IJRAR.ORG E-ISSN: 2348-1269, P-ISSN: 2349-5138

INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS (IJRAR) | IJRAR.ORG

An International Open Access, Peer-reviewed, Refereed Journal

Comparative Analysis Of PI, PID and PID Tunned Method For PMDCM SPEED CONTROL

1 Diksha 2 Mr. Praveen Kumar

1 MTech Scholar 2 Assistant Professor

1,2 Department of Electrical Engineering BIT Sindri Dhanbad , India

ABSTRACT: One of the central problem in a control theory is related to design of the improvement of system performance .The aim of this paper is to provide comparative analysis using PI,PID and FOPID controller in order to optimal regular the speed of a permanent magnet direct current motor. In Proportion Integral (PI) Evolutionary Multi-objective Non Dominated Particle Swarn Optimization (NPSO) algorithm is used while optimal tuning of PID controller gain is based on Particle Swarm Optimization (PSO) technique using Integral Time Squared Error (ITES) Performance index and The FOPID controller parameters (gain and order) using Particle Swarn Optimization (PSO) technique to tune the speed regulator in the permanent Magnet DC (PMDC) motor drive system . The controlling process of PMDC motor is difficult and mathematically tedious because of non-linearity property .The simulation and practice result show that the FOPID controller has more advantage over other tuning method , which they simulated by using MATLAB/Simulink .

Keyword - PMDC (Permanent magnet DC) Motor, Non Dominated Particle Swarn Optimization (NPSO), Particle Swarm optimization (PSO), PI,PID,FOPID

INTRODUCTION: Permanent magnet direct current (PMDC) motor is an electromagnet device that convert electric energy into rotational magnetical energy and is widely in a industrial application due to its reliability ,controllability ,and cost effictiveness .The speed of PMDC motor can be controlled by armature voltage control , proportional –Integral (PI) controller and intelligent controllers which uses Artificial Intellegence (AI) Computing technique like Evolutionary Algorithm ms , neural networks and fuzzy logic

Optimization is a great importance in solving real word design problem and is defined as finding a set a values for vector of design variables and leads to optimum values of objective or cost function . In single-objective optimization problem they may or may not exist some constraint function on design variable and respectively called as constrained or unconstrained optimization problem, while in multi- optimization problem their several objective or cost function (A vector of objective) to be optimized (minimized or maximized) Simultaneously .These objectives often conflict with each other so that one objective function improves another deteriorates .Therefore , there is no single optimal solution that is best with respect to all objective function .Algorithim used here are NPSO for PI and PSO for PID and FOPID respectively .

PI Control technique provide reliable control to improve steady state response .PID based control technique is preferred in many application due to its simple structure and advantages like good transient response , faster control and reduced settling time .Recently , PID control schemes have been extended to their generalized form using fraction calculus involving integration and differentiation of fractional order known as FOPID controller .

PMDC MOTOR

Permanent magnet motor are probably most commonly used DC motor , which operate from direct current power source . The overwhelming majority of smaller Dc motor use permanent magnet fields and provides relatively high torque at low speed and also provide some inherent self- braking power to the motor to shutoff .

MATHEMATICAL MODELING OF PMDC

The equivalent circuit of dc motor is shown in Fig 1.The torque, T is related to the armature current, i by a constant factor $K_\tau I_a$ For the separately excited DC motor, the back emf, e is related to the rotational velocity by: e = $K_b\omega_\tau$.

: $L_s\frac{di_s}{dt} + R_a i_a = V_a - K_b\omega_\tau$

In SI units Kt (armature constant) is equal to Kb (motor constant). From Fig. 2

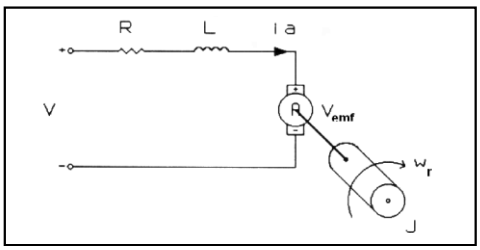


Fig: Equivalent circuit of dc motor

V = input voltage (V)
R = nominal resistance (Ω)
L = nominal inductance (H)
J = Inertial load (kgm2/s2)
Vemf = back emf voltage (V)
b = damping constant (Nm.S)
τ = motor output torque (Nm)
θ = motor shaft angle (rad).

