Speed Control of SSTP Inverter Fed Induction Motor Drive

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Abstract - *A three-phase induction motor is an a.c machine. Its stator winding is directly connected to a.c source, whereas rotor winding receives its energy from stator by means of induction. Balanced three phase currents in three phase windings produce at constant amplitude rotating m.m.f wave. The stator m.m.f wave and rotor m.m.f wave, both rotate in the air gap in the same direction at synchronous speed. The vector control theory is the base of a special control method for induction motor drives. The most commonly used controller for the speed control of Induction motor is Proportional plus Integral (PI) controller. This has been carried out by the design and implementation of inverter and control circuit which estimates rotor flux, unit vectors and torque by taking voltage and current reference from machine terminals. Based on the output from PI controller and difference between actual speed and set speed, the signal processor (TMS320F2802x) generates pulse width modulated (PWM) pulses to the power switches of the inverter. The width and frequency of pulses are adjusted such that to maintain the constant v/f ratio of inverter output voltage to achieve the desired speed. This system has been tested with different loads and different speed.*

Key Words: *Induction motor, Proportional integral controller, Signal processor, PWM pulses, v/f ratio*

1. INTRODUCTION

Induction motor is the most common electrical machine used in modern industries. It has gained such popularity due to its various advantages. The various advantages are high efficiency, low cost, good self-starting, simplicity in design, the absence of the collector brooms system, and a small inertia. Induction motor has disadvantages, such as complex, multivariable and nonlinear of mathematical model of induction motor, and the induction motor is not inherently capable of providing variable speed operation.

Induction motors have been used more in the industrial variable speed drive system with the development of the vector control technology. The most commonly used controller for the speed control of Induction motor is Proportional plus Integral (PI) controller. The vector control methods are normally classified into two types, direct vector control and indirect vector control methods. In this project the Indirect Vector Control method is used because of its fast dynamic response and speed response without cogging or torque pulsations at low speed, smooth speed reversal under any torque conditions.

The implementation of proposed work has been carried out in two stages. The first stage is the design and development of Six Switch Three Phase Inverter using IGBT .In the second stage, design of proportional integral controller using indirect vector control along with a high speed digital signal controller using TMS320F2802x.Controller circuit has been designed to estimate the rotor flux, unit vectors and torque by taking reference current signal from the motor terminals. The estimation mechanism uses continual on-line training to learn unknown stator model dynamics and estimates rotor fluxes of an inverter-fed induction motor. Based on the output from PI controller and speed difference between set speed and actual speed of a motor digital signal controller generates Pulse Width Modulated (PWM) pulses of required width and frequency to the inverter switches to achieve the desired speed. The system is tested for different load and speed.

1.1 Block diagram

Block diagram consists of power circuit, PI controller with indirect vector control and driver circuit.Figure1 shows the block diagram.

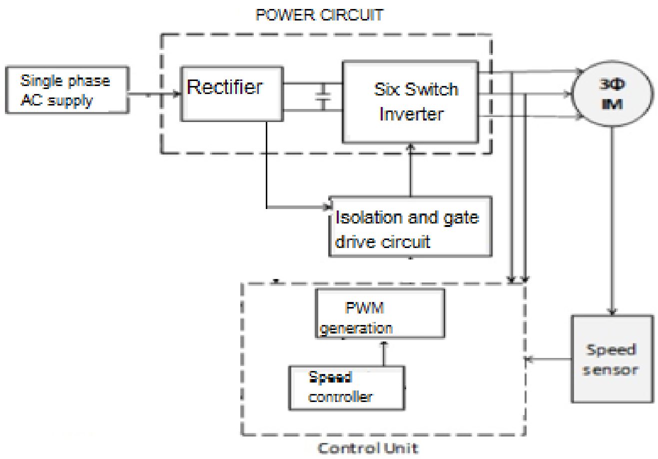

Fig1:Block Diagram

Power circuit consists of bridge rectifier and Six Switch Three Phase Inverter. Rectifier converts AC input into a DC output which is smoothened by two series capacitors, the output of bridge rectifier is fed to the IGBT based SIX switch three phase inverter. Driver circuit amplifies control signals to the level required by the power switches and it restricts

the flow of any disturbances to the power devices. The pulses available at the output of the logic circuit are applied to the gate of individual IGBT through separate driver circuit; power supply required for driver circuit is obtained by the regulated dc supply.

