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Speed Control of Permanent Magnet Synchronous Motor Using Hybrid PI Controller

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ABSTRACT: Speed control of permanent magnet synchronous motor is controlled by HYBRID FUZZY PI CONTROLLER. And vector control techniques is also used. The software used is PSIM and FUZZY. For PI controller PSIM software is used. For fuzzy and hybrid PSIM MATLAB interface is used. Speed is controlled by varying iq and id is grounded. Park's and Clarke's transformation is used. It is observed that the performance of vector controlled PMSM drive with these hybrid fuzzy PI speed controllers in terms of the response and torque ripples is very promising.

I. INTRODUCTION

An important factor in industrial progress during the past five decades has been the increasing sophistication of factory automation which has improved productivity many fold. Manufacturing lines typically involve a variety of variable speed motor drives which serve to power conveyor belts, robot arms, overhead cranes, steel process lines, paper mills, and plastic and fiber processing lines to name only a few. Prior to the 1950s all such applications required the use of a DC motor drive since AC motors were not capable of smoothly varying speed since they inherently operated synchronously or nearly synchronously with the frequency of electrical input. To a large extent, these applications are now serviced by what can be called general-purpose AC drives. In general, such AC drives often feature a cost advantage over their DC counterparts and, in addition, offer lower maintenance, smaller motor size, and improvedreliability. However, the control flexibility available with these drives is limited and their application is, in the main, restricted to fan, pump, and compressor types of applications where the speed need be regulated only roughly and their application is, in the main, restricted to fan, pump, and compressor types of applications where the speed need be regulated only roughly and where transient response and low-speed performance are not critical. The various method used to control the speed of permanent magnet synchronous motor are Direct torque control, Field oriented control, Sensorless field oriented control and Vector control. The

conventional Proportional-Integral (PI) speed control has been. Used in many industrial application due to their simple design and tuning methos. Fuzzy logic controller with adaptive input and output scaling factors enhances the performance of the system especially at high load inertia. The performance of the fuzzy logic controller (FLC) is better under transient conditions, while that of the proportional plus integral (PI) controller is superior near the steady-state condition. The combined advantages of these two controllers can be obtained with hybrid fuzzy-PI speed controller.

II. CONTROL TECHNIQUES

A. Vector Control

The instantaneous position of voltage, current and flux space vectors are controlled, ideally providing a correct orientation both under steady-state and transient conditions. With the vector control scheme, the magnitude, phase and the frequency of the motor currents are controlled. The stator currents are resolved into torque producing and flux producing components with coordinate transformations, and are controlled independently. For operating under the

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constant torque region, the torque angle is maintained at 90, and for maximizing the torque per ampere, the d-axis current is set to zero [1].

Fig.1 shows the schematic diagram of a vector controlled PMSM drive with hybrid fuzzy-PI speed controller in the outer loop and two PI current controllers in the inner loops. With the phased currents sensed at the instant of sampling, the torque and flux producing current components are obtained through the coordinate transformations [2-4]. The two currents are then compared with their respective reference values and the errors are processed by the individual PI current controllers, which determine the voltage to be impressed at the motor terminals. The reference value of the d-axis current is set to zero for constant torque angle control. The actual motor speed is sensed and compared with the commanded reference value [5]. The speed error is processed by the hybrid fuzzy-PI speed controller, which determines the reference value of the q-axis current.

