- OFF is a major concern of the converter's reliability. Overlap time for +safe current commutation is needed in the current source converter, which also causes waveform distortion, etc. The main switches of the current source converter have to block reverse voltage that requires a series diode to be used in combination with high-speed and high performance transistors such as insulated gate bipolar transistors (IGBTs). This prevents the direct use of low-cost and high-performance IGBT modules and intelligent power modules (IPMs).

## V. VOLTAGE SOURCE CONVERTER AND CURRENT SOURCE CONVERTER COMMON PROBLEMS.

They are either a boost or a buck converter and cannot be a buck–boost converter. That is, their obtainable output voltage range is limited to either greater or smaller than the input voltage. The VSI is a buck (down) inverter where AC output voltage cannot exceed DC input voltage. CSI is a boost (up) inverter where AC output voltage is always greater than the DC voltage feeding the inductor. For applications exceeding available voltage range an additional boost (or buck) DC/DC converter is needed. This increases the system cost and decreases the efficiency.

Their main circuits cannot be interchangeable. In other words, neither the voltage source converter main circuit can be used for the current source converter, or vice versa. They are vulnerable to EMI noise in terms of reliability. For a VSI, the upper and lower switches cannot be ON simultaneously which may cause a short circuit. On the other hand, for a CSI one of the upper switches and one of the lower switches have to be ON to provide a path for the continuous input current. The VSI (CSI) requires dead time (overlap time) to provide safe commutation which causes waveform distortion. In a CSI, switch implementation requires diodes Parallel diodes implementation, as is usually manufactured in series with the switches. This Prevents the use of low cost switches which come with anti

## VI. RESEARCH OBJECTIVES

The objectives for research work are:
- Implementation of PV cell in MATLAB Simulink.
- Simulation of conventional inverter for induction motor drive fed from solar PV source
- Study of ZSI and its simulation in MATLAB
- Comparative performance characteristics analysis of conventional inverter with ZSI

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## VII. PROPOSED MEHODOLOGY

The proposed work is planned to be carried out in the following manner:

1. Study of basic concepts of Induction motor
2. Study of basic concepts of Z- source Inverter.
3. Finding the problems from conventional
4. System by surveying literature.
5. Design VSI fed induction motor drive/.
6. Analysis of the proposed topology.
7. Study of the control strategies of system.
8. Simulation of the model can be done in MATLAB software. Evaluation of the performance

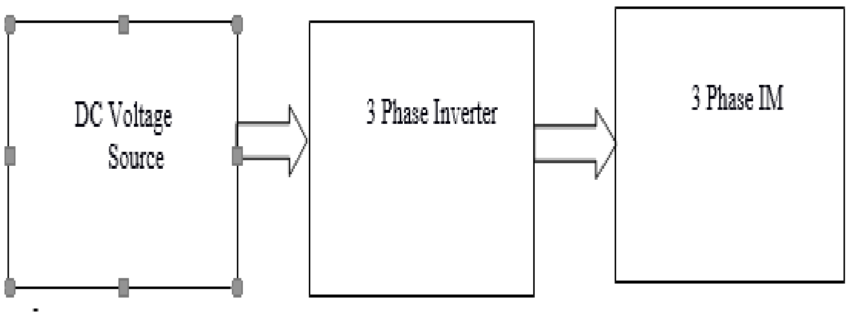


Fig. 2: Block Diagram of Voltage -Source Inverter fed Induction Motor drive

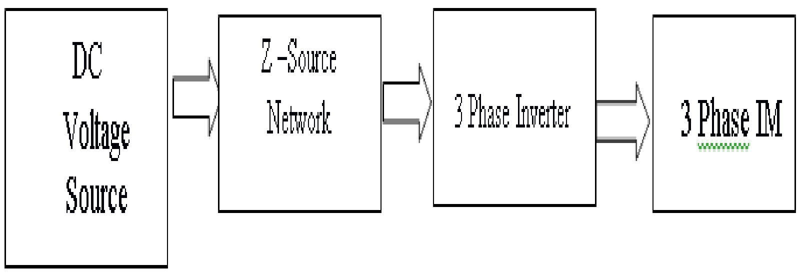


Fig.3: Block Diagram of Z-Source Inverter fed Induction Motor drive without Controller

Z source inverter system and Voltage Source inverter fed induction motor system is explained in details. Limitation of convectional converter and advantages of ZSI are also listed and explained. The PV module is used as a source to fed the complete system. The design requirements of PV module and mathematical modelling have been presented with I-V and P-V characteristics indicating the maximum operating conditions.

The MPPT control with P&O and Incremental Conductance is explained. The ZSI fed induction motor drive by PV source and VSI fed Induction motor drive by PV source modelling using MATLAB Simulink and result discussed. From the observations, it can be concluded that the Z source inverter fed induction motor drive has better settling time, less torque ripples, improved stator and rotor current for the same load and speed as compared to the Voltage Source inverter fed induction motor drive.

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