Speed Control of Separately Excited DC Motor with PID Controller

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ABSTRACT

Separately excited DC motors are most suitable for wide range speed control, therefore we are used in many adjustable speed. It can operate in stable condition with any field excitation and gives wide range of output voltage. This paper is made to connect PID controller in series with plant system (SEDM) to observe and control the speed response of the dc motor by using Matlab simulation program, this mean the combination of proportional control, integral control and derivative control will reduce the error signal between the desired speed and the measured speed.

KEY WORDS: DC motor, PID controller, speed control, SEDM, proportional control, integral control, and derivative control.

الخلاصة

تعد محركات التيار المستمر المتحمسة بشكل منفصل هي الأكثر ملاءمة للتحكم في السرعة على نطاق واسع ، لذلك نحن مستخدمون في العديد من السرعات القابلة للتعديل. يمكن أن تعمل في حالة مستقرة مع أي إثارة مجال وتوفر نطاقًا واسعًا من جهد الخرج. صمم هذا البحث لربط المتحكم التفاضلي النسبي PID في سلسلة مع نظام المصنع (SEDM) لمراقبة استجابة سرعة محرك التيار المستمر والتحكم فيها باستخدام برنامج محاكاة Matlab ، وهذا يعني أن الجمع بين التحكم النسبي والتحكم التكاملي والتحكم التفاضلي سيقلل من نسبة الخطأ بين السرعة المطلوبة والسرعة المقاسة.

1.INTRODUCTION

Direct current (DC) motor converts electrical energy in to mechanical energy. The construction of the DC motor and generator are the same but the DC motor has wide range of speed and good speed regulation in electric traction[1].A direct current motor is equipped with magnets , either permanent magnets or electromagnetic windings, that produce the magnetic field when the current passes through the armature ,the field generated by the armature interacts with field from the magnets and applies torque[2]. The proportional – integral – derivative (PID) controller operates the majority of the control system in the world. It has been reported that more than 95% of the controllers in the industrial process control applications are of PID type as no other controller match the simplicity, clear functionality, applicability and ease of use offered by the PID controller [10], [11]. PID controllers provide robust and reliable performance for most systems if the PID parameters are tuned properly. The major problems in applying a conventional control algorithm (PI, PD, PID) in a speed controller are the effects of non-linearity in a DC motor. The nonlinear characteristics of a DC motor such as saturation and fiction could degrade the performance of conventional controllers [8],[9].

Traditionally armature control method was widely used for the speed control of low power DC motor .The desired speed characteristics could be achieved by the use of conventional proportional, integral, derivative (PID) controllers. As PID controllers use a control loop feedback mechanism to control process variables and to keep the actual output from process as close to the target as possible [3]. In this paper, the speed control of the DC motor system was done by using PID controller. This controller will calculate the error signal between the desired speed and the measured speed, therefore we can tune the PID controller by using trial and error method. In this method, we have to set Ki and Kd values to zero and increase the proportional control (Kp) until the system reaches oscillating behavior [4]

2. SPEED CONTROL TECHNIQUES IN SEPARATEIY EXCITED DC MOTOR

The speed of DC motor (SEDM) could be varied from zero to rated speed mainly by:

A-Varying the armature voltage in the constant torque region.
B- In the constant power region, the field flux should be reduced to achieve speed above the rated speed [5] [6][7].

The physical parameters of DC motor are armature resistance, armature inductance, moment of inertia and frication coefficient are listed in table 1.

Parameters	Value of parameters
Ra	0.8Ω
La	H $5.8*10^{-3}$
Kb	0.8598 NmA^{-1}
Jm	Kg-$m^2 6.8*10^{-4}$
Bm	0.02 N.m/rad/sec

Table1: physical parameters of separately excited DC motor

3. SIMULATED BLOCK DIAGRAM AND SIMULATION results

Separately Existed DC Motor is designed by using matlab Simulink as shown in figure1. First, we design block diagram of the closed loop dc motor without PID controller and assume the reference input signal unit step.

