

# Controlling Speed of PMSM Using PID Controller In MATLAB Simulation

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**ABSTRACT:-** Now a day's PMSM (Permanent magnet synchronous motor) is widely used in high performance application such as industrial robots and machine tools because of its compact size, high power density, high air gap flux density, high torque capability and less maintenance. So PMSM has emerged as an alternative to Induction motor due to increasing energy saving demand.so we can achieved speed control of PMSM using this method,and checking an output on output scope of simulation block. The speed control of PMSM in closed loop operation and to deals with existence of transient consider a PID control problem , based on common contole engineering knowledge. if the transient error is big,that good transient performance can be obtained by increasing the P and I gain and decreasing D gain.to autotune the control parameter of the PID controller, the Evolutionary algorithms are developed.

**Keywords:** PMSM, PID

## INTRODUCTION:-

In recent years, the permanent magnet synchronous motor (PMSM)has emerged as an alternative to induction motor due to increasing energy saving demand. PMSM are widely used high performance application such as industrial robots and machine tools because of its compact size, high power density, high air back flux density, high air gap flux density, high torque /inertia ratio, high efficiency and free maintenance.

Many researchers have proposed great deals of advanced PMSM control methods, e.g. model predictive control, switching control, internal model control, adaptive back stepping control, fuzzy speed regulator method, adaptive control, fuzzy PI current control, adaptive fuzzy controller etc.

The advancement in magnetic material, power devices and control theories have made the PMSM drives play a vitally important role in motion control application. The rotor of PMSM is connected to the load that causes low pulsation torque quality. PMSM required the power in inverter to the operate at higher switching frequency so that in attains overlap control and noise reduction in order to achieve the performance of PMSM as the behavior of dc motor , direct control of stator current is needed.

The electric machine prepared for our fuzzy control is a brushless DC motor, which is a PMSM with an inverter and a position sensor attached. All characteristics are similar with those of the DC motors. Permanent magnet synchronous machines do not need electric drives for wide range variable speed in a . PMSM are controlled by using one of these methods:

- open loop control with no feedback reaction, mostly used for simple applications (pumps, fans);
- closed loop control with feedback reaction, used for complex drives, with encoders or transducers.

The control of PMSM by using a fuzzy regulator is considered to be a closed loop control method, based on the elements of the fuzzy logic (FL).FL is a type of artificial intelligence with a very recent history and application. Lotfy Zadeh invented the theory of fuzzy logic [2], [3], and, from the beginning, in 1965, he argued that human thinking is more like fuzzy, vague, or imprecise by its own nature, and, therefore, it cannot be represented by using only yes (1) or no (0). The fuzzy control is also nonlinear and versatile by nature, having an excellent response under parameter variations. In our days modern control techniques based on uncertainty and vague- ness have an important position, supporting all non-linear design techniques [4], [5].

A standard fuzzy logic-based controller adapt the system input in order to get a specific output by just looking at the output, without having any mathematical model for the controlled system That's why it could be used in motor control drive applications. Each fuzzy set of instructions is defined by a so-called linguistic variable (low, large) which is practically defined by a multi valued membership function (MF).

An MF has values between 0 and 1 and could take a range of shapes. The simple and logical operations on fuzzy sets and crisp sets are the classic ones, like AND (intersec- tion), OR (reunion), NOT, SUM, prod.

The fuzzy inference systems (FIS), in case of our electric drive presented in Fig. 1, are:

- the so called fuzzification of all input variables;
- the application of the fuzzy operators in the IF area of the rules;

- the implication, starting from the antecedent to the consequent which are part of the rule;
- the aggregation of the consequents across all the rule;
- The defuzzification.

The evolutionary optimization algorithm operate by representing the optimization parameters via gene like structure and subsequently utilizing the basic mechanism of Darwinian natural selection to find a population of superior parameters .algorithm including evolution strategies, evolutionary programming and genetic algorithm. these various algorithm are similar in their basic concept of evolution and differ mainly in their approach the parameter repretation.PID control is basic feedback mechanism which is used in control system these type of controller also termed as three term controller. by controlling the three parameters- proportional integral and derivative we can achieve different control action for specific work. PID is considered to be the best controller in control system. in PID controller , two parameters are work while keeping the third one to zero. So PID controller becomes sometimes PI(Proportional Integral) ,PD(Proportional Derivative) or even P or I. The derivative term responsible for noise measurement, while integral term is meant for reaching the targeted value of system.

