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Modelling and Simulation Of Permanent Magnet Synchronous Motor Using Fuzzy Controller With Variable Torque

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ABSTRACT: As many electrical drives use the mechanical gear and pulley system to control the speed of the motor shaft which causes greater number of losses and wear and tear losses. So to eliminate these losses we can use the Fuzzy controlling techniques. In this paper work controlling of permanent magnet synchronous motor is done using fuzzy controlling technique utilising Voltage control mechanism while there is a change in the torque. The low speed constant AC drives are used for Industrial purposes. The best motor for Industries is Permanent Magnet Synchronous motor as it works in low speed, compact and reduced weight. Our mechanism uses Fuzzy controlling techniques for maintaining constant speed of motor while varying torque of the motor. Today low speed constant AC drive in Industries are utilised greatly. The proposed circuit can be utilised for Low speed constant AC drive in Industrial applications. This project would help in making a compact and efficient controlling technique used in Permanent magnet synchronous motor.

KEYWORDS: Voltage source inverter, Fuzzy logic controller (FLC), Permanent magnet synchronous motor (PMSM), Speed controller, MATLAB Simulation Modelling, pulse width modulation (PWM).

I.INTRODUCTION

In today's scenario of motor controlling the best possible way is to use the Drive system which is generally AC Drive and DC Drive system. Industrial drive application generally considers for only constant speed drive and variable speed drive systems. Previously AC motors were used for constant speed with constant frequency system. DC motors were used for variable speed drive system, but problem is there when low constant speed is required with less Electrical losses with small area of operation is required. In this project a PMSM motor is utilized as it uses a permanent magnet which reduces the weight of the motor by reducing the weight of the dc copper field winding. It also makes the motor compact in size. For low-speed applications, below 150 rad/sec, PM machines may further eliminate the need of a gearbox [2]. To adapt the speed and torque of the machine, a gearbox is traditionally coupled to a standard induction machine. It is advantageous to remove this mechanical element because it is costly, decreases the drive efficiency, and needs maintenance. Low-speed (or high-speed) drives without a gearbox are termed direct drives, since the machines are directly coupled to the load. Low-speed direct-drives with PM machines are used in a large variety of applications, from a few kilowatts in washing machines or elevators to several megawatts in boats or wind turbines [1]. PMSMs generally have concentrated and distributed stator windings. The non-overlapping concentrated windings have been used with better efficiency as stator windings in PMSMs than distributed windings for certain working applications [3]. The Non-overlapping concentrated windings are used for several reasons as high constant power speed range, short end-windings, good fault-tolerant capability and a low cogging torque. Therefore, PMSMs with non-overlapping concentrated windings have been used efficiently.

II. IMPLEMENTED CIRCUIT

As shown in three phase AC source is supplying power to the diode rectifier which is directly connected to a DC Battery. The diode rectifier converts alternating current to direct current and reduces harmonic ripples [6]. The DC battery provides a constant DC voltage to the inverter. If there is some extra voltage at Supply source then DC battery is charged. If voltage is low DC battery provides the extra voltage. The Inverter is connected to the LC filter which filters the harmonics produced by the commutation of thyristor and improves the power quality of the supply provided to the PMSM Motor [5]. The Fuzzy controller with PWM Pulse generator is used to control the gate signals of the

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switching devices. The controller output is given to the driving circuit from that the output signals are given to the gate terminals of the switching devices.

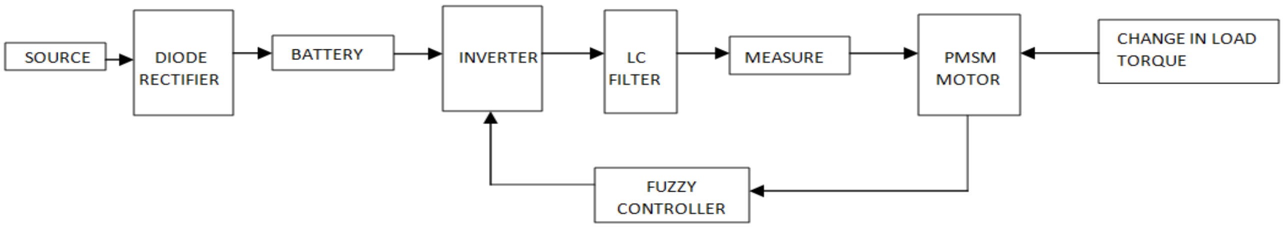

Figure 1: Circuit diagram of proposed PMSM motor drive.

