Performance Comparison of P, PI and PID for Speed Control of Switched Reluctance Motor using Genetic Algorith

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Abstract:-In this report the simulink model for the speed control of switched reluctance motor is carried out using different speed controller. The simulink model design for P, PI and PID controller separately and their performance result is compared with load and without load. The speed controllers applied here are based on conventional P and PI controller and other one is PID controller. As form of Simulation output we can check that the starting time is minimum for PID and maximum for P controller.

Keywords:- SRM(Switched Reluctance Motor), Control strategy, Genetic Algorithm, Speed Control.

I. INTRODUCTION

Here we analyze the working principle of switched reluctance motor. A Switched reluctance motor is a singly exited, double silent machine in which the electromagnetic torque is develop due to variable reluctance principle. We also analyse mathematical model and expression of SRM model[1].

In this paper the simulink model for the speed control of switched reluctance motor is carried out using different speed controllers. The simulink models designed for P, PI & PID controller separately and their performance result is compared. The Switched Reluctance Motor is an electric motor which runs by reluctance torque. The speed controllers applied here are based on conventional P& PI Controller and the other one is AI based PID Controller. We are use tunning method for controller. we are use Genetic Algorithm for tuning P,I and D value. A comprehensive review has been done for SRM machine modeling, design, simulation, analysis and control.

II. SWITCH RELUCTANCE MOTOR AND IT'S CONTROL STRATERGY

A. Switched reluctance motor

A Switched Reluctance Motor is a singly excited, doubly- salient machine in which the electromagnetic torque is developed due to variable reluctance principle. Both stator and rotor has salient poles but only stator carries winding. As in dc motor the SRM has wound field coils for stator windings. However the rotor has no attached coils or magnets. The projecting magnetic poles of salient pole rotor are made of soft magnetic material. When the excitation is given to the stator windings, a force is created by rotor's magnetic reluctance that bid to align the rotor pole with the adjacent stator pole. In order to preserve sequence rotation, the windings of stator pole switches in a sequential manner with the help of electronic control system so that the magnetic field of rotor pole was lead by the stator pole, pulling towards it[1].

The rotor pole is said to be "fully unaligned position" when the rotor pole is equidistant from the two adjacent stator pole. This position is called as maximum magnetic reluctance for the rotor pole. In aligned position the rotor poles are fully aligned with the stator poles, this position is called as minimum reluctance of rotor pole. Figure 1 illustrates the 6:4 SRM drive which consists 6 stator poles and 4 rotor poles[2].

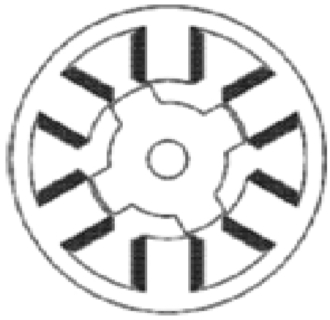

Fig. 1. Structure 3 phase 6/4 SRM

The voltage equation of SRM is given by,

$$V= r\, i + d\Psi / dt \qquad (1)$$

$$\psi=Li=N\varphi \qquad (2)$$

For r = 0,

$$V = L\, di/dt + i\, (dL /d\theta)\, (d\theta/dt) \qquad (3)$$

This equation determines that the dev loped torque depends only on current magnitude and dL/d_ direction but it is independent on current direction[2].

B. Block Diagram

The position of rotor is sensed by the rotor position sensor and it provides its corresponding out put to the error detector. Error detector compares reference speed and actual speed to generate error signal which is give n to controller block. The controller either P, PI or PID gives control signal to the converter according to the error signal. The speed of the motor is controlled by the converter through proper exci tation of their corresponding windings[2].

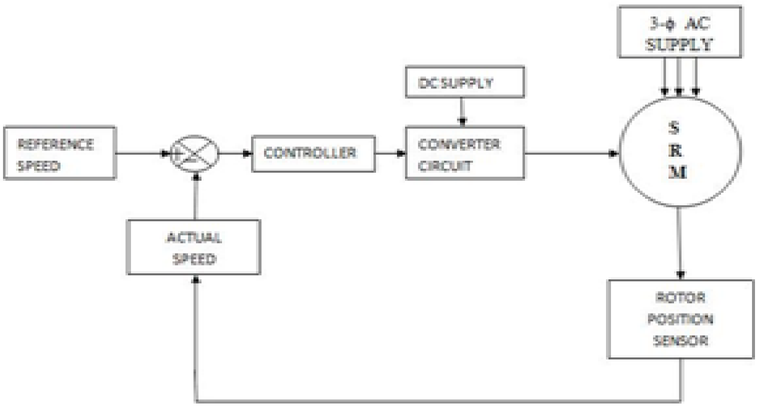

Fig. 2.Block diagram of SRM speed control.