In early days, PID controller was used in mechanical device. In modern days PID controllers are used in PLC (Programmable Logic Control) in industry. The proportional, integral, derivative parameters can be expressed as  $K_p$ ,  $K_i$ ,  $K_d$ . All these parameters have effect on closed loop control system. It effects the rise time , settling time , overshoot and steady state error. PI controller are usually preferred, but due to it's fixed proportional gain and integral time constant , the performance of PI controller effected by parameter variations, load disturbance and speed variations. The complexity of PI controller tuning and high response time is overcome by fuzzy controller.

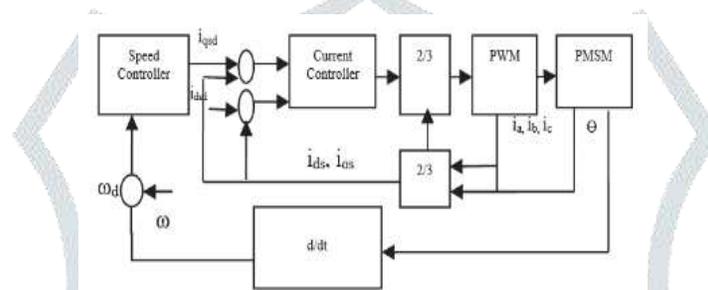


Fig . Block Diagram of PMSM control system

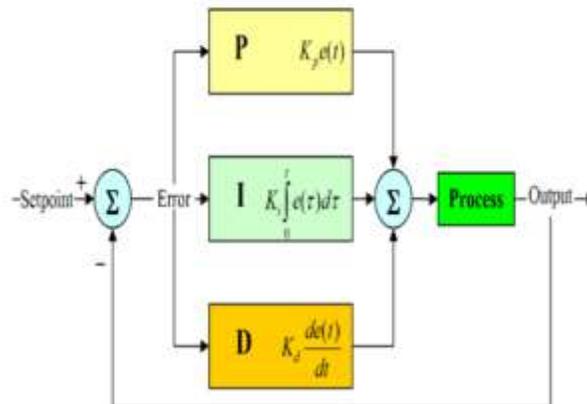
**PID CONTROLLER:-**

A proportional–integral–derivative controller (PID controller) is a generic control loop feedback mechanism (controller) widely used in industrial control systems. A PID controller attempts to correct the error between a measured process variable and a desired setpoint by calculating and then outputting a corrective action that can adjust the process accordingly.

The PID controller calculation (algorithm) involves three separate parameters; the Proportional, the Integral and Derivative values. The *Proportional* value determines the reaction to the current error, the *Integral* value determines the reaction based on the sum of recent errors, and the *Derivative* value determines the reaction based on the rate at which the error has been changing. The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve or the power supply of a heating element.

By "tuning" the three constants in the PID controller algorithm, the controller can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the setpoint and the degree of system oscillation. Note that the use of the PID algorithm for control does not guarantee optimal control of the system or system stability.

Some applications may require using only one or two modes to provide the appropriate system control. This is achieved by setting the gain of undesired control outputs to zero. A PID controller will be called a PI, PD, P or I controller in the absence of the respective control actions. PI controllers are particularly common, since derivative action is very sensitive to measurement noise, and the absence of an integral value may prevent the system from reaching its target value due to the control action.



**LOOP TUNING:-**

If the PID controller parameters (the gains of the proportional, integral and derivative terms) are chosen incorrectly, the controlled process input can be unstable, i.e. its output diverges, with or without oscillation, and is limited only by saturation or mechanical breakage. **Tuning** a control loop is the adjustment of its control parameters (gain/proportional band, integral gain/reset, derivative gain/rate) to the optimum values for the desired control response.

The optimum behavior on a process change or setpoint change varies depending on the application. Some processes must not allow an overshoot of the process variable beyond the setpoint if, for example, this would be unsafe. Other processes must minimize the energy expended in reaching a new setpoint. Generally, stability of response (the reverse of instability) is required and the process must not oscillate for any combination of process conditions and setpoints. Some processes have a degree of non-linearity and so parameters that work well at full-load conditions don't work when the process is starting up from no-load. This section describes some traditional manual methods for loop tuning.

There are several methods for tuning a PID loop. The most effective methods generally involve the development of some form of process model, then choosing P, I, and D based on the dynamic model parameters. Manual tuning methods can be relatively inefficient.

The choice of method will depend largely on whether or not the loop can be taken "offline" for tuning, and the response time of the system. If the system can be taken offline, the best tuning method often involves subjecting the system to a step change in input, measuring the output as a function of time, and using this response to determine the control parameters.