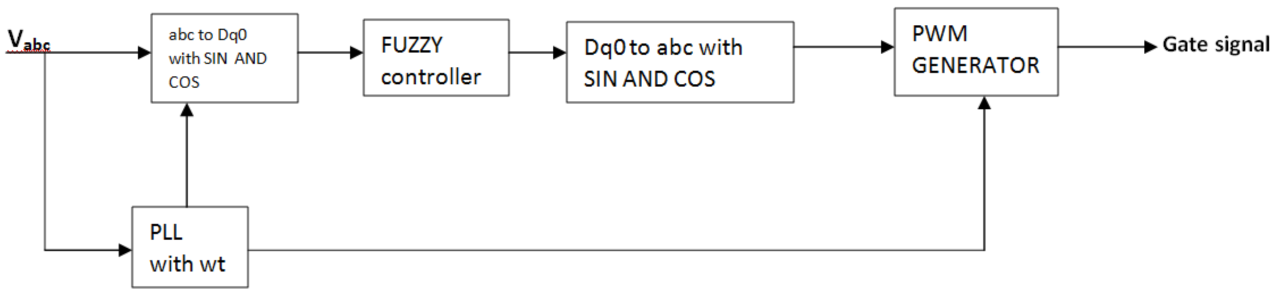

Figure 1a: Circuit diagram of Controller used in PMSM motor drive.

Figure 1 represents the proposed circuit diagram of the PMSM motor drive which is used in this project. Figure 1a. Is the circuit diagram used in controller circuit which is using Fuzzy controller? A Diode rectifier which is used in this project is not connected with the gate signal as it is only using Diodes for rectification purpose. The utilization of capacitor and inductor, in the system ensures the maximum power factor in the motor side. An inverter is used by the voltage controller for changing the voltage in the inverter side so that speed of the motor remains constant. The gate signal is applied to the inverter containing six MOSFET devices which is a power electronics device that is used for switching purpose [5]. The output of the inverter is given to the permanent magnet synchronous motor. The voltage source inverter consists of six switches which is MOSFET in this system. A power MOSFET is a called as metal oxide semiconductor field-effect transistor (MOSFET) designed to work on different power levels [7].

$$f(ac) = \frac{f\left(\frac{n}{w}\right) - N(rotor)*P}{120} \qquad (1)$$

The frequency shown in equation (1) [3].

III. SIMULATION AND RESULTS

This proposed PWM based fuzzy controller has been applied to the speed control of Permanent Magnet Synchronous Motor by a gate controlled inverter system with varying load torque and verified with the conventional controlling techniques. The simulated results with graphs are shown.

The Matlab diagram shows that a 220V, 60Hz supply is given to the three phase diode rectifier and is connected to the battery circuit which is connected to the inverter circuit. The voltage stability is maximized by the circuit consists of inductor and capacitor filter, and one switch i.e., MOSFET. Fig-3- shows the convertor waveforms of the MOSFET voltage and current. The voltage rating is about 220V and the current rating is about 20A. The voltage and current of fewer ripples and with improved power factor is given to the stator of PMSM motor. Fig-6- Shows the waveform of stator current of the PMSM motor for each phase. Fig-7- shows the quadrature and direct axis stator current which is 17A and 10A respectively. It shows the less ripple content in the each phase of the current i.e., I_{abc}. These output current from the motor are about ±20 A about 220V and the current rating is about 20A. Fig-4- shows voltage at inverter side (V_{abc}), current at the inverter side (I_{abc}), Battery voltage (V_{dc}) which shows 220V providing to Inverter and

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MI value which is 0.92 of convertor which is provided to the Inverter bridge for change in voltage. Fig-5- shows the active and reactive power taken by the PMSM motor in the system. In Fig8 Rotor speed which remains constant at 80 rad/sec with change in loading torque, Rotor angle increases and Electromagnetic torque remains constant with 10Nm waveform of PMSM is shown.