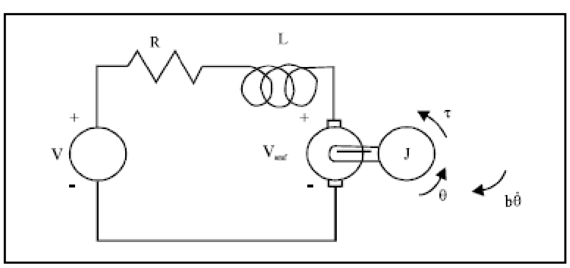


Fig : Electro-mechanical model of dc motor

The DC motor equations based on Newton's lawcombined with Kirchoff's law:

$$J\frac{d\omega}{dt} + B\omega = K_\tau i_s - T_L$$

Where J = L -The moment of inertia
B = ωτ -Damping ratio of the mechanical system
R = Ra -The electrical resistance of the armature circuit
L = La -The electrical inductance of the armature circuit

PI CONTROLLER:

PI controller is a feedback control loop that calculates an error signal by taking the difference between the output of a system. The optimal tuning of the PMDC speed regulator using evolutionary multi-objective algorithm is being performed.

The main algorithm of NPSO

Step 1 : Initialize a random initial population.
Step 2 : Front ranking of the population is done basedon the dominance criteria.
Step 3: Assign each individual a fitness (or rank) equalto its non-domination level
Step 4: Randomly choose one individual as *gbest* for for Ntimes from the nondominated solutions, and modify each searching point.
Step 5 : Combine the offspring and parent population
Step 6 : Sort the extended population based on nondomination and fill the new population of size N with individuals from the sorting frontsstarting to the best.
Step 7: Modify the *pbest* of each searching point

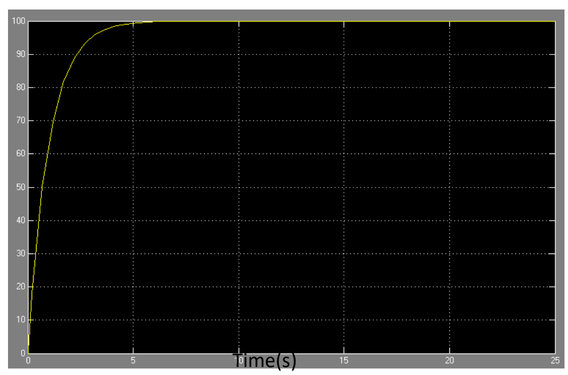


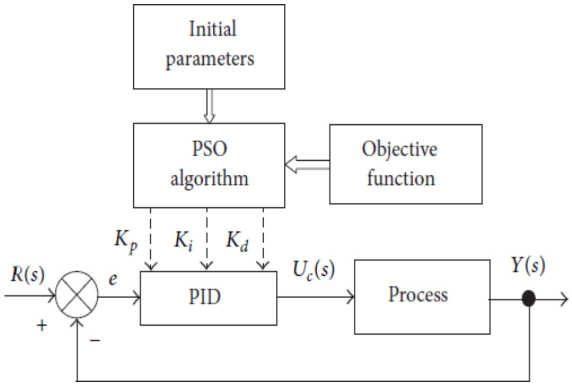
Fig: PI controller response (Speed V/S Time)

PID CONTROLLER:

The major purpose of the controller is to use a certain algorithm to keep the output in the desired range. PID controller includes the proportional (P), integral (I) and derivative (D) parameters which they are set by using a certain tuning algorithm , where the (P) parameter is responsible for the desired set- point, (I) parameter is responsible for accumulating the recent errors and (D) parameter is responsible for determining therate of changeof error of the plant.

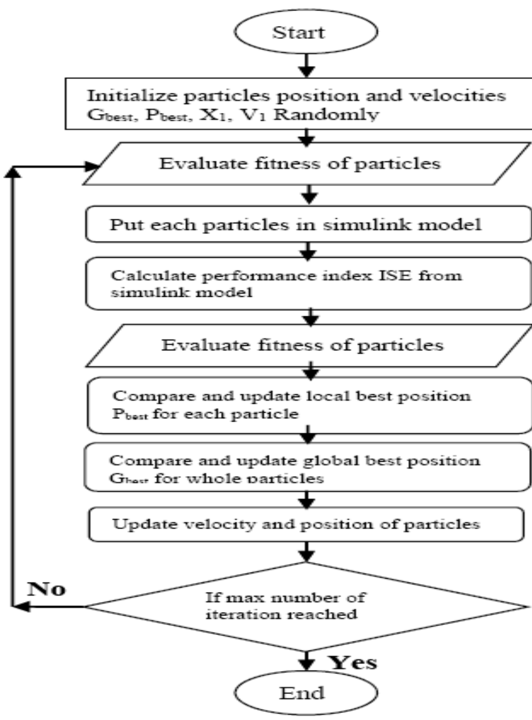
The PID controller transfer function is presented PID controller performance could be effectively obtained with suitable tuning gains for its parameters