**FLOWCHART FOR EVOLUTIONARY(GENETICE) ALGORITHM:-**

The general Evolutionary algorithm is as follows,

Step 1:create a random initial state: an initial population is created from a random selection of solution. This is unlike a AI (artificial intelligence) where initial state is already given.

Step 2: evaluate fitness: a value of fitness is assigned to each solution is depending on how close is actually is to solving the problem.

Step 3: reproduce: those chromosomes with a higher fitness value are more likely to reproduced offspring. The offspring is the product of father and mother; whose composition consists of a combination of genes from the two.

Step 4:next generations: if the next generation contains the solution that produced an output that is closed enough, then the problem has been solved. if these is not the case, then the new generation will go through the same process as their parents this will continue until a solution reached.

EA are used to auto tune the PID parameters. The EA based PID controllers provides better transient performance and instability and steady state error are overcome by using this method

EA is used to autotune the PID parameters which is represented in following steps

**A. Encoding/Decoding of Chromosomes:**

The PID control parameters are represented as a chromosome which is depicted. The maximum PID gains can be calculated from the tuning methods. Triangular membership function is for finding the final solution .and here we starts our task using EA.

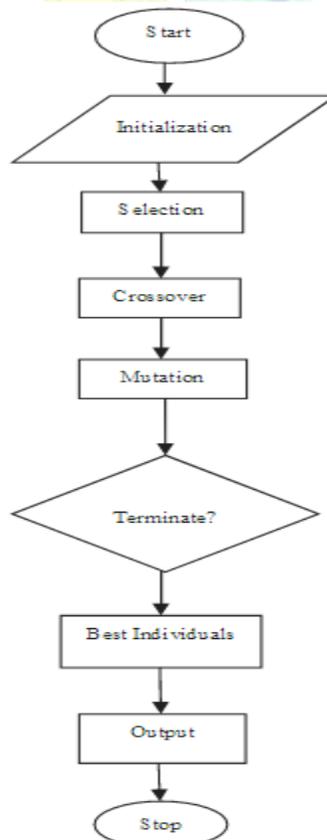


Fig: Flowchart for evolutionary Algorithm

**B. Initialization:**

Before we actually start to autotune the PID parameters we need to set essential parameters of EA and also create the  $N_p \times N_v$  initial population matrix  $P_0$  whose entire randomly generated values between 0 and 1.

**C. Selection:**

We rank the chromosomes according to their fitness functions. Using the fitness function, we evaluate the PID control laws corresponding to  $N_p$  chromosomes. and we rank the chromosomes according to fitness value. Next we select the best  $X_{pN_p}$  chromosomes into a mating pool for reproduction.

**D. Crossover:**

Randomly take two parents from the mating pool ( $C_m$  and  $C_d$ )

**E. Mutation:**

In mutation process genes are randomly selected from the offspring and the selected genes are replaced with uniform random numbers between 0 and 1.

**F. Stopping criteria:**

If the maximum fitness value becomes large than a prescribed value, we terminate the algorithm and we choose best chromosomes as the final solution. Otherwise, if the maximum number is reached, we stop.