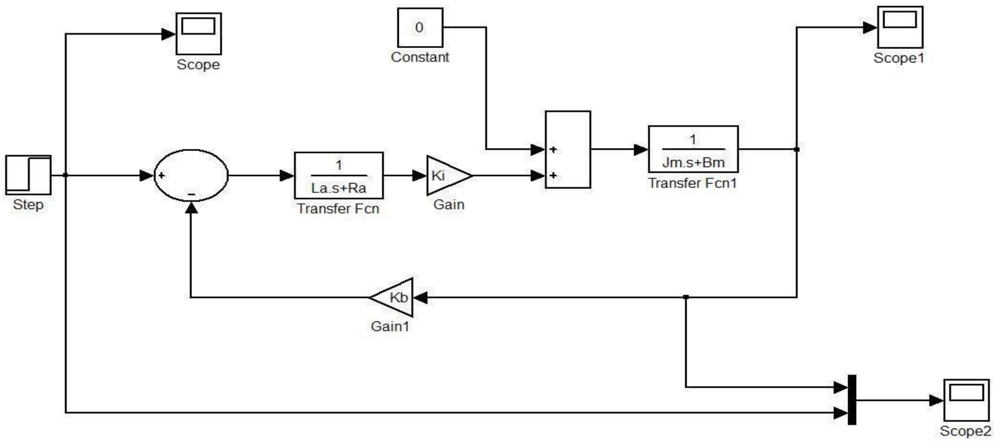

Fig.1:Block diagram of separately excited dc motor circuit

When run m-file in Simulink of matlab the response of speed is appear as shown figure2. It shows maximum overshoot, higher steady state error , therefore we use the PID controller connected in series with dc motor to avoid machine damage and high overshoot (violet color refers to the desired speed and yellow color refers to the measured speed).

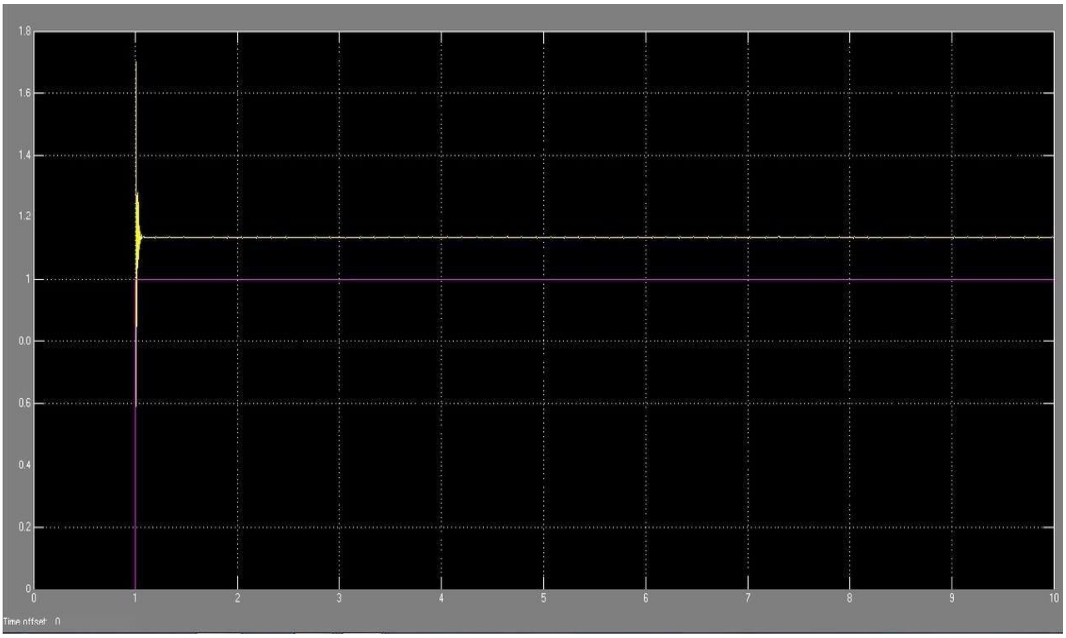

Fig.2:Speed response of separately excited DC motor without PID controller

4. SIMULINK MODEL OF DC MOTOR SPEED BY USING PID CONTROLLER

. Figure3 Shows block diagram of separately excited DC motor with PID controller.