: $u(t) = K_p e(t) + K_i\int e(t)d(t) + K_d\frac{de(t)}{dt}$

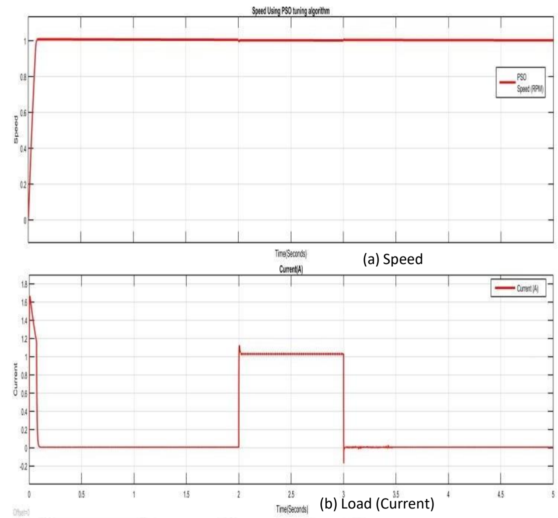


PSO IN PID:

PSO is inspired by the social behavior of flocking of birds and schooling of fish.



SIMULATION AND RESULT:



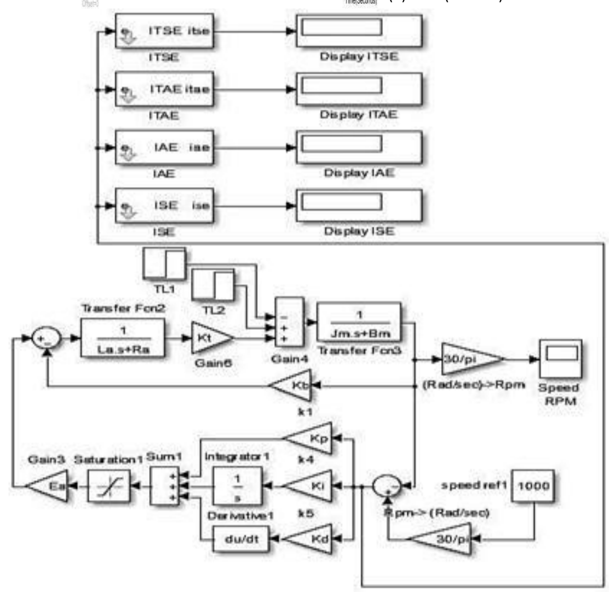


Fig: MATLAB Simulink

Fig: PID controller response (speed v/s time and load current v/s time respectively)

FOPID:

Fractional Order Proportional Integral Derivative controller (FOPID) is a most powerful type of PID controller in which the order of derivative and integral are fractional ($PI^{\lambda}D^{\gamma}$) rather than integer number. Great property of FOPID controller in conjunction with ordinary PID controller is it offers an effective tools to descript the inheriting memory features. In addition, the fractional order controller is more convenient than integer-order models in the control of dynamical systems. Another advantage is the fact that fractional order controllers are insensitive to parameters variation of the system and also the controller parameters . The FOPID control system present a high degree of stiffness to overcome any disturbance or load variation, also its time and frequency responses can be adjusted efficiently as compared with the model predictive controller. The dominant parameters, of the proposed controller, are tuned by using the Particle Swarm Optimization (PSO) technique.

