A survey on Different Control Strategy of Inverter Fed Induction Motor Drive

Aftab Beg[1], Anurag Soni[2], Amol Barve[3]
PG Scholar, LNCT, Bhopal, M.P., India[1]
Associate Professor, LNCT, Bhopal, M.P., India[2]
Head of Department, LNCT, Bhopal, M.P., India[3]
aftabbeg.01@gmail.com[1], anurag.ashok25@gmail.com[2]

ABSTRACT
A control system speed control of impedance source inverter fed induction motor drive with peak dc link voltage control is proposed here. It will overcome the restrictions of voltage source inverter and might provide higher speed control and drive operation throughout voltage sags and traditional operating conditions. The peak dc link voltage utilized so as to achieve wonderful transient performance which reinforces rejection of disturbance, as well as thee input voltage ripple and load current variation, and have sensible ride through for voltage sags. An easy boost control PWM is used in switch algorithmic rule.

Keywords: VSI, CSI, ZSI, ST, SBC, MBC, MCBC, MSVMBC etc.

INTRODUCTION
Many research works are focusing in the development of the efficient control algorithms for high performance variable speed induction motor (IM) drives. Induction motor has been operated as a work horse in the industry due to its easy build, high robustness and generally satisfactory efficiency. Recent development of high speed power semi conductor devices, three phase inverters take part in the key role for variable speed AC motor drives. Traditionally, Three Phase inverters with six switches (SSTP) have been commonly utilized for variable speed IM drives; this involves the losses of the six switches as well as the complexity of the control algorithms and interface circuits to generate six PWM logic signals. So far researchers mainly concentrated on the development of new control algorithms. However, the cost, simplicity and flexibility of the overall drive system which are some of the most important factors did not get that much attention from the researchers. That is why, despite tremendous research in this area, most of the developed control system failed to attract the industry. Thus, the main issue of this work is to develop a cost effective, simple and efficient high performance IM drive.

The traditional inverters are Voltage source inverter (VSI) and Current source inverter (CSI), that carries with it diode rectifier front end, DC link and inverter Bridge. So as to enhance power issue, either an AC inductor or DC inductor is normally used. The DC link voltage is roughly capable to1.35 times the line voltage and also the Voltage source inverter is a buck converter that may solely manufacture produce AC voltage restricted by the dc link voltage. As a result of this nature, the Voltage source inverter primarily based PWM VSI and CSI are characterized by comparatively low efficiency as a result of switch losses and wide electromagnetic Interference (EMI) generation.

In order to satisfy the pressing wants for one a single capable of each voltage boosting and inversion, several new inverter topologies are proposed within the recent past. Among these new topologies, Impedance-Source inverter converter (ZSI) is that the most promising and competitive technology over the others primarily as a result of it continues to use a standard VSI because the power converter however with a changed dc link stage. The impedance source inverter employs a novel impedance network including inverter and rectifier; it overcomes the conceptual barriers and limitations of the traditional converters. The Impedance-source inverter purposely utilizes the shoot through zero states to boost dc voltage and to produce an output voltage larger than the initial dc voltage. At a similar time, the Impedance -source structure enhances the reliable of the inverter greatly as a result of the shoot through states, which could cause by EMI noise, will now not destroy the inverter. Control methods of the ZSI are important issue and a number of other feedback control methods are investigated in recent publications.

Since the ZSI was proposed in 2003 [1], lots of work had been done in the Soot through (ST) control methods. Four different ST control methods have been proposed in the literature, which are: simple boost control (SBC) [1], maximum boost control (MBC) [2], maximum constant boost control (MCBC) [3] and modified space vector modulation boost control (MSVMBC) [4] methods. In [5], the authors present a review of these four ST boost control methods and present a comparison between them based on simulation and experimental results. They concluded that the MCBC method seems to be the most suitable boost control method for inserting the ST state within the switching states of the ZSI. Therefore, the MCBC method will be used in this paper. The control strategy of the ZSI is an important issue and several feedback control strategies have been investigated in recent publications [6-21]. There are four methods for controlling the ZSI DC link voltage, which are: capacitor voltage control

