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PSO Based Model Reference Adaptive PI Controller for 3 Phase Induction Motor

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Abstract— ***Induction motors are highly nonlinear in nature. Vectorial analysis with rotor flux orientation is used to formation of mathematical model of the motor for speed control. A model reference adaptive PI controller is used for speed control. Adaptation mechanism uses MIT rule. Simulation results show that Particle Swarm Optimization (PSO) Based Model reference Adaptive PI Controller fast response when it compares with other PI controller.***

1. INTRODUCTION

Principal of three phase induction motors is the creation of rotating and sinusoidally distributing magnetic field in the air gap. Synchronously rotating magnetic field created by Sinusoidal three phase power supply in the three stator windings. Induction motor can runs at its rated speed. External load changes interferes the stable operation.

This paper deals with the speed control of three phase induction motor through (PSO) Particle Swarm Optimization based model reference adaptive control approach.

2. MATHEMATICAL MODEL OF THE MOTOR

In vector control direct axis stator current is analogous to field current in a dc motor and quadrature axis stator current is analogous to armature current in a DC motor[1]. Electromagnetic torque produced by the motor can be expressed as

$$T_e(t) = k_d \psi_{rd}(t) i_{sq}(t)$$

kd is a positive constant, ψ_{rd} is the direct axis rotor flux linkage. Induction motor dynamics can be expressed by equation(2).

$$J d\omega(t)/dt = T_e(t) - B\omega(t) - Tl(t)$$

Here J is rotational speed's the moment of inertia, $Te(t)$ is the electromagnetic torque. B is the damping constant. $Tl(t)$ is the load torque, w is the rotor angular.

$$JS\omega(S) = (k_d \psi_{rd} i_{sq}(s))/J - B/J\, w(s)$$

$$\omega(s) = k_p / s + a_p$$

$$k_d \psi_{rd} / J = k_p$$

$$B/J = a_p$$

$$k_d = 21.8, \psi_{rd} = 87.5\times10^{-5}$$

Weber,

$$B = 5.65\times10^{-3}\, kgm^2/s\ ,\ J = 5\times10^{-4},$$

$kp = 3797.56$, $a_p = 11$ for a .25 HP motor.

The reference Model Chosen here is

21 / (S+21)

3. MODEL REFERENCE ADAPTIVE PI CONTROL

MIT Rule is that the time rate of change of θ is proportional to negative gradient of the cost function (J), that is:

$$\frac{d\theta}{dt} = -\gamma \frac{\partial J}{\partial \theta} \quad = -\gamma \epsilon \frac{\partial \epsilon}{\partial \theta}$$

The adaptation error

$$\varepsilon = y_p(t) - y_M(t).\ J(\theta) \quad = \quad \frac{1}{2}\varepsilon^2(t)$$

Standard 2nd order differentials equation was chosen as the reference model given by

$$H_M(s) = \frac{b_M}{s^2 + a_{M1} + a_{M0}}$$

Then the approximate parameter adaptation laws are as follows

$$K_p^* = \left(\frac{-\gamma_p}{s}\right)\epsilon\left(\frac{s}{a_0 s^2 + a_{M1}s + a_{M2}}\right)e$$

$$K_i^* = \left(\frac{-\gamma_i}{s}\right)\epsilon\left(\frac{1}{a_0 s^2 + a_{M1}s + a_{M2}}\right)e$$

In Model Reference Adaptive PI controller and γi values are set by trial and error method. Whereas in GA based MRA-PI controller and γi values are obtained using GA.

To optimize Complex problems and to solve system of non linear equations Genetic Algorithm is used by random search method. Instead of deterministic rules .It handles population of potential solution like individuals or chromosomes to evolve iteratively. Each iteration is a generation. Evolution solution is simulated by Genetic operators and fitness function like mutation and crossover.

4. PSO BASED MODEL REFERENCE ADAPTIVE PI CONTROL

In Model Reference Adaptive PI controller and values are set by trial and error method. Whereas in PSO based MRA-PI controller and values are obtained using PSO.