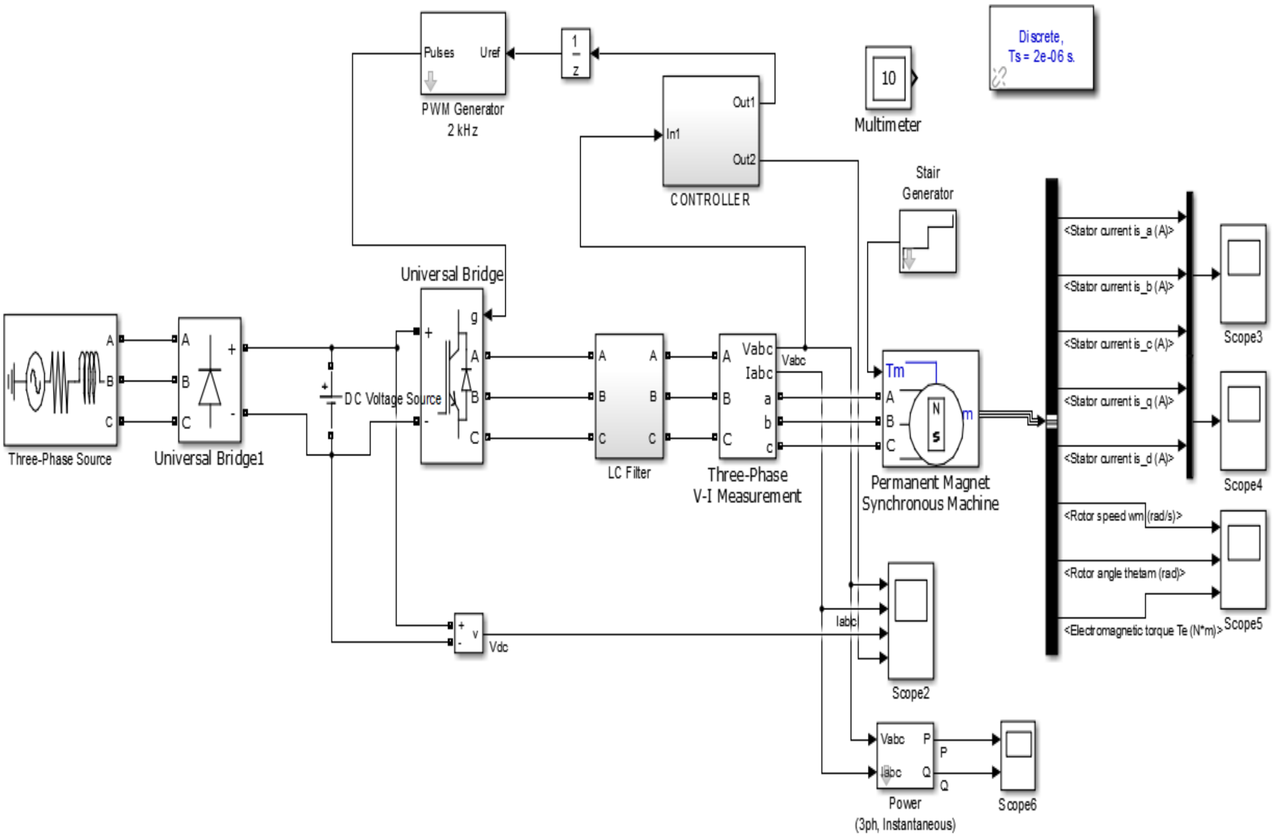

Figure 2: Simulation of main circuit.