C. Speed Control of SRM using P, PI &PID Controller

A proportional controller (Kp) will h ave the effect of reducing the rise time and will reduce, but never eliminate, the steady-state error. An integral control (Ki) will have the effect of eliminating the steady-state error, but it may make the transient response worse. A derivative control (Kd) will have the effect of increasing the stability of the system, reducing the overshoot, and improving the transient response. Effects o f each of controllers Kp, Kd, and Ki on a closed-loop sy stem are summarized in the table shown below[4]. Table 1 shows effect of Kp, Ki and Kd on response.

Table 1 : Response Of Kp,Ki&Kd

CL Response	Rise Time	Overshoot Time	Settling Time	S-S Error
Kp	Decrease	Increase	Small Change	Decrease
Ki	Decrease	Increase	Increase	Eliminate
Kd	Small Change	Decrease	Decrease	Small Change

Note that these co-relations may not be exactly accurate, because Kp, Ki, and Kd are dependent of each other. In fact, changing one of these variables can change the effect of the other two. For this reason, the table should only be used as a reference when you are determining the values for Ki, Kp and Kd[4].

D. P,I &D Value Tunnin By Genetic Algorithm

It is a heuristic optimization technique inspired by the mechanisms of natural selection. GA starts with an initial population containing a number of chromosomes where each one represents a solution of the problem in which its performance is evaluated based on a fitness function. Based on the fitness of each individual and defined probability, a group of chromosomes is selected to undergo three common stages: selection, crossover and mutation. The application of these three basic operations allows the creation of new individuals to yield better solutions then the parents, leading to the optimal solution [14].