[6-14], indirect DC-link voltage control [15, 16], direct DC-link control [17-19] and unified control [20, 21]. In [6-8], the capacitor voltage is controlled by regulating the ST duty ratio using different control methods. Where, in [6] a PID controller is used to control the ST duty ratio and the modulation index is set to be $M = 1 – D_0$ using the SBC method. While, in [7] a PI controller with saturation is used to control the ST duty ratio and a PI controller tuned by a neural network for wide range control is used in [8], where the MSVMBC method is used in [7-8]. In [9-11], nonlinear control methods are used to control the capacitor voltage using the SBC method, where the gain scheduling combined with the state feedback control was used in [9, 10] and sliding mode control method was used in [11]. In [12-14], the capacitor voltage is controlled by the regulating the ST duty ratio and the output voltage is controlled by regulating the modulation index using the MSVMBC method with two separate control loops with PI controllers as in [12, 13] and a neural network controllers as in [14]. In [15], a PID-like fuzzy controller is used to indirectly control the average DC-link voltage using the SBC method, where the average DC-link voltage is calculated by measuring the capacitor voltage using the following relation $V_i = V_c/(1 – D_0)$. Moreover, in [16], the peak DC-link voltage is indirectly controlled by controlling the peak AC output voltage using a PI controller to regulate the modulation index and the ST duty ratio is calculated by measuring the input voltage and comparing it by the required peak DC link voltage using the MSVMBC method. In [17, 18], the peak DC link voltage is directly controlled by regulating the ST duty ratio, the peak DC-link voltage is measured using an additional circuit, because of its pulsating nature, which makes the control algorithm more complex, the SBC method was used in [17] and the MSVMBC was used in [18]. In [19], the peak DC-link voltage is directly controlled by regulating the ST duty ratio using the SBC method, where the peak of the DC-link voltage was estimated by measuring both the input and the capacitor voltages, as $V_{ip} = 2V_c – V_{in}$. In [20, 21], the unified control method is used to regulate the modulation index and the ST simultaneously by controlling the AC output voltage using a single PI controller using the MSVMBC method.

The paper presents detailed analysis of closed loop speed control of induction motor drive from low speed to rated speed also the implementation of Impedance source inverter for controlling them. The peak dc link voltage control is used to enhance the performance of the system.

II POWER CONVERTERS FOR WECS

This section presents a comparative study of the most important control strategies (Scalar control (V/f), indirect field orientated control (IFOC) associated direct torque control (DTC)) for an induction motor fed by a ZSI for automotive applications. The three control techniques are implemented using PWM voltage modulation. The comparison is predicated on various criteria including: basic control characteristics, dynamic performance, and implementation quality.

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Scalar control (V/f) Technique

The closed-loop speed control by slip regulation, that is an improvement of the open loop *V/f* control, is shown in Figure 1. The speed loop error generates the slip command ω_{sl}^* through a proportional integral (PI) controller with a limiter. The slip is added to the feedback speed signal to generate the slip frequency command ω_e^*. So the frequency command generates the voltage command through a *V/f* generator, which includes the low frequency stator drop compensation. Hence this control technique is simple; it provides limited speed accuracy particularly within the low speed range and poor dynamic torque response.

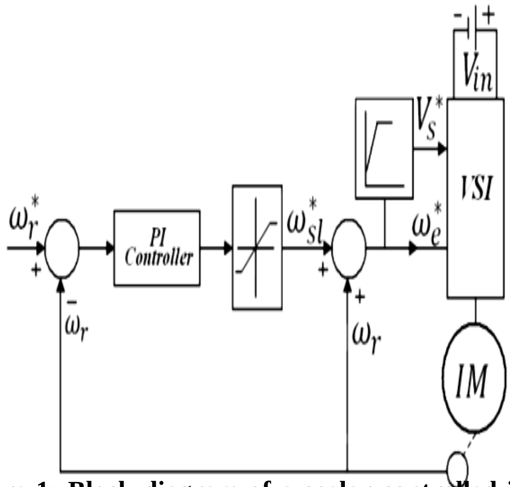

Figure 1: Block diagram of a scalar controlled induction motor

Indirect Field Oriented Control (IFOC) Technique

In the indirect field oriented control method, the rotating reference frame is rotating at synchronous angular velocity, ω_e. This reference frame permits the three phase currents to be viewed as two dc quantities under steady state conditions. The q-axis component is responsible for the torque producing current, i_{qs}, and the d-axis is responsible for the field producing current, i_{ds}. These two vectors are orthogonal to each other so that the field current and the torque current can be controlled independently. Figure 2 shows the block diagram of the IFOC technique for an induction motor. The q-axis component of the stator reference current, i_{qs}^*, may be computed using the reference torque, T_{ref}, which is the output of a PI speed controller, as:

$$i_{qs}^* = \frac{2}{3}\frac{2}{p}\frac{L_r}{L_m}\frac{T_{ref}}{\psi_r} \quad (1)$$

Where ψ_r, is the estimated rotor flux, which is given by:

$$\psi_r = \frac{L_m}{\tau_r s + 1} i_{ds} \quad (2)$$

Where L_m, L_r and τ_r are the magnetization inductance, the rotor inductance, and the rotor time constant, respectively.