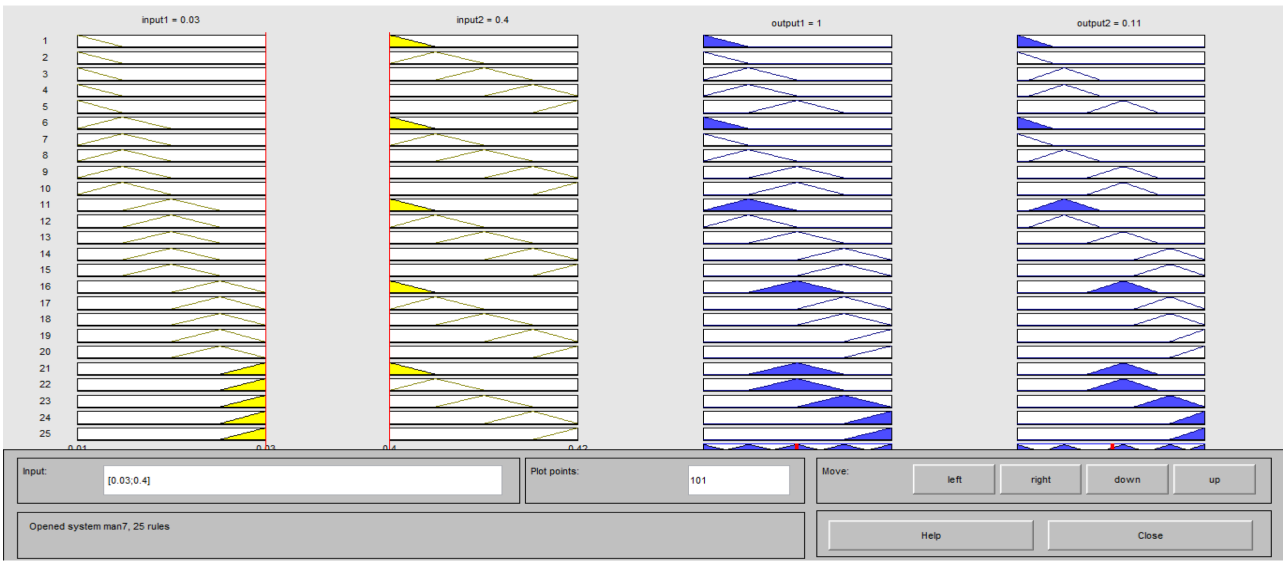

Figure 2a: Fuzzy Inference System used in Fuzzy controller.

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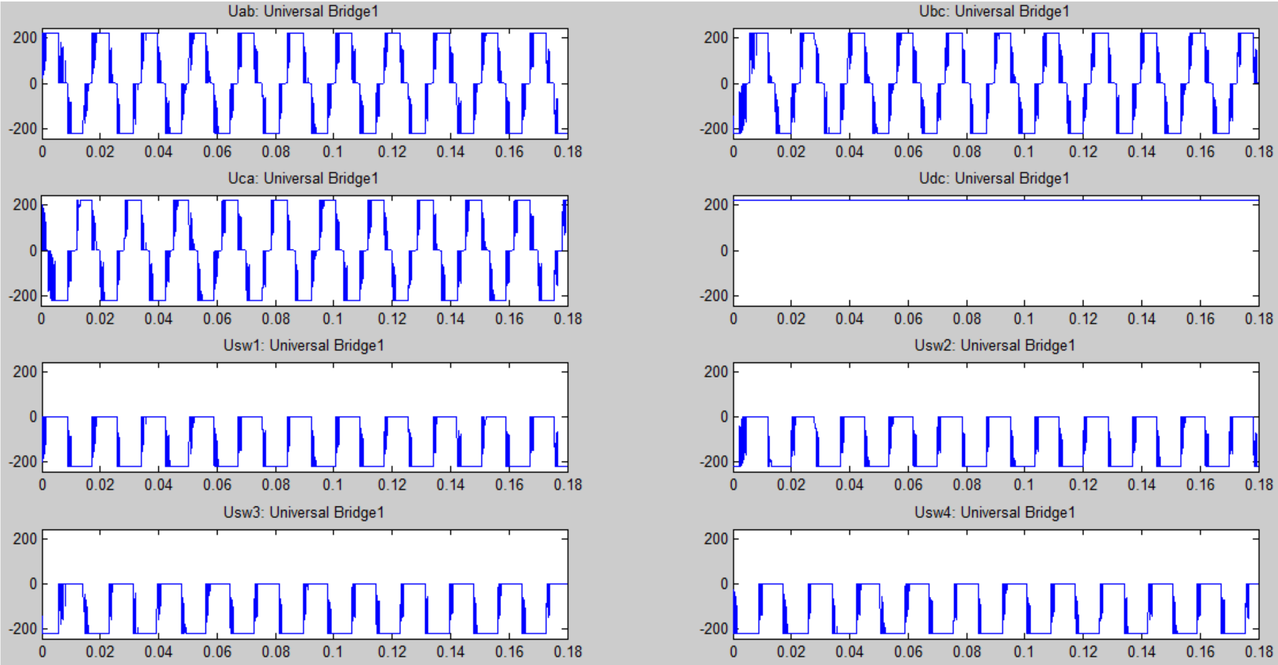

Figure 3: Converter bridge wave form for supply voltage, dc bus voltage.