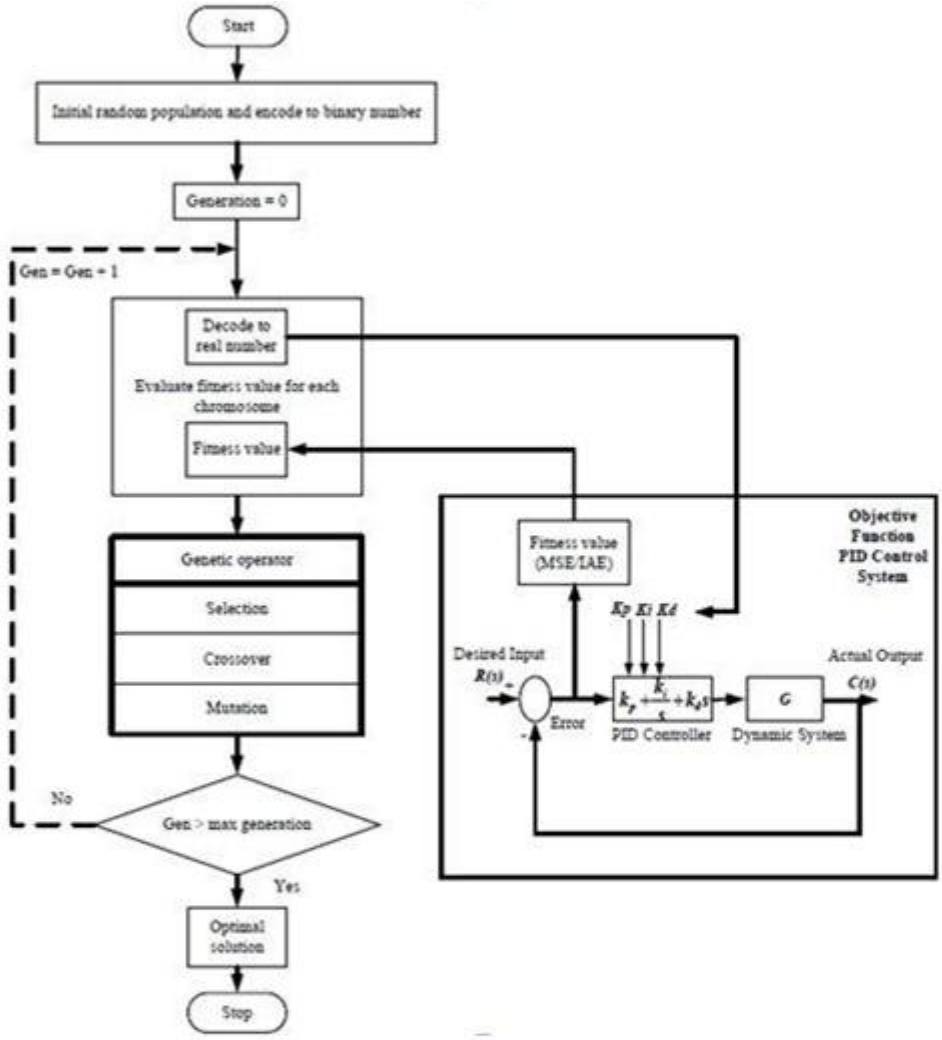

Fig 3.flow chart of genetic Algorithm

From simulation of GA we getting the values of P, I & D as under

Table 2: Values of KP, Ki & KD

III. REASULTS

The SRM is fed by a three phase asymmetrical power converter having three legs, each of which consists of two IGBTs and two freewheeling diodes. During conduction periods, the active IGBTs apply positive source voltage to the stator windings to drive positive currents into the phase windings. During freewheeling periods, negative voltage is applied to the windings and the stored energy is returned to the power DC source through the diodes. The fall time of the currents in motor windings can be thus reduced. By using a position sensor attached to the rotor, the turn on and turnoff angles of the motor phases can be accurately imposed. These switching angles can be used to control the developed torque waveforms. The phase currents are independently controlled by three hysteresis controllers which generate the IGBTs drive signals by comparing the measured currents with the references. The IGBTs switching frequency is mainly determined by the hysteresis band.