The generalized form of the PID-controller, which also known as $PI^{\lambda}D^{\gamma}$ controllers, is as follow:

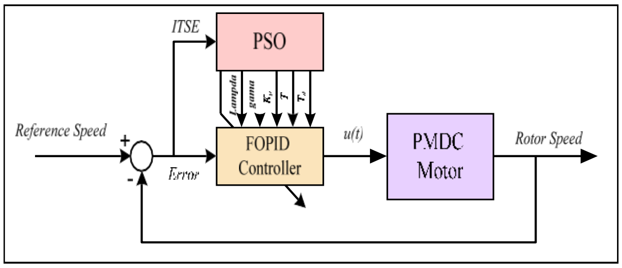


Fig: Block diagram of PSO algorithm based FOPID controller

Where , λ and γ are the integrator and differentiator orders respectively. Then: :$G_c(s) = K_p(1 + \frac{s^{-\lambda}}{T_i} + T_d s^{\gamma})$

The time domain output is:
Given by: $u(t) = K_p e(t) + K_i D^{-\lambda} e(t) + K_d D^{\gamma} e(t)$

Where $K_i = \frac{K_p}{T_i}$ and $K_d = K_p T_d$

The fractional order $PI^{\lambda}D^{\gamma}$controller is the global form of the conventional PID controller.

PARTICLE SWARM OPTIMIZATION (PSO) in FOPID:

It is one of the powerful optimization techniques seeking algorithm having a random probability distribution or pattern inspiring by a community habit of the flock of birds. PSO is a set of rules which associates both cognition and public collaboration of birds. In this method, each bird "particle" searches for the optimum position by updates its location within
the swarm, according to the advantage of its memory of the best position and knowing about the global best
location.

: $\mathbf{v_i(k+1) = Wv_i(k) + C_1R_1(g_{best} - x_i(k)) + C_2R_2(p_{best} - x_i(k))}$

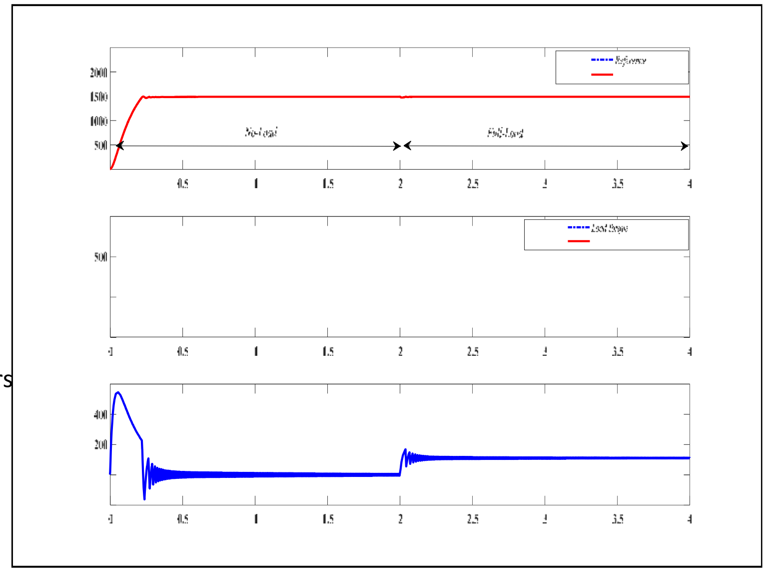
: $\mathbf{x_i(k+1) = x_i(k) + v_i(k+1)}$; i=1,2,……n

Where: v_i is the ith particle velocity, x_i is the ith particle position, k iteration number,
C1, C2 known as the cognitive and social coefficients, w inertia weight factor,
R1, R2 random variables of from 0 to 1,
p_{best} individual best position of particle i, g_{best} best global position of all the particles in the swarm, and n number of birds (particles).

If: $f(x_{ik}) = f(p_{best})$;
then $p_{best} = x_{ik}$

where, f perform the minimization objective fitness function.

Fitness criteria to evaluate system performance is Integral of Time Square Errors
ITSE= $\int_0^{\infty} te^2(t)\, d(t)$



