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# Implementation of Voltage Source Inverter Fed Induction Motor Drive with SVPWMand PI based Closed-Loop Control

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**Abstract:** In Induction motors run at rated speed and are used widely in the applications of conveyors, pumps, cranes, compressors, etc. Some applications need variation in speed of operation. Speed control can be achieved by various control methods and also by designing suitable controllers. Moreover, many control strategies dealt with the control of speed regulation, flux optimization, power factor correction in induction motor drive. Hence proposed system is designed by the Space Vector Pulse Width Modulation (SVPWM) technique using a PID controller where the performance of the system has been improved. In Sinusoidal Pulse Width Modulation (SPWM) oscillations are more in torque waveform when compared to SVPWM. When torque increases speed will be decreased. This is the main drawback of the closed system of SPWM. Hence the performance is predicted by using voltage source inverter fed by three-phase induction motor drive using the PID controller. Simulation results are obtained using MATLAB/SIMULINK.

## I.INTRODUCTION

Three phases of induction motor are widely used in many industries nowadays, but the speed of the induction motor is not able to control easily. Hence several control techniques were adapted to control the speed of the motor. Usually, the dc motor is used for high-speed variations. Since induction motors have some advantages than dc motors like low cost, easy maintenance, simple in construction and with their characteristics it is more suited for industrial necessities. Variation in speed can be done

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by the machine which is at the net supply frequency. Still, there is no power electronics development for varying frequencies which are easy and effective. We use DC or AC power for electric traction applications. Three phases inverter is necessary to interface because of their change in frequency and flexibility in voltage. For control issues in the motor, a suitable controller is designed for high speed operations for three phase linking system and an induction motor.

At present PID controller is well developed to control the speed of the motor by the variation in reference values. Usually, the PID controller stabilizes the system which is controlled [1]. It will not meet its own objective with high accuracy. Finding state equation and switching parameters are very easy. For switching states, the value for the given variable must be changed.

Many types of research have been made by using a PI controller which is employed for closedloop control and it provides fast response and also stability of the system improves. Speed/ torque regulations liked with magnetic circuits to be linear and eliminating power conversion requirements [2]. It is important that speed regulations are not able to obtain at normal efficiency, or wide scope of speedset- point and burden torque, except if the attractive circuit nonlinearity is unequivocally represented in the machine model [2]. Hence it dealt with three control techniques like speed regulation for variable speed range, flux optimization and correction in power factor. Induction motor with indirect vector control used SVPWM technique fed by the neuro-fuzzy logic controller. This torque is minimized. A controller is compared with the PI controller where torque ripple is reduced without adding any filter circuits and this was implemented with and without load conditions [3]. New control technique by a transistor (IGBT) based on converter

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with the function of filtering. The performance of induction motor drive and to control torque SVM technique is employed with the PI controller [5].

Though Induction motors are constant speed motor, speed of induction motor gets varied when the torque of motor gets varied (load varies) and reduction in efficiency of motor [6]. While analyzing speed control of Induction motor using power converter, motor torque widely varies oscillating because of distorted voltage waveform generated by VSI. This is because of sinusoidal PWM techniques used in inverter [7]. Instability of closed-loop controllers will result in an increase in peak overshoot and an increase in settling time.

## II. Block Diagram of Proposed System

The block diagram consists of four blocks, they are the inverter, induction motor, SVPWM generator, a controller as shown in Fig 1[8].

The block diagram of the proposed network for PID controllers appears in Fig 1. This comprises of DC voltage source associated with a three-stage inverter using IGBT which is sustained to motor [8]. An ordinary proportional integral derivative (PID) controller is utilized to control pulse for inverter switch. On the fluctuating pulse of the inverter, a steady (V\F) proportion is kept up for getting the speed of the motor.

The inverter has the ability to decrease or increase output voltage as it uses a three-phase IGBT circuit and the output voltage will depend on the requirements. By using an inverter, it provides operation even in the least load conditions [9].

## III. Circuit Diagram of Proposed System

The generalized circuit diagram for threephase inverter fed induction motor using PID controller [10] and SVPWM technique is shown in Fig 2.