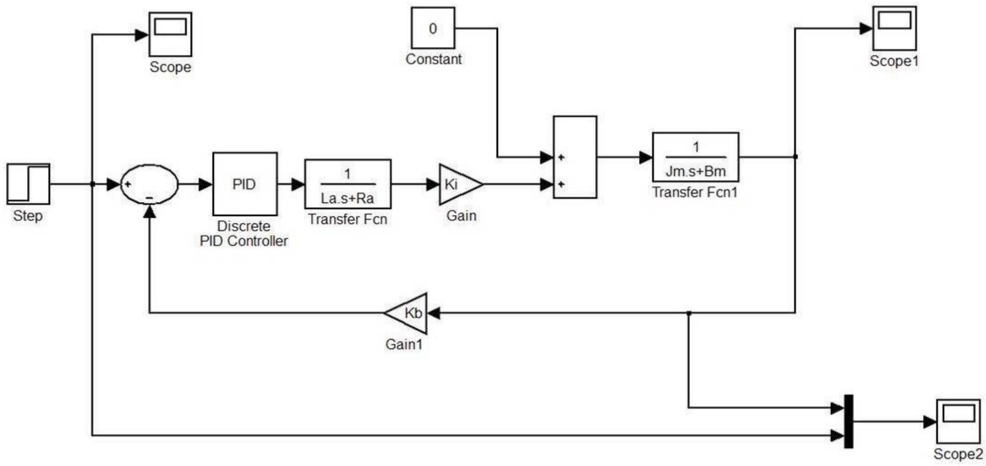

Fig.3: Block diagram of dc motor circuit with PID controller

PID is one of the most popular control methods when combines the action of proportional control, integral control and derivative control which provides minimum errors.

5. Tuning PID Controller Parameters

First, we choose values of PID controller as following the response of system as shown in the figure 4

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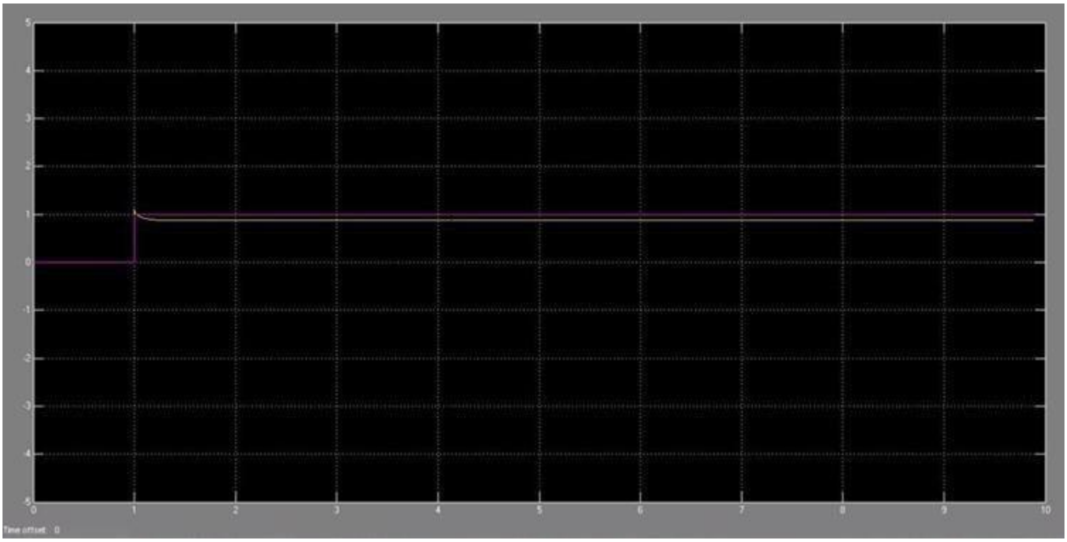

Fig.4: Step response for Kp=0.08, Ki = 0.000008, Kd=0.008

It shows the response of speed motor with PID controller, there are difference between desired speed and measured speed therefore we try to change the parameters of PID to reduce the error, this tuning of PID depends on trial and error method. When increase kp, ki and kd we get fast response, minmum overshoot and steady state error is eliminated slowly as shown in figure5. .