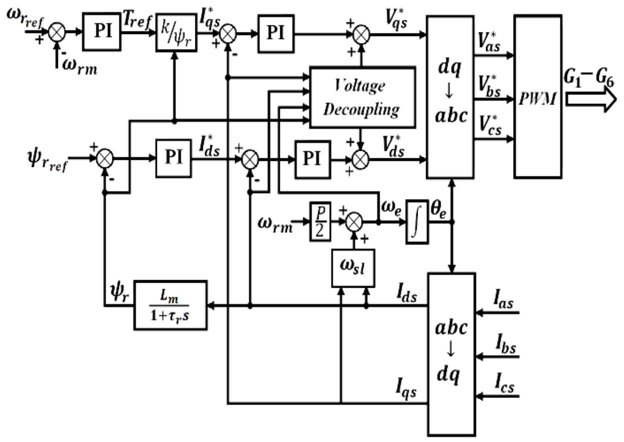

Figure 2: Block diagram of the IFOC of an induction motor

The d-axis component of the stator reference current, i_{ds}*, may also be obtained by using the reference input flux, ψ_{ref} which is the output of a PI flux controller, as:

$$i_{ds}^* = \frac{\psi_r}{L_m} \quad (3)$$

By using the rotor speed, ω_{rm} , and the slip frequency, ω_{sl} which is given by:

$$\omega_{sl} = \frac{1}{\tau}\frac{i_{ds}^*}{i_{qs}^*} \quad (4)$$

The angle of the rotor flux, θ_e, may be evaluated as:

$$\theta_e = \int(\omega_e + \omega_{rm})dt \quad (5)$$

Proportional integral controllers regulate the stator voltages, v_{ds}* and v_{qs}*, to achieve the calculated reference stator currents, i_{ds}* and i_{qs}*. The required voltage is then synthesized by the inverter using pulse width modulation (PWM). During motor operation the actual rotor resistance and inductance can vary. The resulting errors between the values used and the actual parameters cause an incomplete decoupling between the torque and the flux. In order to compensate for this incomplete decoupling, the values of compensation voltages are added to the output of the current controllers. This voltage compensation can improve the performance of the current control loops. The compensations terms are given by:

$$\left.\begin{aligned} v_{dsc} &= -\omega_e \sigma L_s i_{qs}^* \\ v_{dsc} &= \omega_e \sigma L_s i_{qs}^* + \frac{L_m}{L_r}\omega_r \psi_r \end{aligned}\right\} \quad (6)$$

Direct Torque control with space vector Modulation technique

The conventional DTC scheme has many drawbacks, such as: variable switching frequency, high current and torque ripples, starting and low-speed operation problems, in addition to high sampling frequency needed for digital implementation of the hysteresis controllers. To overcome these drawbacks, the space vector modulation is combined with the conventional DTC scheme for induction motor drive to provide a constant inverter switching frequency. In the DTC-SVM scheme, as shown in Figure 3, the torque and flux hysteresis comparators are replaced by PI controllers to regulate the flux and torque magnitudes respectively.

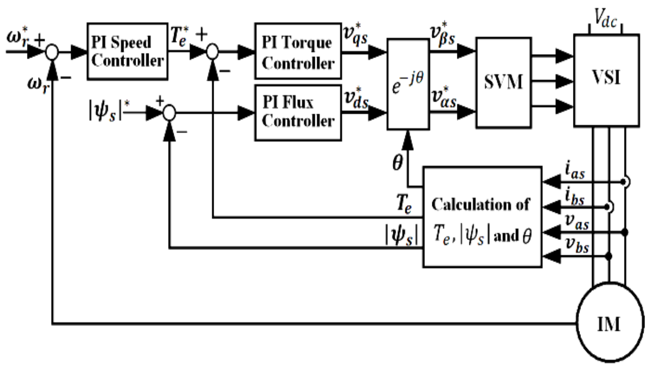

Figure 3: Block diagram of the DTC-SVM based IM drive.