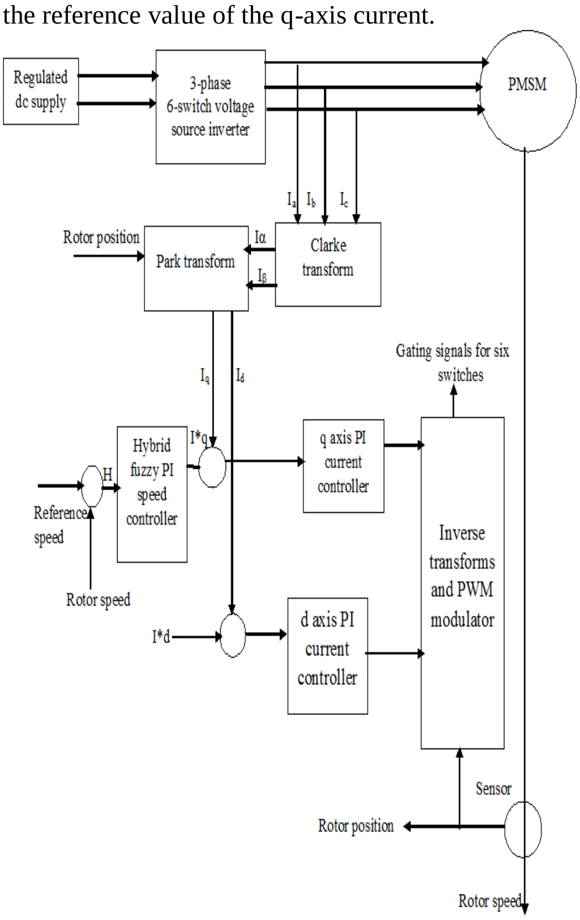

Fig. 1Block Diagram of Vector Control for Permanent Magnet Synchronous Motor

B. Hybrid Fuzzy PI Controller

Hybrid fuzzy-PI speed controller combines the advantages of PI controller and fuzzy controller [1]. PI controller is active during and near the steady state conditions [7], whereas the fuzzy controller is active during the dynamic conditions [6]. The main focus of the controller design is not only to improve the performance of the speed controller, but also to reduce the computational burden and thereby to reduce the algorithm execution time. Fig.2 shows the schematic diagram of the hybrid fuzzy-PI controller. The speed error is processed by the fuzzy algorithm, which has speed and rate of change of speed as inputs, and the PI controller. Output of the fuzzy and PI controllers are used to determine the hybrid fuzzy-PI controller output.

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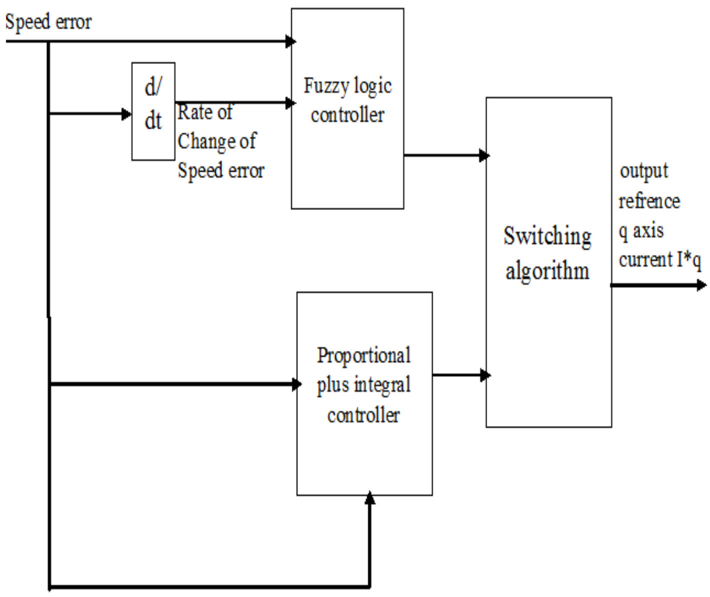

Fig. 2 Block Diagram of Hybrid Fuzzy PI Controller

III. SIMULATION RESULTS

Simulations have been carried for hybrid PI controller for the vector control of 400V, 4.1A, 6 poles, 1500rpm, and 2.2kw with PMSM fig 3, 4, 5 represents output waveform of current, speed and electromagnetic torque by PI controller alone from which it can be observed that there are no oscillations, overshoots or dips in the motor speed [8-10]. The settling time is 0.6sec reached reference value of 2000rpm.The line current is fairly sinusoidal the maximum current being 2.5 A at starting [15].