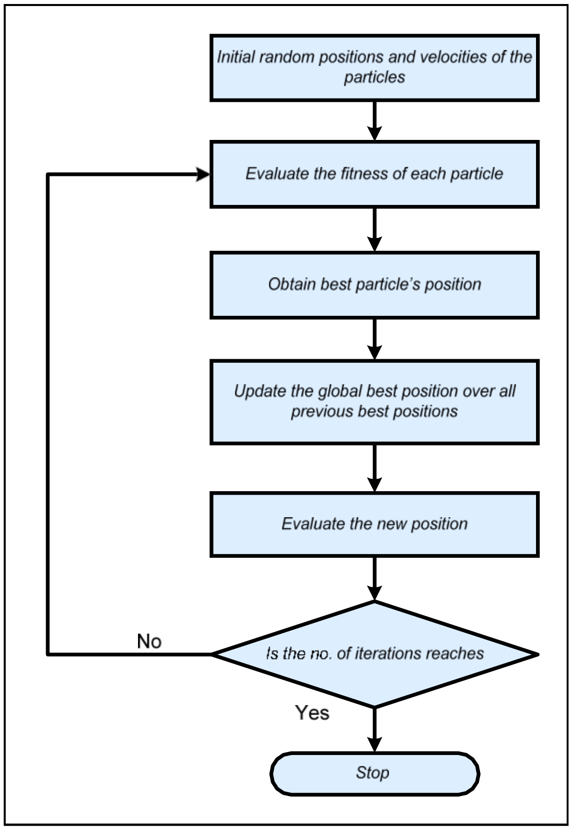
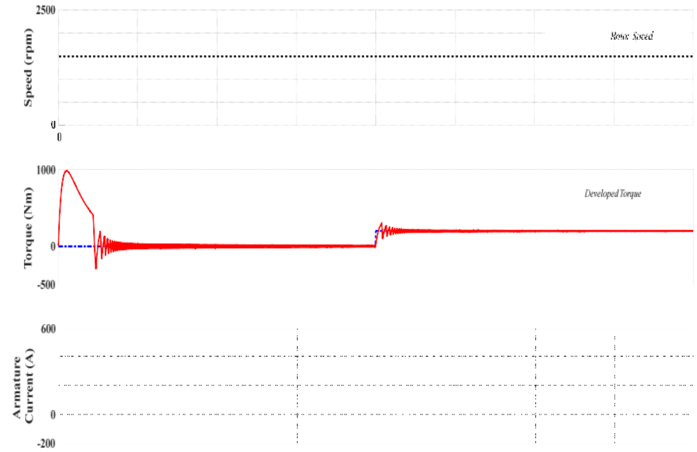
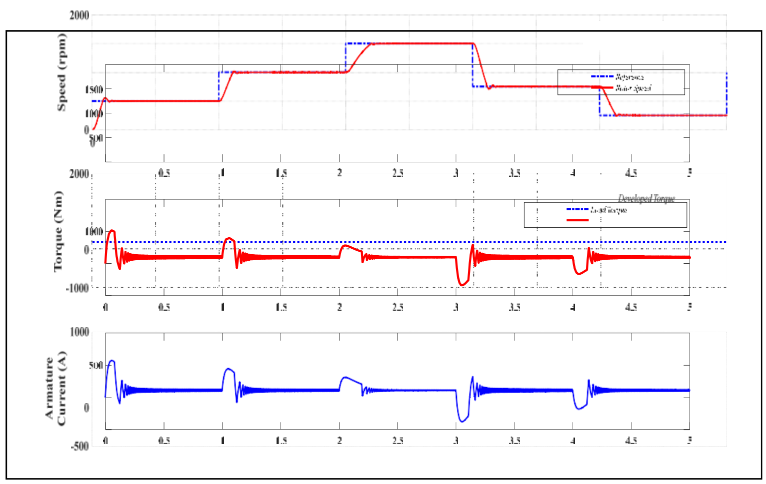
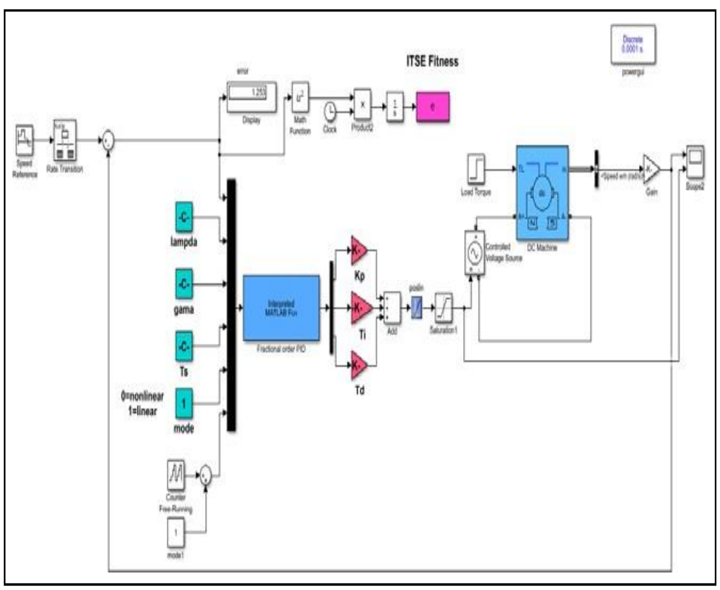