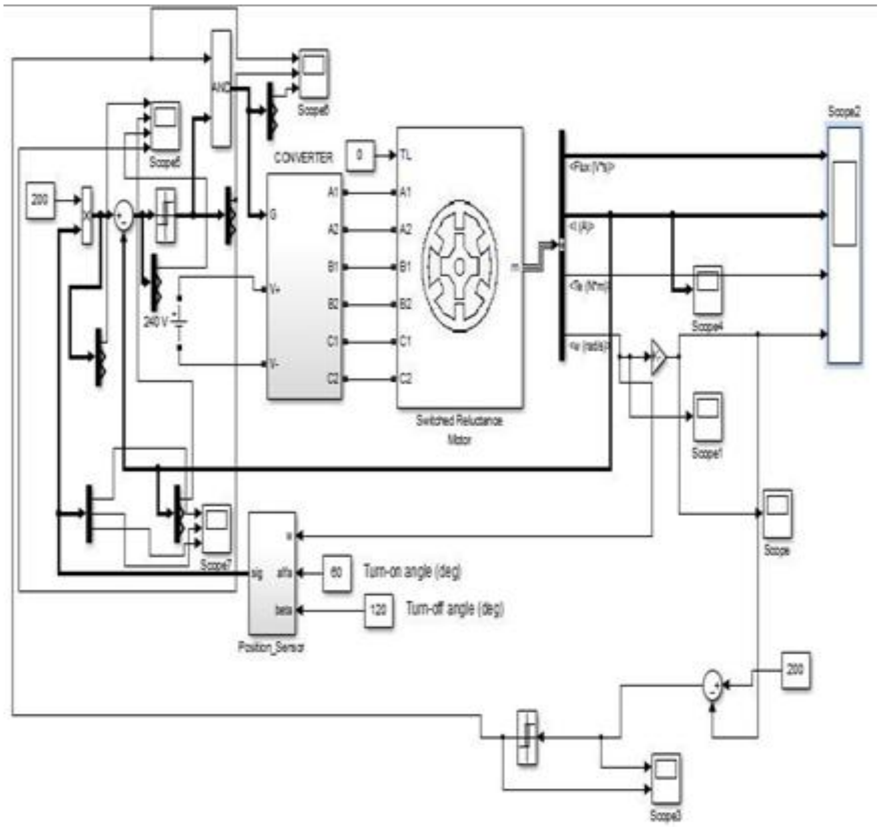

Fig. 4. Simulink model of SRM without controller

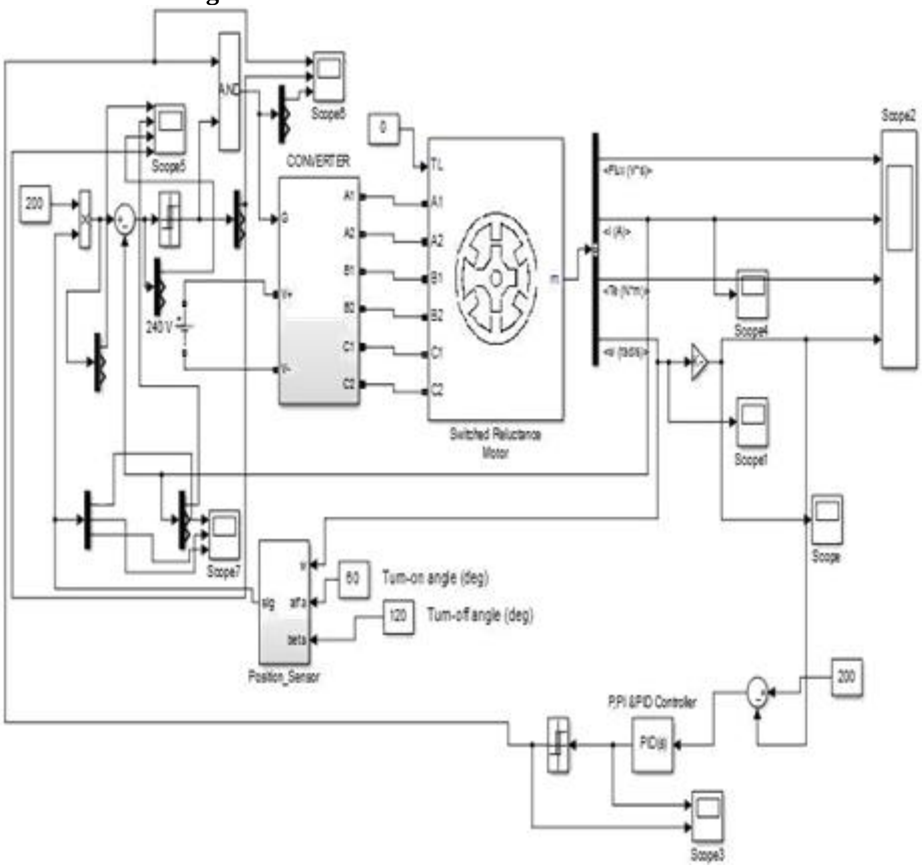

Fig. 5 Simulink model of SRM with controller

In this model, a DC supply voltage of 240 V is used. The converter turns on and turnoff angles are kept constant at 60 deg and 120deg, respectively, over the speed r ange. The reference current is 200 A and the hysteresis band is chosen as +10 A. The SRM is started by applying the step referen ce to the regulator input. The acceleration rate depends on the load characteristics. To shorten the starting time, a very light load was chosen. Since only the currents are controlled, the m otor speed will increase according to the mechanical dynamics of the system.

A. Output of Speed Control of Switched Reluctance Motor without controller

Here fig. 6 shows the output Speed control of SRM without load.

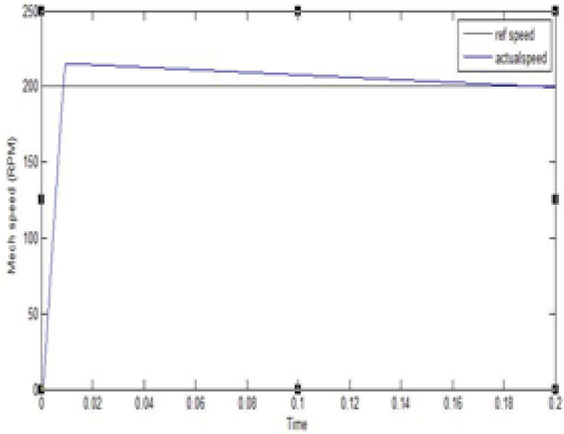

Fig. 6. Output of Speed Control of Switched Reluctance Motor Without load

Here fig. 7 shows the output of Speed Control Of SRM with load (TL=1)