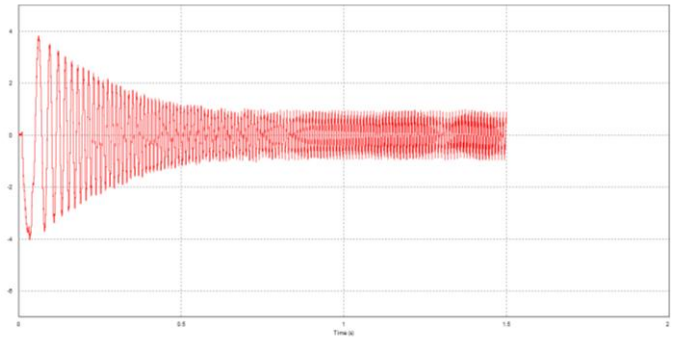

Fig. 3 Current Waveform of PI Controller (I_a)

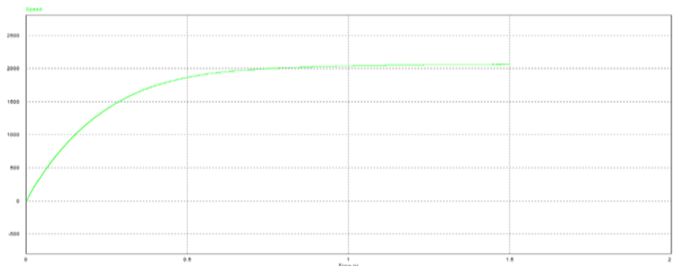

Fig. 4 Speed Waveform of PI Controller (N)

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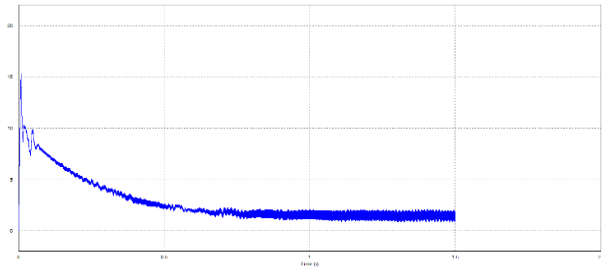

Fig. 5 Electromagnetic Torque Waveform of PI Controller (Tem)

Simulations have been carried for hybrid PI controller for the vector control of 400V, 4.1A, 6 poles, 1500rpm, and 2.2kw with PMSM fig 6,7,8 represents output waveform of current, speed and electromagnetic torque by fuzzy controller alone from which it can be observed that there are no oscillations, overshoots or dips in the motor speed [11]. The settling time is 0.7sec reached reference value of 2000rpm. The line current is fairly sinusoidal the maximum current being 3.5 A at starting. Starting current is more as compared to PI controller [12-13].

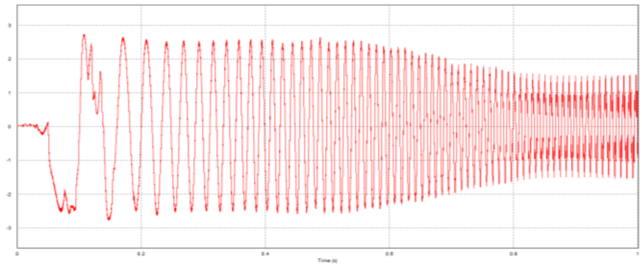

Fig. 6 Current Waveform Of fuzzy Controller (I_a)

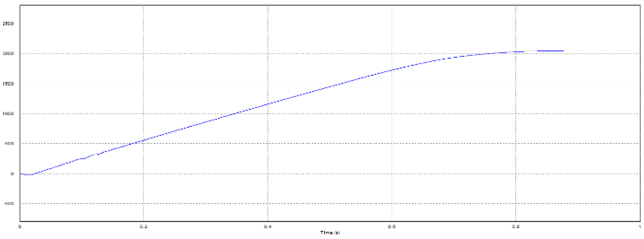

Fig. 7 Speed Waveform Of fuzzy Controller (N)