The motor stator flux and the motor developed torque can be estimated by:

$$\left.\begin{aligned} \psi_{ds} &= \int(v_{ds} - R_s i_{ds})dt \\ \psi_{ds} &= \int(v_{qs} - R_s i_{qs})dt \end{aligned}\right\} \quad ((7)$$

$$\left.\begin{aligned} |\psi_s| &= \sqrt{\psi_{ds}^2 + \psi_{qs}^2} \\ \theta_{\psi_s} &= tan^{-1}\frac{\psi_{qs}}{\psi_{ds}} \end{aligned}\right\} \quad (8)$$

$$T_e = \frac{3}{2}P(\psi_{ds} i_{qs} - \psi_{qs} i_{ds}) \quad (9)$$

The output of theses PI controllers generates the d and q components of the reference voltage command (v_{ds}* and v_{qs}*) in the stator flux oriented coordinates. After coordinate transformation, using the stator flux angle $\theta_{\psi s}$, we get the reference voltage vectors v_{ds}^* and v_{qs}^*) in the stationary frame.

These two components, which can control stator flux and torque separately, are delivered to space vector modulator (SVM). The space vector modulator generates the inverter control signals, which ensures fixed inverter switching frequency. So the inverter switching frequency is significantly increased, and the associated torque ripple and current harmonics can be dramatically reduced, in comparison with the conventional switching table based DTC scheme.

III PROBLEM FORMULATION

The traditional inverter based induction motor drive system consists of a front end three phase diode rectifier, DC link LC filter, and three phase Inverter Bridge. It has some common limitations and problems such as the obtainable output voltage is limited quite below the input line voltage. Momentary supply voltage sags can interrupt the performance of the overall drive system and shut down critical loads and processes. Hence the performance and reliability are compromised by traditional inverter structure. Two inverter topologies are used with the existing induction motor drives to supply required power to the motor terminals: (i) a conventional three phase PWM based voltage source inverter and (ii) a three phase PWM inverter with a DC-DC boost converter, which is also very popular in other applications such as photovoltaic and fuel cell. For the wide voltage range and limited voltage level, the conventional PWM inverter topology imposes high stresses to the switching devices and motor, consequently limits the motor's constant power-speed ratio. The DC-DC boost PWM inverter topology can alleviate the stresses and limitations; however it suffers the problem of high cost and complexity associated with the two-stage power conversion.

IV PROPOSED WORK

A Z-source inverter could elevate most of the problems associated with traditional voltage source and current source inverters. Figure 4 shows the complete block diagram of the closed loop speed controlled IM fed by a high performance ZSI. A dual loop controller is designed to control the average value of the dc link voltage by controlling the magnitude of its peak voltage based on a small signal model of the high performance ZSI.

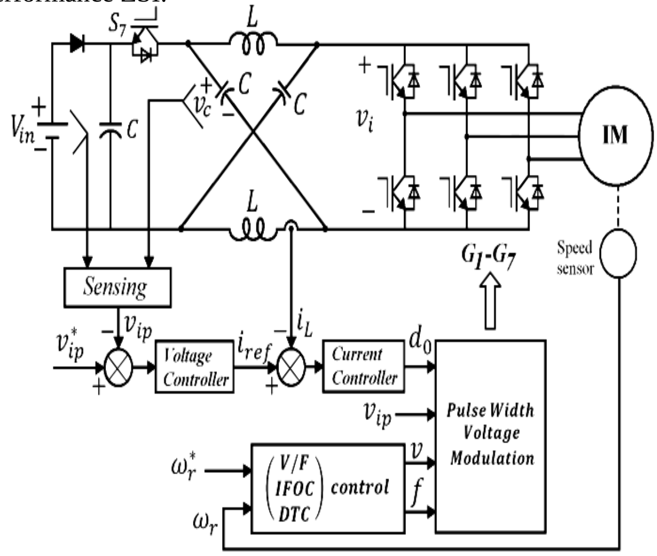

Figure 4: Closed loop speed control of three phase induction motor fed by a high performance ZSI

V CONCLUSION

The induction motor plays the major role in the current scenario. So the speed control is necessary for them in different application. This paper presents a complete control application evolve to control the induction motor. Also here a basic problem is introduced in the control of induction motor. Also discuss how to reduce this problem by the application of impedance source inverter method.

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Aftab Beg is a research scholar of LNCT Bhopal a primer institute of central India. He is doing his M.Tech in Control System. His email id is aftabbeg.01@gmail.com.
Anurag Soni working as Asst professor in Electrical Department of LNCT college Bhopal. His area of research is control system. His email id is anurag.ashok25@gmail.com.
Amol Barve is working as Head of Department of Electircal Engineering in LNCT Bhopal. His area of research is Power Electronics, Electrical Drive, Control system.