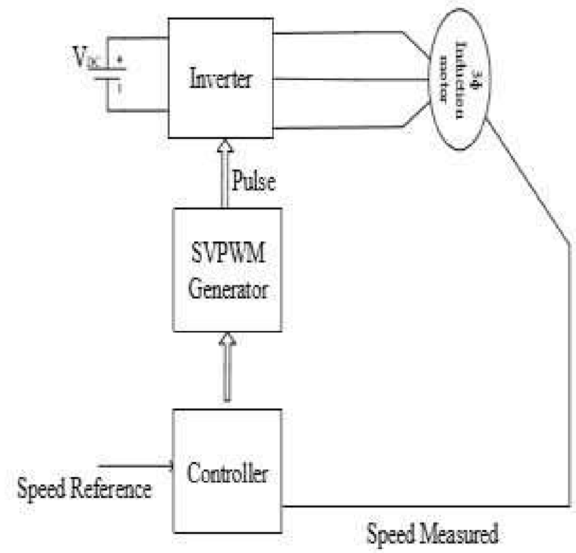


Fig 1. Block Diagram of Closed-loop proposed System

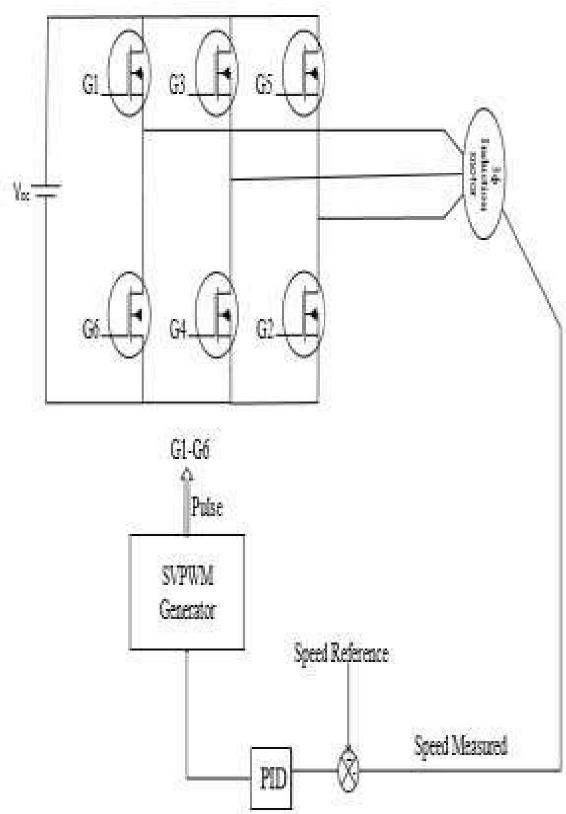


Fig 2. Circuit Diagram of Proposed System

## IV. Simulation and Result

For proposed topology simulation is done MATLAB/SIMULINK is shown in Fig 3.

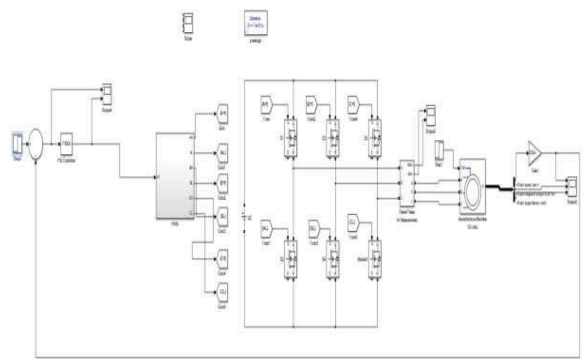

Fig 3. Simulation Diagram of Proposed System

## V. Closed-Loop Transfer Function

PID controllers are used as a compensator to generate compensation signals with respect to an error received. Generally, negative feedback is used due to the reduction of gain of the overall transfer function by improving the stability of the system. The transfer function of the PID controller has two finite zeros and one pole at the origin. Due to poles at the origin, the steady-state error gets reduced. Finite poles improve the stability of the system. The overall closed-loop transfer

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function is given by where Gc(s) - Gain of PID Controller (s) - plant transfer function. Due to poles at the origin, the steady-state error gets reduced. Finite poles improve the stability of the system. The overall closed loop transfer function is given by

$$T(s) = \frac{G_c(s) * G(s)}{1 + G_c(s) * G(s)}$$

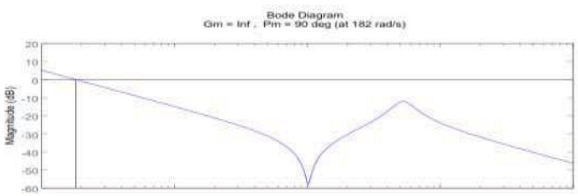


Fig 4. Bode Plot for IM

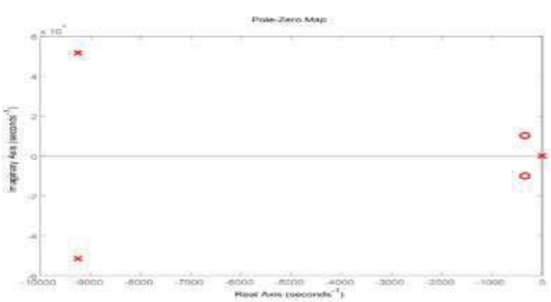


Fig 5. Pole Zero Map of IM

From the pole-zero map, all poles are plotted left of s plane implies that the system is operating in the stable. But from the bode plot, Gain is infinite. This shows that the system is stable but not generates bounded output.