The conventional PI controller is one of the most common approaches for speed control in industrial electrical drives. It also improves the dynamic response of the system and reduces or eliminates the steady state error and the error sensibility. This is achieved by providing a proportional gain (Kp) for the error input term with an integral component correction (Ki)

$$U(t) = Kp\, e(t) + Ki \int e(t)\, dt$$

Where, u (t) is the output of the PI controller and e (t) is the error signal

2. MATLAB SIMULATION

Simulation for the proposed system for speed control of induction motor drive consists of Motor, Controller circuit and Power circuit. Open loop simulation with no feedback is shown in figure 2.Closed loop simulation with speed controller is shown in figure 3.

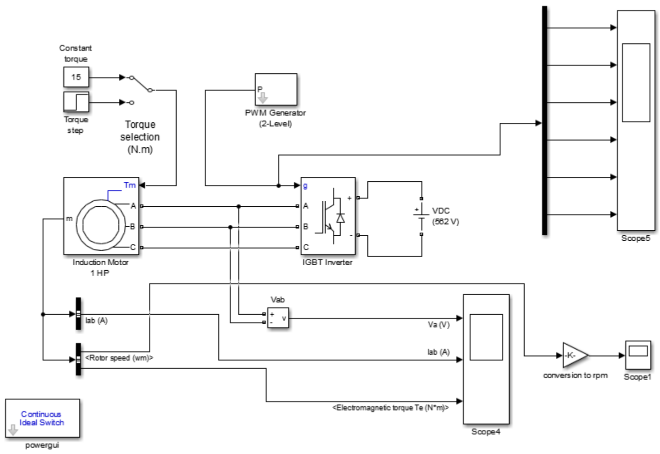

Fig2: Open loop simulation

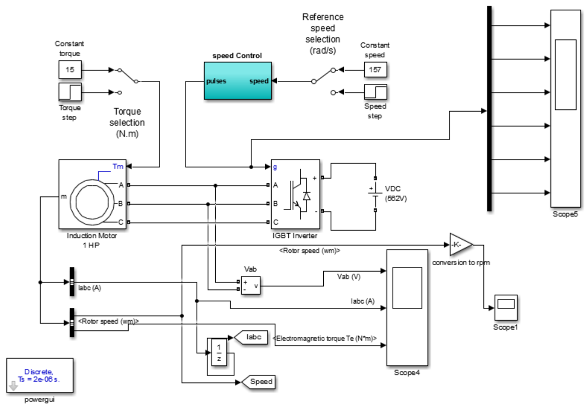

Fig3: Closed loop simulation.

2.1 Simulation results

The performance characteristic of a 1 hp, 415 V, 50 Hz IM, operating at various conditions with a PI speed controller was done and the following where the results:

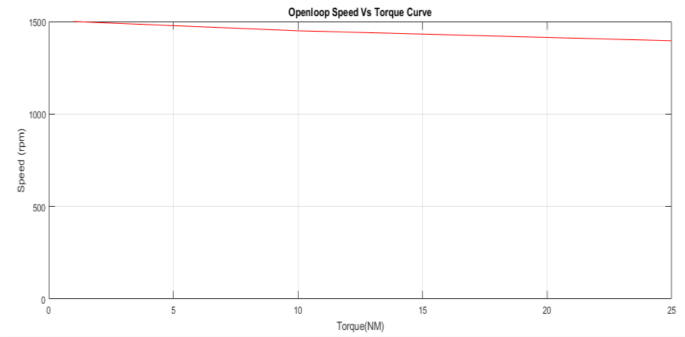

Fig4: Open loop speed vs torque

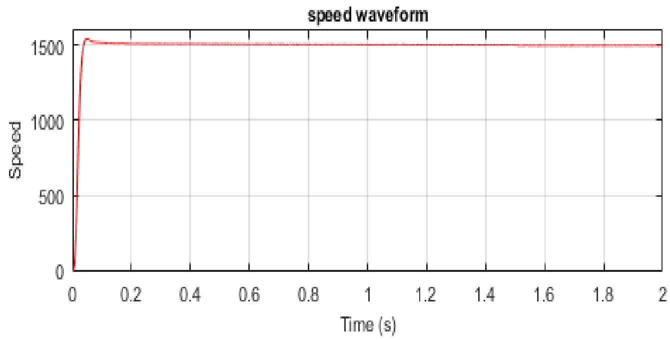

Fig5: Closed loop speed

3. EXPERIMENTAL SETUP

The circuit diagram for hardware implementation of the system is shown in figure 6