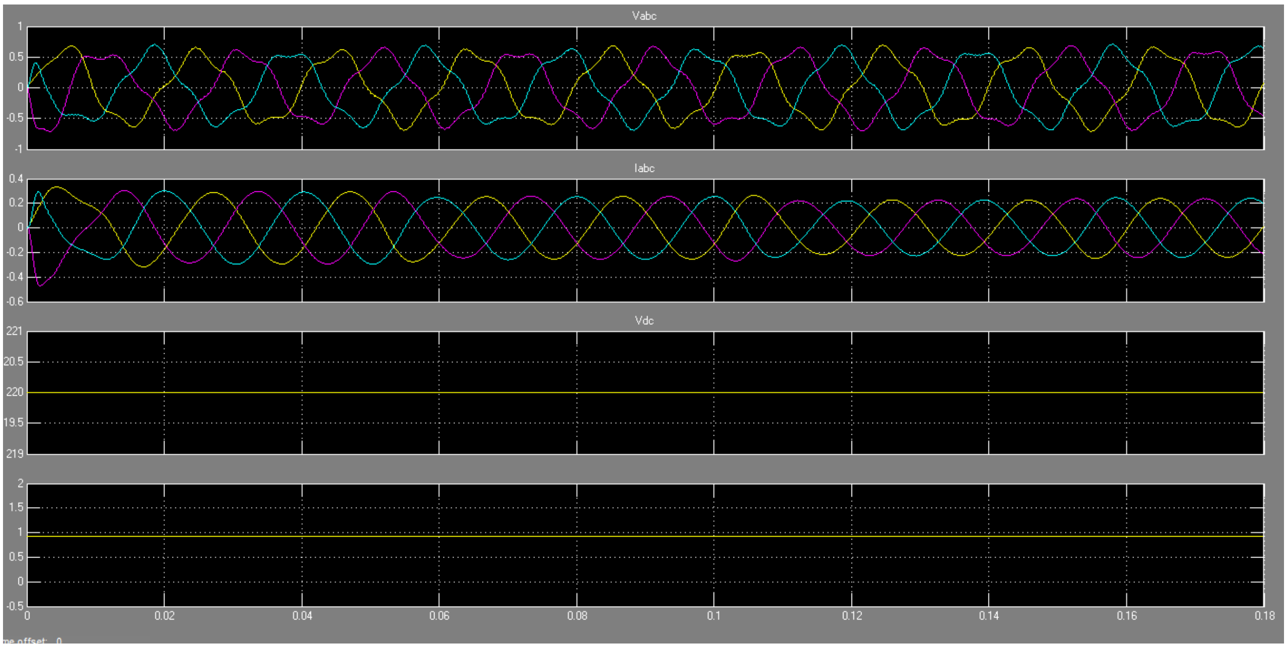

Figure 4: V_{abc} , I_{abc}, V_{dc} to Inverter and MI value of Convertor bridge wave form.

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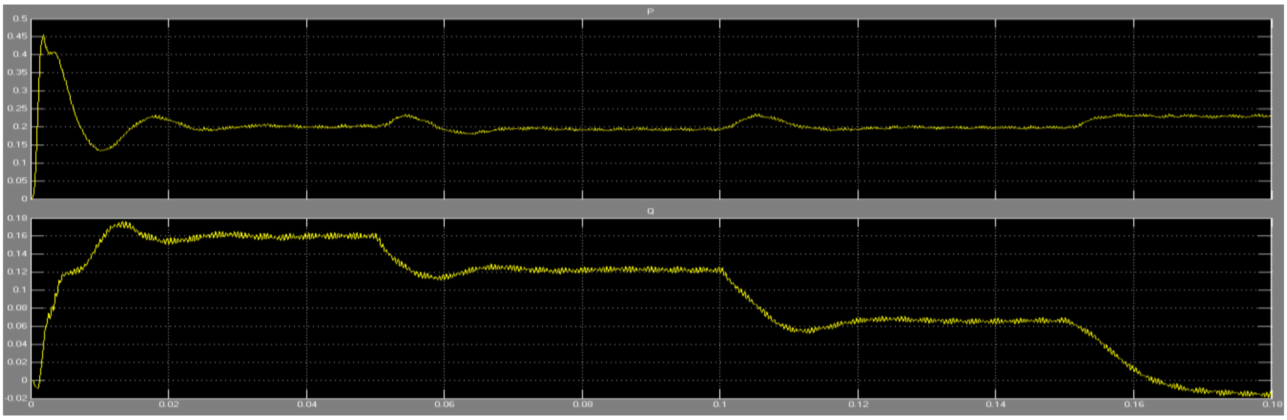

Figure 5: Active and Reactive Power in PMSM waveform Shown.

