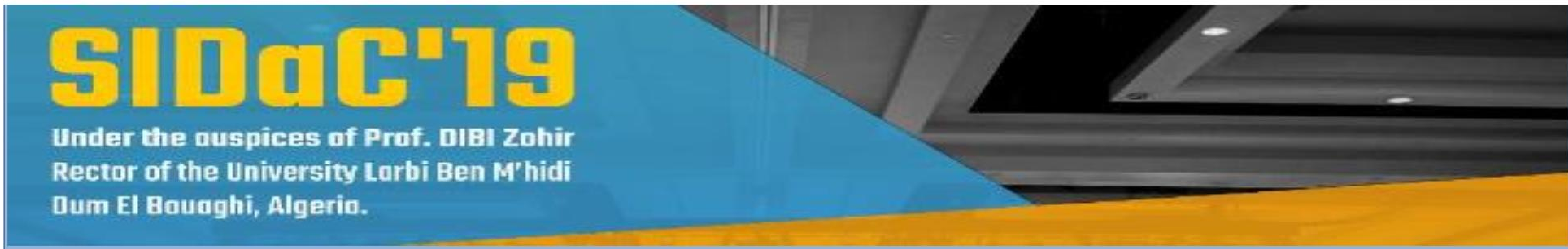

Using genetic algorithms to optimize controller parameters For MRAC to Control a peed of a Separately Excited DC Motor

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Abstract— **The classical control method is insufficient to satisfy the expected performance of variable speed drives DC motor's, It is subject to deterioration in performance in the presence of structural and environmental disturbances, such as temperature increase, inertia and load torque variation and others. These disturbances lead to a loss of decoupling, resulting in a deterioration in the motor's performance. Then it is necessary to use an online command to calculate the controller parameters; This investigation is concerned with the model reference adaptive using MIT rule based PID control when we implemented a Genetic Algorithm (GA) to optimize the initial values of PID controller and MARC paramaters. Incorporating separately excited DC motors, subjected to uncertainties including parameter variations and ensuring optimum efficiency. The idea is to find further perfection for MRAC using MIT rule method and to provide an even more smooth control to the a Separately Excited DC Motor. This is examined when combining the MRAC method using MIT rule with the PID control. The performance of the drive system obtained, formed a set of test conditions with simulation MATLAB Simulink.**

Keywords: a Separately Excited DC Motor, MRAC method, *PID controller; Genetic algorithm.*

1. INTRODUCTION

Sometimes conventional feedback controllers may not perform well online because of the variation in process dynamics due to nonlinear actuators, changes in environmental conditions and variation in the character of the disturbances[2]. An effort has been made in recent years to develop an identification theory closer to the needs of robust control.

This paper also deals with the use of MIT rule along with the normalized algorithm to handle the variations in the reference signal, and this adaptation law is referred as modified MIT rule. The performances of the proposed control algorithms are evaluated and shown by means of simulation [1], [3]–[5]..

2. Dynamical Model of the Plant

A. Separately Excited DC Motor :

Among the various machines currently used by man, engines are the most important due to its great versatility as almost we can find it anywhere from a toy car, up in large industries. DC motors are the most common and inexpensive, and allow a wide range of speed and can provide high torque-controlled motor easier and cheaper than any AC motor. In this paper we propose the use prototype of DC motors [6], [7].

B. Equation Setting :

Consider that a DC electric motor is governed by the physical equations resulting from its electrical, mechanical and magnetic characteristics.

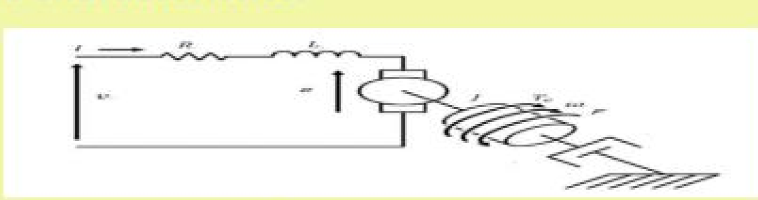

Fig. 1 Scheme of separately excited DC motor.