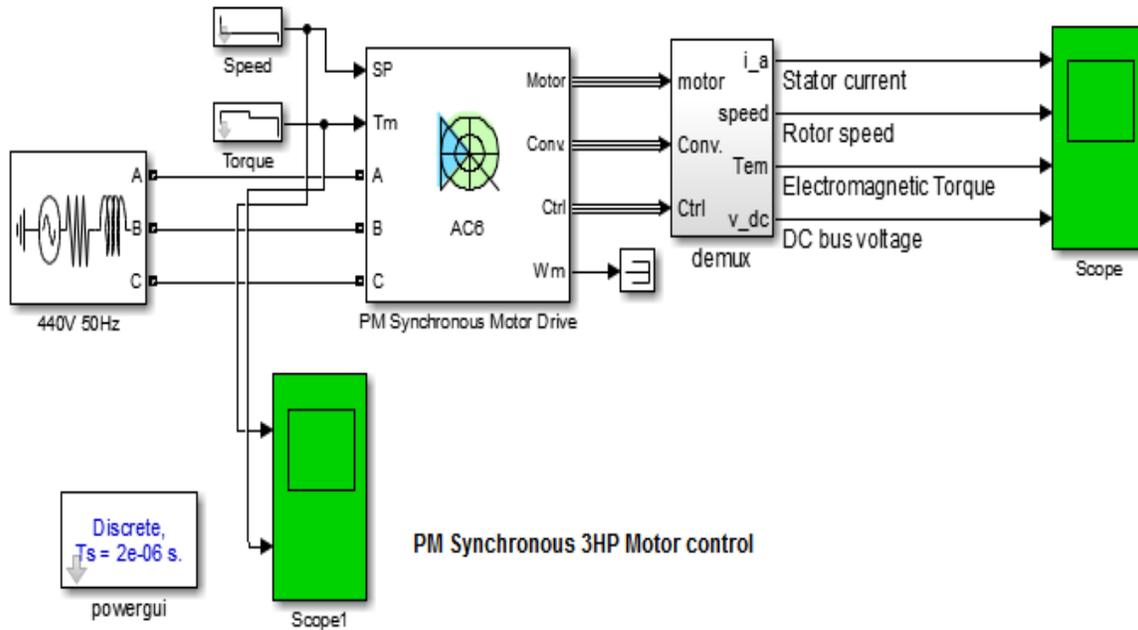
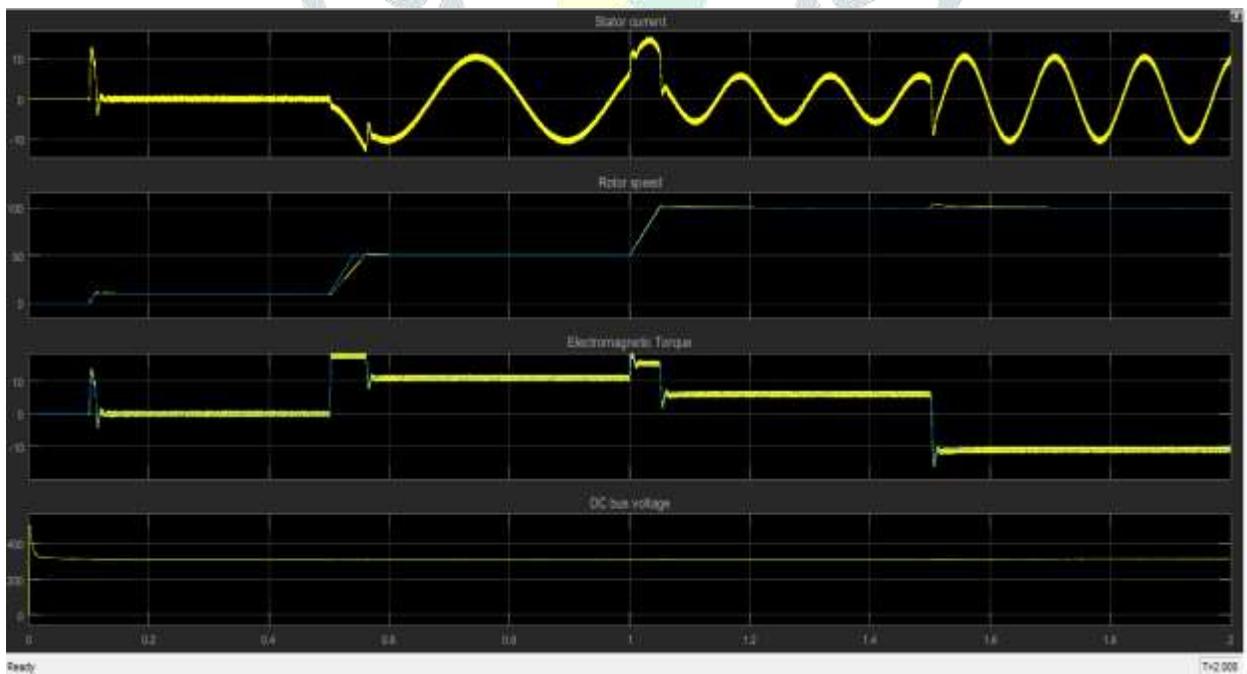
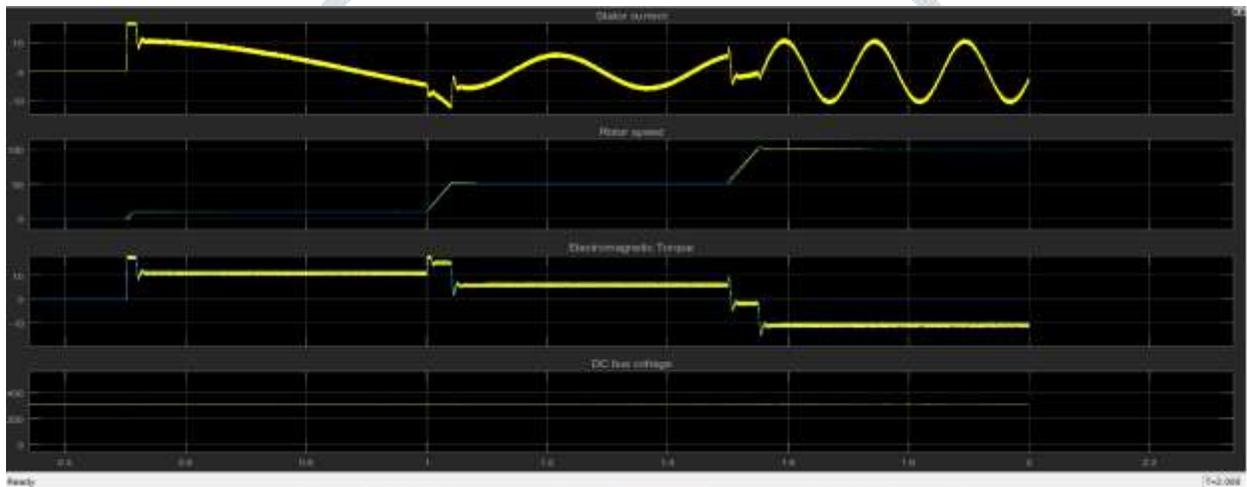
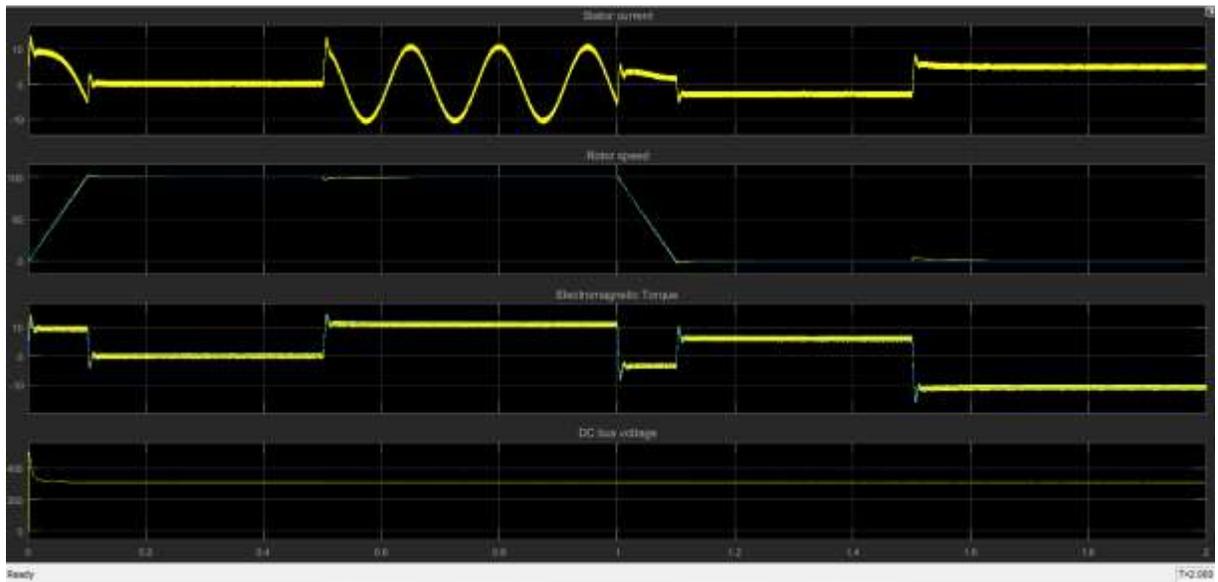


Fig. Simulation diagram of designed system

The DC supply is given to the inverter. The output from the inverter (i.e. three phase AC supply) is connected with permanent magnet synchronous motor (PMSM). The current feedback from the motor is given to the dq transformation block. The speed is

given to the proposed EA based PID controller. The output from both dq transformation block and proposed EA based PID controller is given to the PI current controller. The SVPWM block which generates PWM pulse for inverter. So according to reference, input our output can change the waveforms shown below



So we get above waveforms from given reference input . here reference input is electromagnetic torque and speed. And according to that input output becomes changes it effects on rotor speed and stator current.

**CONCLUSION:-**

In this work ,we controls the speed of PMSM drive ,using PID controller .control design problems is obtained based on common control engineering knowledge. Good transient performance can be obtained by increasing P and I gain and decreasing D gain when transient error is large .then we used EA to autotune PID controller parameters. The speed control achieved by this method .this method also provides better dynamic performance and good stabilization .EA based PID controller has been design successfully for closed loop operation of PMSM drive system so that motor runs at the commanded or reference speed. The simulated system has a fast response with practically zero steady state error thus validating the design method of the speed controller .and we get better performance.

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