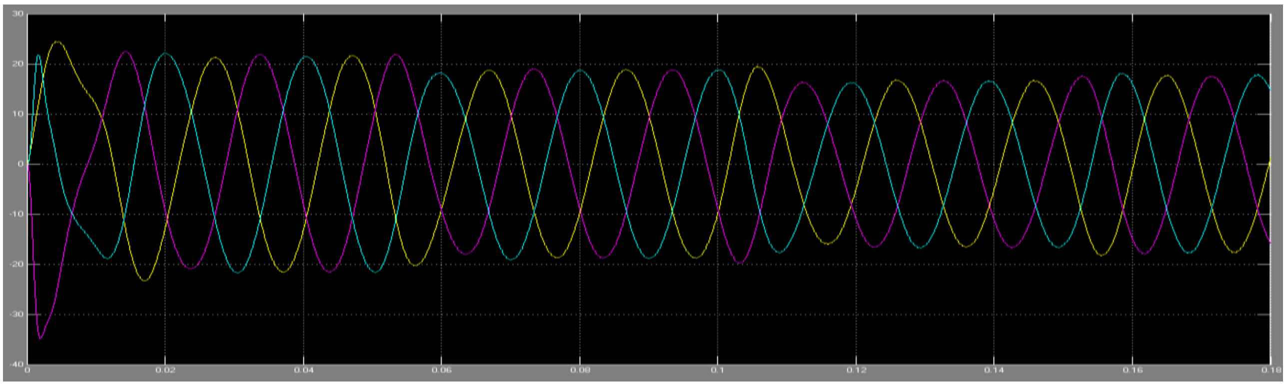

Figure 6: Stator currents waveform.

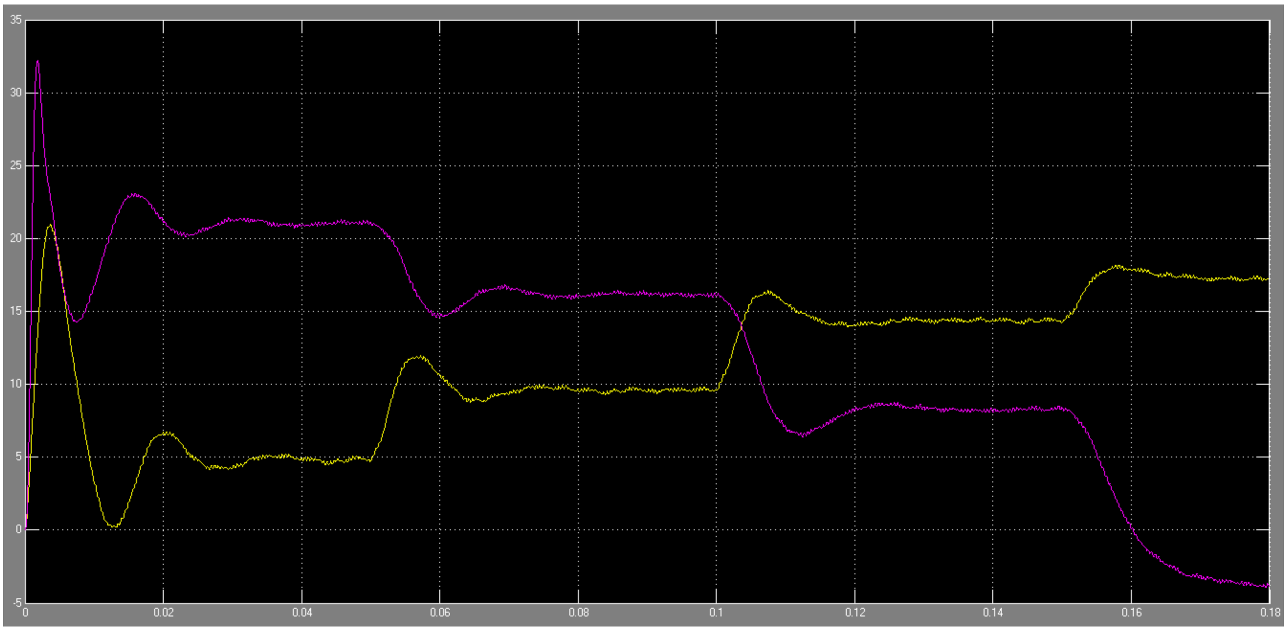

Figure 7: Stator Iq(A) and Id(A) currents waveform.