Model shown has electrical characteristics consisting of: the rotor supply voltage, the current that flows through the rotor, the rotor resistance.

equations (7) to (10) leads us to the principle diagram of a DC motor given in Fig. 2

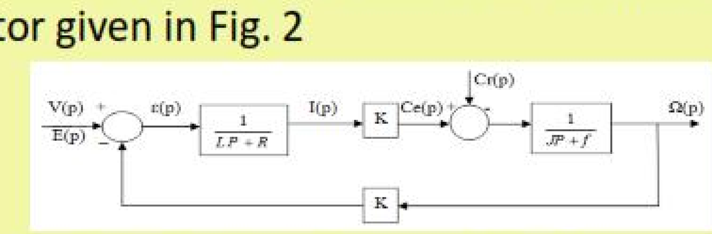

Fig. 2 Functional diagram of DC Motor.

the transfer function of DC Motor $\frac{\Omega(p)}{U(p)}$ rewritten by:

$$\frac{\Omega(p)}{U(p)}=\frac{\frac{K}{(LP+R)(JP+f)}}{1+\frac{K^2}{(LP+R)(JP+f)}}=\frac{K}{(LP+R)(JP+f)+K^2}=\frac{K}{LJP^2+(JR+Lf)P+Rf+K^2}$$

the parameters of DC motor are:

TABLE I

PARAMETERS DC MOTOR.

Rated power	1 KW
Rated armature voltage	220 V
Rated armature current	5.75 A
Rated electromagnetic torque	4.77 $N.m$
Rated speed	2000 tr/min
Armature inductance	0.0119 H
Armature resistance	5.9 Ω
Moment of inertia	0.00705 $Kg.m^2$
Friction coefficient	4.051x10 − 4 $N.m.s$
Constant	0.859

3. Method Based on the MIT Rule

MIT rule was first developed in 1960 by the researchers of Massachusetts Institute of Technology (MIT) and used to design the autopilot system for aircrafts. MIT rule can be used to design a controller with MRAC scheme for any system[4].

To know how to update the θ parameter, an equation must be formed for the change of θ. If the objective is to minimize this error-related cost, the gradient *J* must be moved in the negative direction. This change in *J* is supposed to be proportional to the change in θ. Thus, the derivative of θ is equal to the negative variation of *J* [1], [8]–[10].

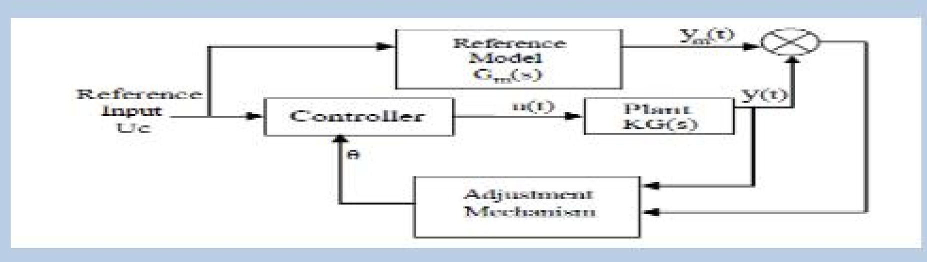

Fig. 3 Model Reference Adaptive Control System.

$$\frac{d\theta}{dt}=-\gamma\frac{\partial J}{\partial\theta}=-\gamma e\frac{\partial e}{\partial\theta} \quad (1)$$

Where, the partial derivative term $\frac{\partial e}{\partial\theta}$ is called as the sensitivity derivative of the system. This term indicates how the error is changing with respect to the parameter[11] . And eq. (1) describes the change in the parameter with respect to time so that the cost function can be reduced to zero. Here is a positive quantity which indicates the adaptation gain of the controller.

$$J(\theta)=|e| \quad (2)$$

The gradient method gives,

$$J(\theta)=-\gamma(\frac{\partial e}{\partial\theta})\operatorname{sign}(e) \quad (3)$$

3. Application of the MRAC control

The parameters of the PID controller are regulated by a manual adjustment method until the desired reference model response is obtained $K_p=51; K_i=96; K_d=0.5$.

Adaptation gains are chosen empirically after several tests:

$$\gamma_p=-7.6; \gamma_i=-2.5; \gamma_d=-0.01$$

The following figure shows the simulation diagram of the MRAC control.

he studied method is evidenced by the simulation, first the no-load motor is tested with a nominal speed reference 200 rad/sec, then a nominal load torque of 4.77 is applied at the time t = 2.5 sec. After a new speed reference will be imposed (reversal of the direction of rotation) 200 to -200 rad/sec, then a test of variation of the motor parameters, in any case the measured speed will be compared to the reference speed (desired).