Particle swarm optimization (PSO) is a population based stochastic optimization technique developed by Dr. Eberhart and Dr. Kennedy in 1995 , inspired by social behaviour of bird flocking or fish schooling. Every particle monitors its directions in the issue space which are related with the best arrangement (fitness) it has accomplished up until now. (The fitness value is also stored.) This value is called Personal Best (P Best). Another "best" value that is followed by the particle swarm enhancer is the best esteem, acquired so far by any particle in the neighbours of the particle. This area is called Local best (L best) at the point when a particle takes all the populace as its topological neighbours, the best value is a Global Best and is called G Best. The projected position of i^{th} particle of the swarm x_i, and the velocity of this particle v_i at $(t+1)^{th}$ iteration are defined and updated as the following two equations,

$$v_i^{t+1} = v_i^t + c_1 r_1 (P_i^t + x_i^t) + c_2 r_2 (g_i^t + x_i^t)$$

$$x_i^{t+1} = x_i^t + v_i^{t+1}$$

where i=1, …., n and n is the size of the swarm, c_1 and c_2 are positive constants, r_1 and r_2 are random numbers which are uniformly distributed, determines the iteration number, p_i represents the best previous position (the position giving the best fitness value) of the i^{th} particle, and g represents the best particle among all the particles in the swarm. At the end of the iterations, the best position of the swarm will be the solution of the problem. It cannot be always possible to get an optimum result of the problem, but the obtained solution will be an optimal one.

5. RESULTS & DISCUSSION

Simulation run of speed control of 3 P h a s e I n d u c t i o n motor system is carried out with PSO based MRAC-PI values. Similar test runs of MRAC -PI and ZN based PI are carried out and the responses of all the cases are recorded in Figure 1 & 2. From the results, the performances are analyzed in terms of Settling Time & Peak Overshoot are tabulated in Table 1. The results prove that PSO based MRAC-PI controller gives better performance than the others . The responses are presented in the Figure 1 & 2 .From the table, it is observed that PSO based MRAC- PI gives superior performance than the other control strategies

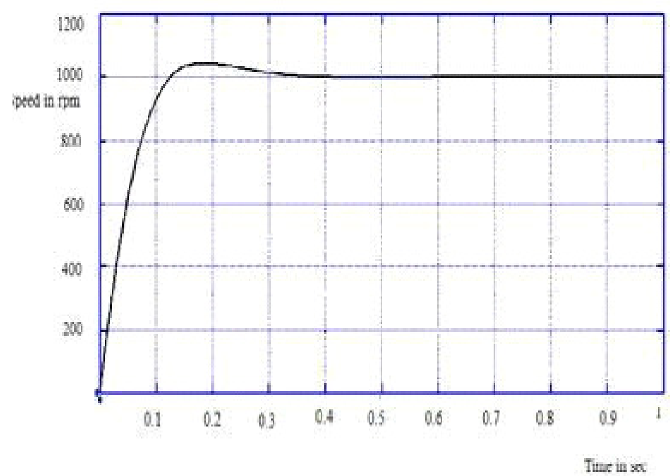

Fig. 1/ Responses with conventional PI controller

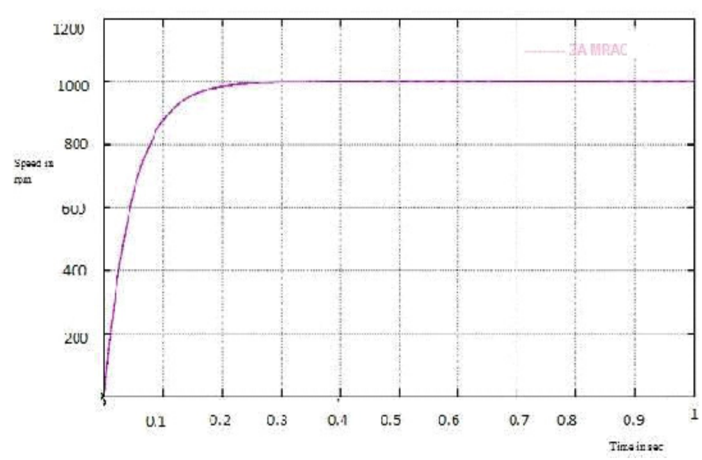

Fig. 2. Responses with PSO Model reference adaptive PI Controller

TABLE 1 COMPARISON BETWEEN MRAC AND CONVENTIONAL CONTROL STRATEGY

Controller	Settling time (in sec)	Peak overshoot
PI	0.4	1050
PSO Model PI referencce adaptive controller	0.21	0

6. CONCLUSION

This paper briefs PSO based MRAPI based the speed control of three phase induction motor. Simulation results confirmed PSO based MRAPI controller has better control performance than other methods. PSO based MRAPI control algorithm reduced overshoot peak and it minimize the settle time of the process.

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