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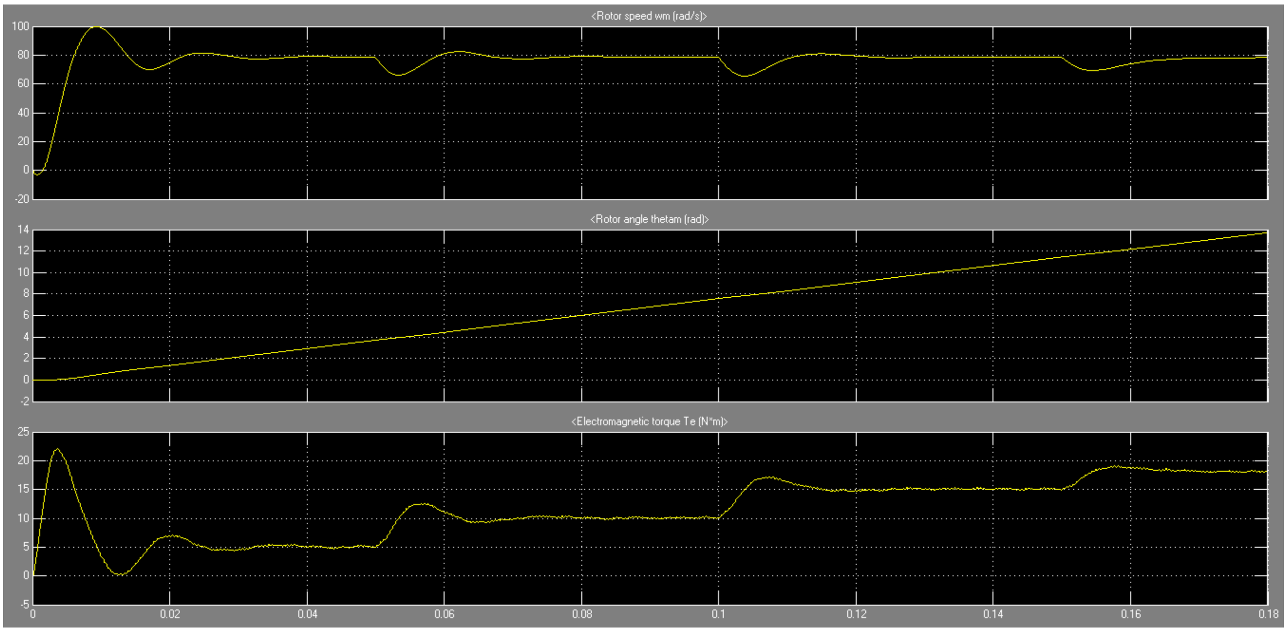

Figure 8: Rotor speed, Rotor angle and Electromagnetic –Torque wave form.

VI.CONCLUSION

An effective control technique is presented above for speed control with variable loading torque of three phases Permanent Magnet Synchronous Motor Drive. In Fig5 Active and Reactive power consumed by PMSM motor wave form for 220V, 60Hz supply voltage is shown. Fig4 shows voltage at inverter side (V_{abc}), current at the inverter side (I_{abc}), Battery voltage (V_{dc}) providing to Inverter and MI value of convertor which is provided to the Inverter Bridge for change in voltage. In Fig6 Stator current (I_{abc}) which is 20A in the PMSM motor wave form is shown. In Fig7 stator current quadrature current Iq(A) and direct Id(A) waveform is shown. In Fig8 Rotor speed, Rotor angle and Electromagnetic torque waveform of PMSM is shown. The simulation shows that at variable loading torque of 5 Nm, 10 Nm and 15 Nm at time of 0.05 sec, 0.1 sec and 0.15 sec the PMSM motor does not stop providing the constant speed that is 80 rad/sec with the help of fuzzy controller.

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