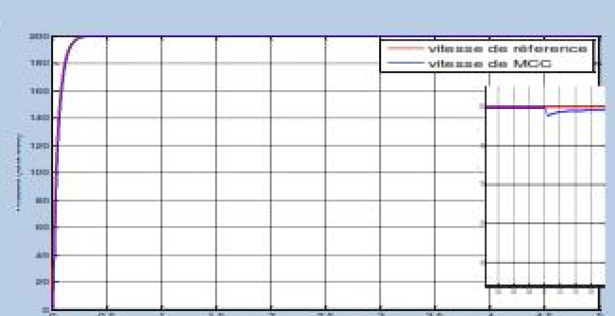

Fig. 3. Speed response(rad/sec)/time(sec) start with no load and application load (Cr=4.77N.m) at t=2.5sec , with Zoom at time application load.

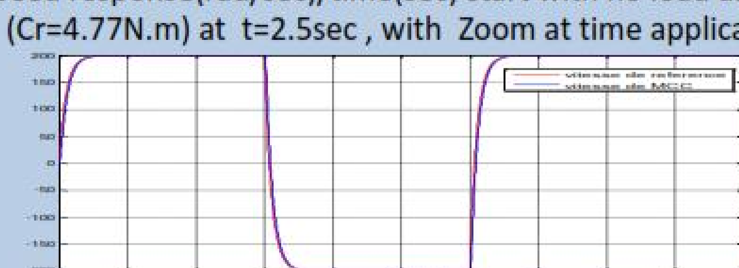

Fig.4. speed response (rad/sec)/time(sec), Reversing the direction of rotation .

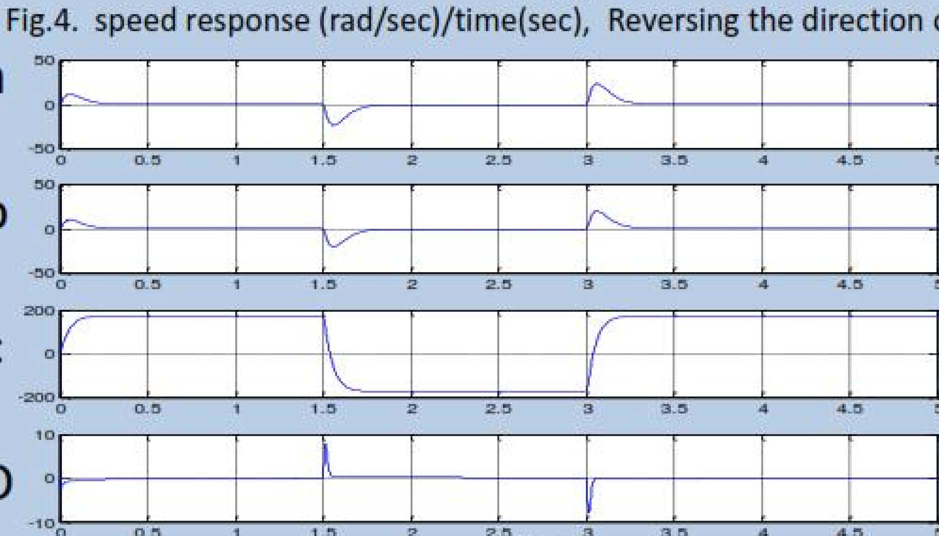

Fig 5. Performances of MRAC with Reversing the direction of rotation .a-Current(A)/time (sec), b-Torque(N/M)/time(sec) c-input command signal(V) /time(sec), c-error of speed motor.

4. Interpretation Of The Results

At idling, the motor speed precisely follows its reference with a dynamic error of less than 1 rad/sec. The introduction of the nominal resistive torque increases the current to its nominal value. It can be seen that the speed error caused by the disturbance of the load is very quickly compensated. The variation of the reference (reversal of the direction of rotation) does not affect the system response. We always have a perfect follow-up.

The current present in the strong pulses at the times of reversal the direction of rotation It reaches a maximum value. This is due to the noise generated by the mechanical part, and after the disappearance of the transient regime, it tends towards the value corresponding to the load.

We note that the impact of parametric variations is insignificant on the speed response, and it does not generate overruns or static errors.

The adaptive parameters change when applying the load torque, reference change, motor parametric variations, which proves the robustness of the adaptive PID controller against internal and external uncertainties.

We note that the effect of the load, the reversal of the direction of rotation and the parametric variations are completely supported by the control system.

5. CONCLUSIONS

A model reference adaptive control system was developed and tested on its response to desired speed. The main objective was to determine whether a MRAC using MIT rule is applicable for rapid response a Separately Excited DC Motor such as no-load speed control and with load.

The proposed contribution is the insertion of variable adaptive gains for the calculation of the control law, which will increase the performance of the system, in the sense that it will ensure low system sensitivity to internal and external uncertainties, and in the simulation results the system response and that of the model are in good agreement. It can be concluded that the control aspects used are more robust and that their speed remains constant regardless of internal and external uncertainties.

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