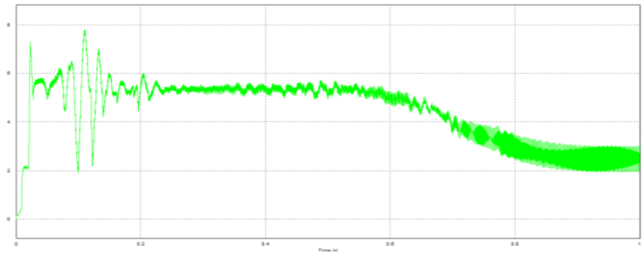

Fig. 8 Electromagnetic Torque Waveform Of fuzzy Controller (Tem)

Simulations have been carried for hybrid PI controller for the vector control of 400V, 4.1A, 6 poles, 1500rpm, and 2.2kw with PMSM fig 9,10,11 represents output waveform of current, speed and electromagnetic torque by hybrid

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fuzzy PI controller alone from which it can be observed that there are no oscillations, overshoots or dips in the motor speed [14]. The settling time is 0.7sec reached reference value of 2000rpm. The line current is fairly sinusoidal the maximum current being 1.5 A at starting.

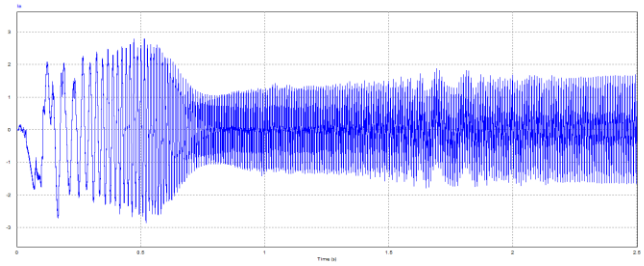

Fig. 9 Current Waveform of Hybrid Controller (Ia)

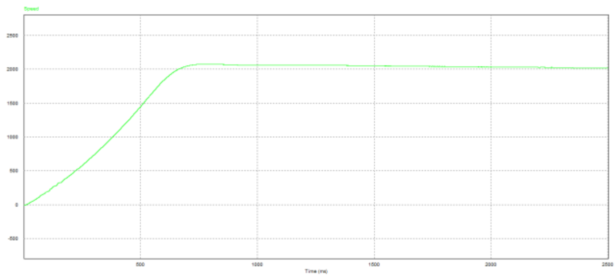

Fig. 10 Speed Waveform of Hybrid Controller (N)

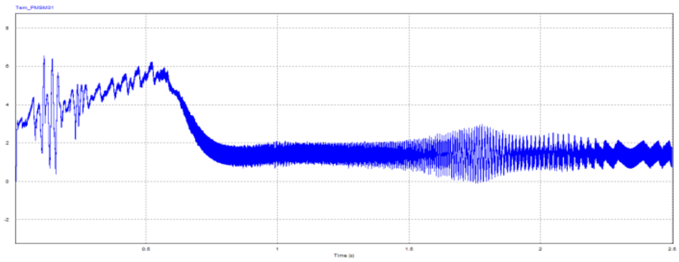

Fig. 11Electromagnetic Torque Waveform of Hybrid Controller (Tem)

IV. CONCLUSION

The hybrid fuzzy-PI speed controllers with both the controller outputs using the output of only the fuzzy controller, only the PI controller and the combination of the outputs of both the controllers, are performing better than the PI alone and fuzzy alone speed controllers. With the output of only the fuzzy controller, the settling time is the least but the starting current is the maximum. With the output of only the PI controller, the starting current is the least and the settling time is the maximum. The case with the combination of the outputs of both the controllers appears to the optimum. Appropriate switching function can be used for the PMSM drives used in various applications.

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