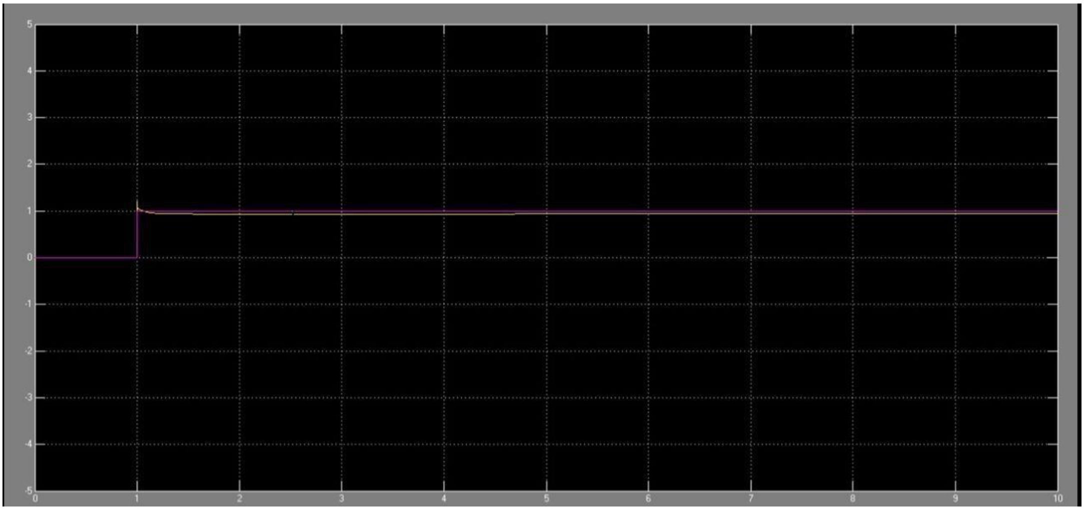

Fig.5: Step response for kp=0.11, ki=0.00005, kd=0.011

Now we must increase Ki more to make steady state error equal to zero we get the response of system as shown in figure6.

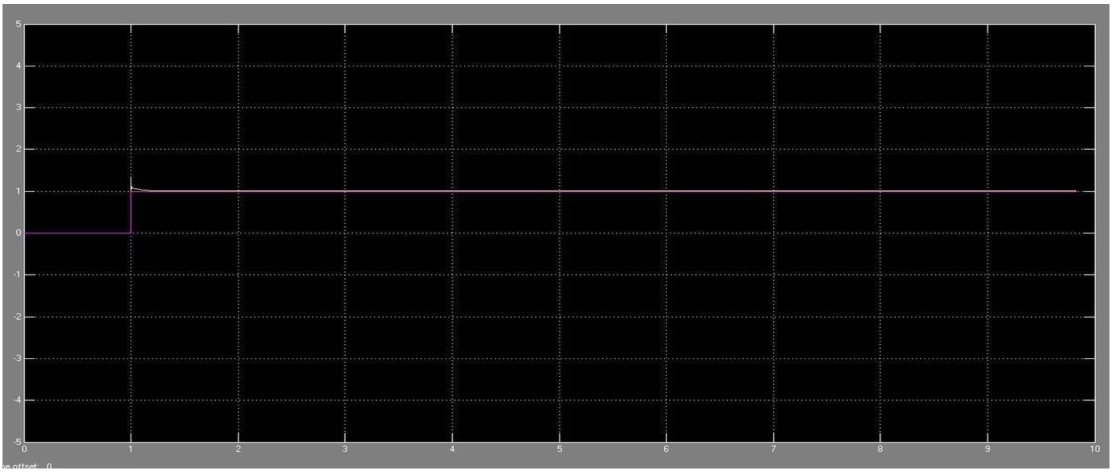

Fig.6: Step response for Kp=0.17, Ki= 0.00111, Kd= 0.017

5. Conclusion

This paper studies the PID controller for the dc motor speed control system. The advantage of PID controller is feasibility and easy to be implemented. This important observation mode during studies are proportional controller Kp will have the effect of reducing the rise time but never eliminate the steady state error, integral controller Ki will have the effect of eliminate the steady state error but it may make the transient response worse and derivative controller Kd will have the effect of increasing the stability of the system and reducing the overshoot and improve the transient response.

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