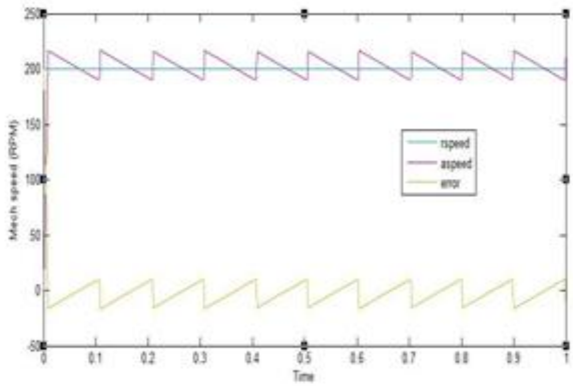

Fig. 7. Output of S peed Control Of Switched Reluctance Motor Without load

B. Output Of Speed Control Of Switched Reluctance Motor with P, PI and PID controller

a. Without load

Here fig. 8. shows the output Of Speed control of SRM with P Controller.

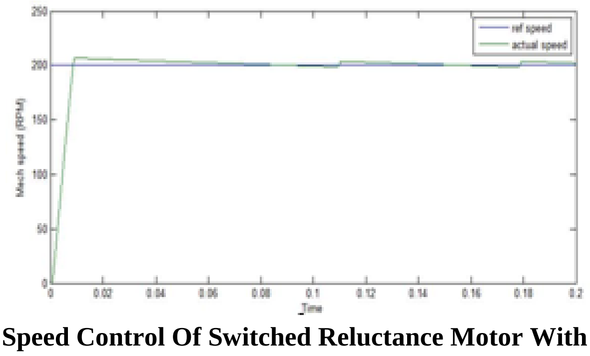

Fig. 8. Output Of Speed Control Of Switched Reluctance Motor With P Controller Here

Fig. 9. shows the output Of Speed control of SRM with PI Controller.

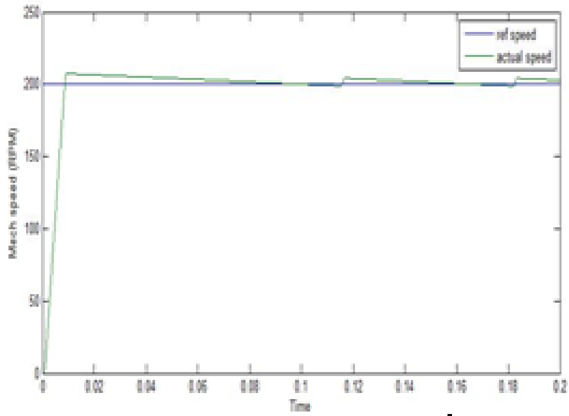

Fig. 9. Output Of Speed Control Of Switched Reluctance Motor With PI Controlle r Here

Fig. 10. Shows the output Of Speed control of SRM with PID Controller.

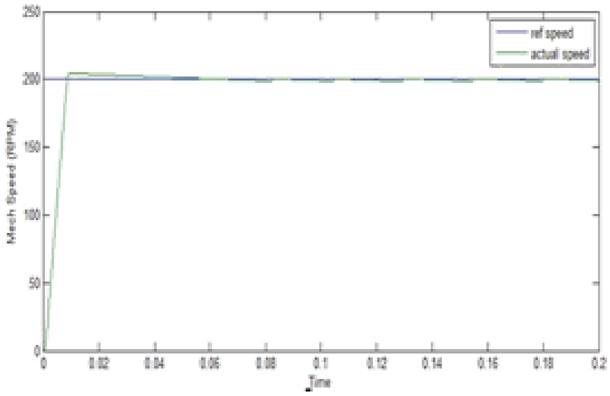

Fig. 10. Output of Speed Control Of Switched Reluctance Motor With PID Controller

B.With load (TL=1)

Here fig. 11. Shows the output Of Speed control of SRM with P Controller.