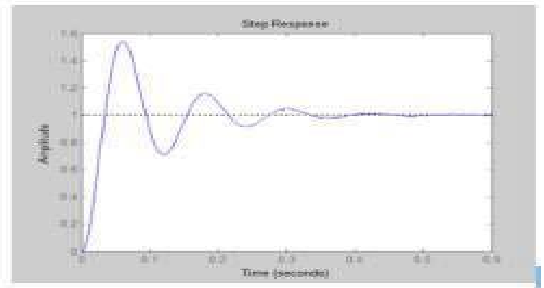


Fig 6. Step Response of IM

From the step response, peak overshoot is around 5.5% higher than that of normal value and settling time is around 0.5 seconds. To improve the stability and reduction of peak overshoot, a suitable controller constant should be chosen. After tuning the PID controller, the overall system response gets improved. The closed-loop transfer function after the tuning controller is given by

$$T(s) = \frac{0.014s^2 + 0.44s + 4}{0.000067s^4 + 0.72s^3 + 0.987s^2 + s}$$

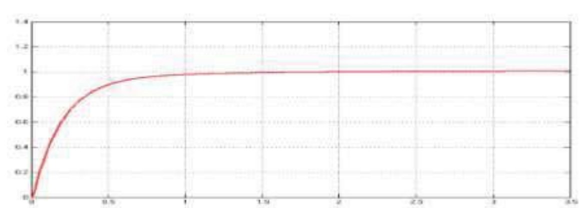

Fig 7. Step Response of Closed Loop Transfer Function

The response of output current and output

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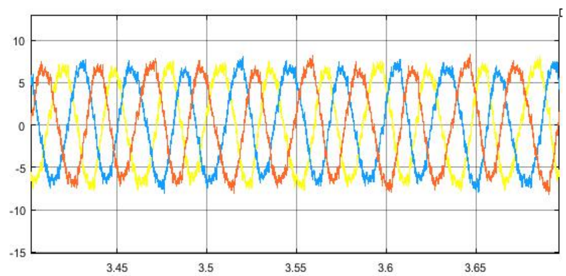
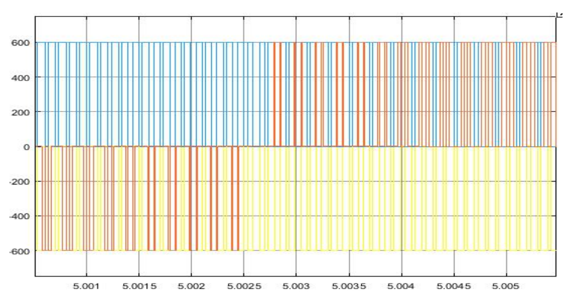
voltage of an inverter is shown in Fig 8. It provides maximum output voltage and reduces ripples in torque [8-13].




(a)




(b)

Fig 8. (a), (b) Output Current and Voltage of an Inverter

The performance of the induction motor with a reference speed of 1000rpm is considered for simulation purposes [14-16]. Hence by using a PID controller the result obtained for the performance of inverter under load changing condition is expressed in Fig 9.

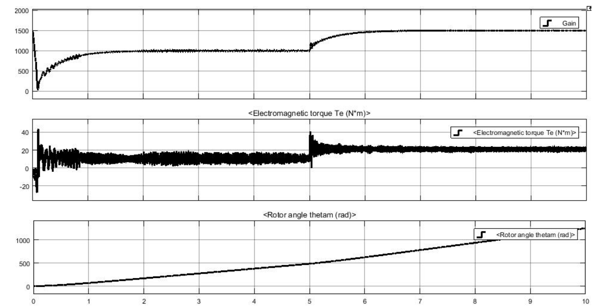



Fig 9. Output Performance of Three Phase Induction Motor by Change in Speed and Torque

Table 1. Specifications of Induction Motor

| Parameters | Range |
|---|---|
| Supply Frequency | 50 Hz |
| Input Voltage | 430 V |
| Stator resistance | 1.404 ohm |
| Rotor resistance | 1.33 ohm |
| Mutual inductance | 0.172 H |
| Inertia | 0.0131 J |
| Pole pairs | 2 |

## VI. CONCLUSION

The main aim of the proposed work is to control the speed of an induction motor for any stepchanging load. This can be achieved by using a closed loop PID controller. In overall perspectives, the Entire performance of the motor improves at different load conditions is achieved with a conventional

PID controller. For any variation in load torque, motor drive operating at a constant speed. Stability analysis of the closed-loop PID controller is tested for different load conditions using a bode plot and pole-zero map. Step response of controller shows peak overshoot is completely reduced and the response speed of controller was improved. In the future, multilevel inverters are developed with closed-loop controllers and with a filter circuit to achieve constant load torque.

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