Fig: Flow chart of PSO Algorithm applied on FOPID





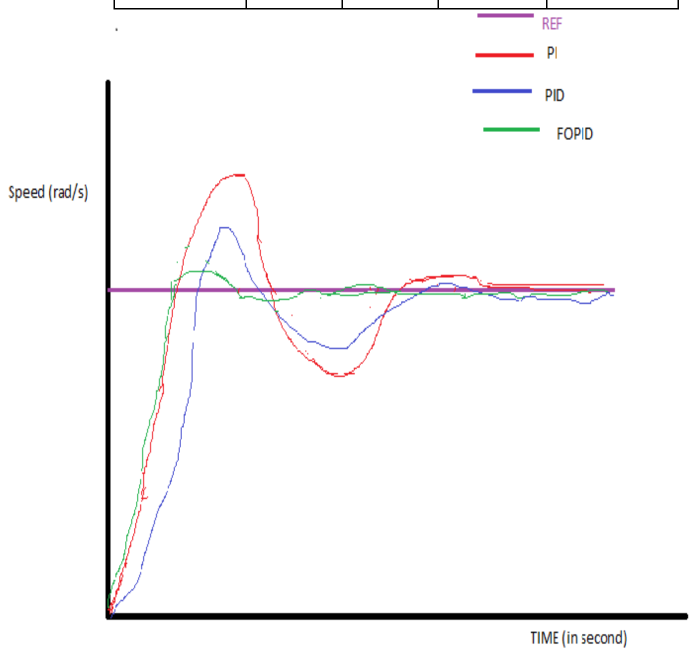
SIMULATION and RESULT:



COMPARISON

Controller	k_P	k_I	k_D	λ	γ
PI	3.65	1.85	0.25	-	-
PID	0.96	0.90	0.068	1	1
FOPID	0.07	1.81	0.069	0.39	0.88

Controller	t_r (s)	OS (%)	t_s (s)	E_{ss} (rad/s)
PI	0.06	16.4	0.39	1.04
PID	0.08	7.9	0.25	0.69
FOPID	0.05	0.8	0.14	0.21



STEP RESPONSE COMPARISON OF PI, PID and FOPID controller

CONCLUSION

This paper proposed the FOPID controller has superior performance over PID and PI controller to control thespeed of the PMDC with considering the non-linear behavior of armature resistance. The fractional- order, PID and PI controllers are simulated, and the responses of them are investigated under different operating conditions. Simulation results show excellent command speeds tracking and superior dynamic response although the variation of system parameter. The FOPID controller shows a high ability to overcome any internal or external disturbance, it performs a high degree of robustness to control the system in motoring and regenerative operating modes. It is observed that FOPID reduces the maximum overshoot, settling time,and ITAE as compared to PI and PID controller.

The results infer that improvement in speed control is achieved with lesser control also current required by the FO-PID controller is less which implies an energy-efficient nature of the proposed controller.

REFERENCES:

1) Manoj Dhondiram Patil, K. Vadirajacharya and Swapnil W. Khubalkar. Design and Tuning of Digital Fractional-Order PID Controller for Permanent Magnet DC Motor.. IETE JOURNAL OF RESEARCH
2) Fadhil A. Hasan, Lina J. Rashad, Fractional-order PID controller for permanent magnet DC motor based on PSO algorithm, International Journal of Power Electronics and Drive System (IJPEDS)Vol. 10, No. 4, December 2019, pp. 1724~1733
3) P.G. Medewar∗ and R.K. Munje†,PSO based PID Controller Tuning for PMDC Motor, 2015 International Conference on Energy Systems and Applications (ICESA 2015)
4) C.Agees Kumar and N.Kesavan Nair, Multi-Objective PI Controller Design with an Application to Speed Control of Permanent Magnet DC Motor Drives, International Conference on Signal Processing, Communication, Computing and Networking Technologies (ICSCCN 2011)
5) K. Hameyer, R. J. M. Belmans, “Permanent Magnet Excited Brushed DC Motors”, IEEE Tranactions on Industrial Electronics, vol.43, no.2, April 1996, pp. 247-255.
6) [] Galijašević, Sanel, Šemsudin Mašić, Senad Smaka, Abdulah Akšamović, and Dinko Balić. "Parameter identification and digital control of speed of a permanent magnet DC motors." In Information, Communication and Automation Technologies (ICAT), 2011 International Symposium on, pp. 1-7. IEEE,
7) Wikipedia