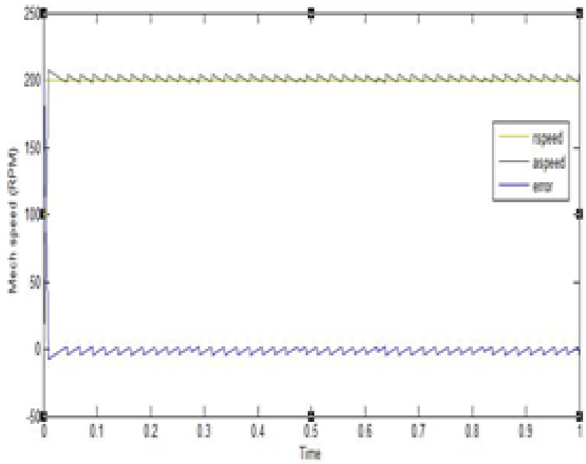

Fig. 11. Output of Speed Control of Switched Reluctance Motor with P Controll er Here

Fig. 12. shows the output Of Speed control of SRM with P Controller.

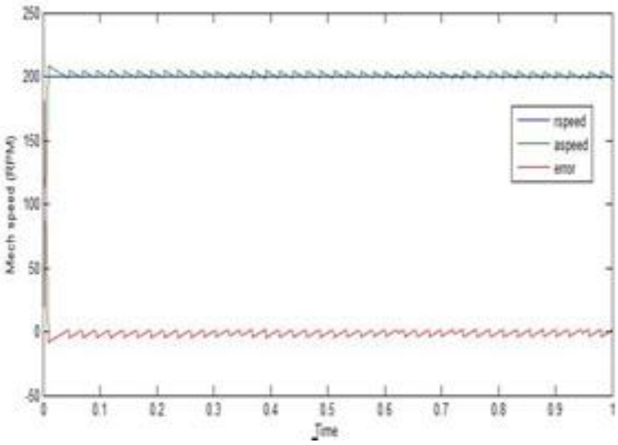

Fig. 12. Output of Speed Control of Switched Reluctance Motor with PI Controller

Here fig. 13. shows the output Of Speed control of SRM with PID Controller.

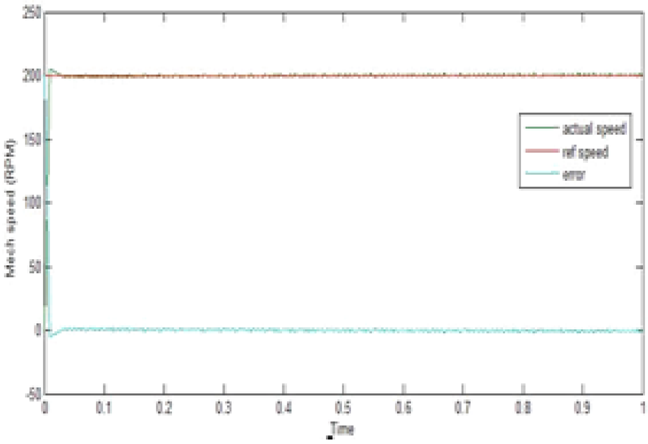

Fig. 13. Output Of Speed Control Of Switched Reluctance Motor With PID Controller

IV. CONCLUSION

Here table 3 shows the analysis of p erformance of SRM with and without controller in unloaded condition. Table 4 shows the analysis of performance of SRM wit h and without controller in loaded condition.

Table 3 Response Of Kp,Ki&Kd without Load

Controllers	Settling Time	Peak Overshoot
Without controller	0.2	220
With P controlle r	0.08	207
With PI controlle r	0.1	209
With PID controller	0.04	205

Table 4 Response Of Kp,Ki&Kd With Load (TL=1)

Controllers	Settling Time	Peak Overshoot
Without controller	0.2	217
With P controlle r	0.8	208
With PI controlle r	1.0	207
With PID controller	0.5	205

From the above tables 3 and 4 we can conclude that without controller strategy is the most sluggish and inaccurate method of speed control for both cases with and without load. Now as we move to the PID controller only P control has high peak overshoot and quit long settling time. For PI controller overshoot value will increase and the settli ng time increase as well. At last for PID controller has lowest settling ti e and peak overshoot. So PID is the most suitable case f or speed control for with and without load.

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