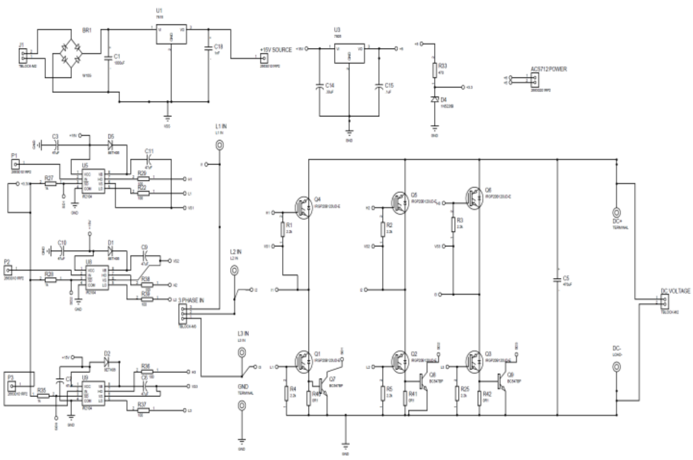

Fig -6: Circuit diagram

A full bridge rectifier is used to rectify the three phase input ac supply to dc. Power diodes MUR460, W10 bridge rectifier IC, voltage regulator 7815 IC, 100 microfarad and 1 microfarad capacitors are used. A three phase six switch inverter using IGBT converts the rectified dc supply from rectifier to three phase ac. Here six number of 25N120ND 600V, 20A IGBTs are used. IR2104 ICs are used as driver ICs. The IR2104(S) are high voltage, high speed power MOSFET and IGBT drivers.

The circuit setup in printed circuit board is shown in figure7.

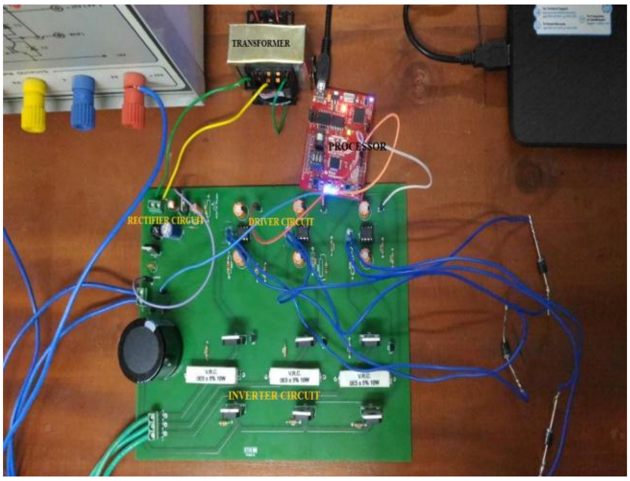

Fig 7:Circuit setup in PCB

The complete hardware setup is shown in figure 8.

Fig 8:Hardware Setup

Inverter output pulses is shown in figure 9.

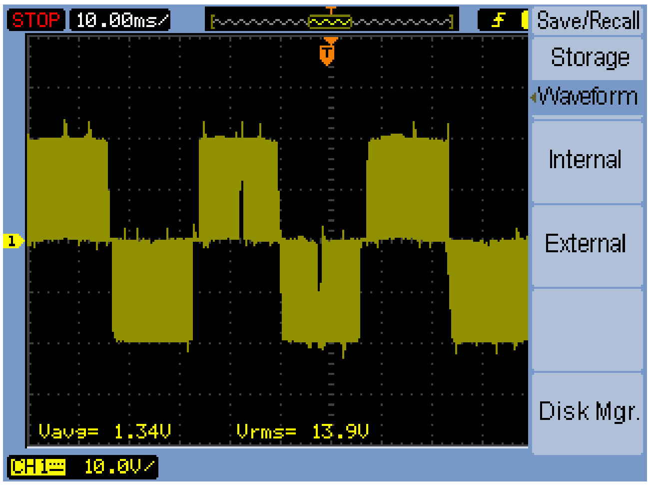

Fig 9:Inverter output pulse

4. CONCLUSION

The project was successfully modeled and designed using MATLAB/Simulink and it was simulated at various conditions. This topology reduces the cost and complexity of control algorithm. In open loop system the speed decreases as load increases. In the closed loop system using this topology the speed remains constant with the varying load. The PI controller is studied for speed control of indirect vector control of induction motor drive. At different conditions the controller were simulated and their result and data from the motor drive such as motor current, motor torque and speed was obtained at no load and different load conditions. It improves the dynamic response of the system and reduces the steady state error, the error sensibility, high performance and smooth speed response.

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