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Simulation Model of PID Controller for DC Servo Motor at Variable and Constant Speed by Using MATLAB

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Abstract—**The current simulation is conducted in order to develop an appropriate design for the control systems and control the speed of the electric motor. To obtain the appropriate and required design, work is carried out for two cases, a constant speed and the other case at variable speed in different conditions for operation of dc servo motor, these conditions include rotating in a clockwise direction, break and returns rotating in the opposite clockwise direction. Through the proposed working conditions, it is possible to obtain the best values for the parameters of the control unit that improve the working performance of dc servo motor, which were shown by the simulation results and their values were kp =5, ki=3 and kd=5 for PID controller. Which changed the system response speed, rise time and the upper and lower bypass ratio at acceptable rates and ratios to prove an improvement procedure in the work of the electric motor.**

Keywords— DCSM; PID Controller; Speed; Position

I. INTRODUCTION

Due to the high specifications that DC servo motors (DCSM) possess, high torque, low inertia torque, so they are used in computers and drives (printers, disks, tapes and word processing) and all of these fields require speed control, high accuracy and precise positioning. Where the speed and position of the servo motor are controlled by the control unit that sends signals in the feedback [1-5]. In addition to the above advantages, the servo motors (SM) have other advantages of high flexibility, low cost, and high reliability. There are problems when controlling the motor speed where the characteristics are non-linear and the engine is a time-varying nature, so servo motor needs highly efficient control units or they are called expert controllers it is added to the traditional controllers to control the speed and position of the motor or to improve the performance [6-10]. The study presented [11] a simulation model of the (SM), the use of the PID controller, and the simulation of the mathematical model of the motor in improving the performance of the motor. In research [12], the PI controller was used to control the speed of the (SM), the use of data for real experiments, and the use of genetic algorithms technology to reach the best results, which are used as input to the pi controller, so that pi became fast response, less raise and sufficient stability time. Paper [13] include a powerful PID regulator was used to control the position of the DCSM by adjusting the PID parameters (Kd, Kp and Ki) as well as the use of MATLAB in accounts that applied to multiple cases depending on the ideal coefficient to integrate the time-doubled absolute error criterion into the unit step and slope. In Mezher [14] refer two types of conventional controllers, PI and PID, were used to control the speed of a DCSM. Multiple inputs were tested in a simulation program and the results were presented using LABVIEW. The researcher presented in the paper [15] building a dynamic model of DC motor and using Matlab/Simulation as a sub-system of the motor, and then using PID and FLC as a logic controller to control the motor speed. For centuries, PID controllers have been used in industrial applications for their ease of application, high efficiency and robustness [16-22]. PID controllers have three basic control modes (kp, ki, kd), which are characterized by ease of implementation and good performance, enabling them to be widely used in industrial fields [23-28]. When designing the PID control mechanism, its parameters are adjusted in order to reach the optimum operation of the motor (reduce rise time, overshoot, steady state error and hold time [29-34]. This paper proposes using PID controller to speed control of DCSM in order to develop and obtain best results.

II. MATHEMATICAL MODELS OF DCSM

Due to the good electrical and mechanical performance of the (SM) when compared with a DC motor therefore, this paper includes the study of controlling the speed of this type of motor because of its importance in the practical and industrial fields, especially the field of control. Fig. 1 show model representation of the motor [35], while Fig. 2 illustrates dynamic behavior of DCSM by block diagram. [36-41].

Equation (1) refers to the transfer function of (DCSM), also Table 1 shows parameters of (DCSM) [42]:

$$\frac{\Theta_s}{V_a} = \frac{K_t}{s(L_a s + R_a)(J_m s + B_m) + K_t K_b s} \qquad (1)$$

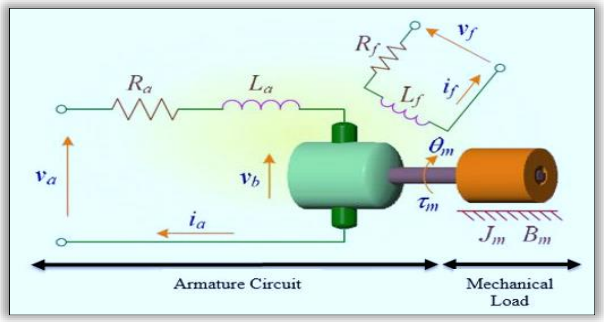

Fig. 1. Model representation of DCSM

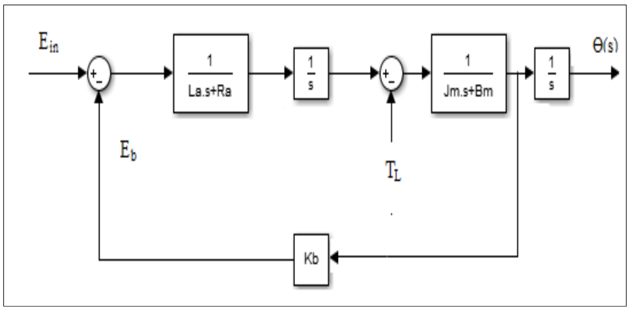

Fig. 2. Block Diagram representation of a (DCSM)

TABLE I. TABLE TYPE STYLES

Criterion	Symbols	Amounts	Units
Armature resistance	Ra	2.23	ohm
Armature inductance	La	0.23	H
Moment of inertia	Jm	0.00006286	Kg.m2
Friction coefficient	Bm	0.0000708	Rad /sec
Torque constant	KT	0.121	N-m-s / rad
Back emf constant	KB	0.121	V/(rad/s)

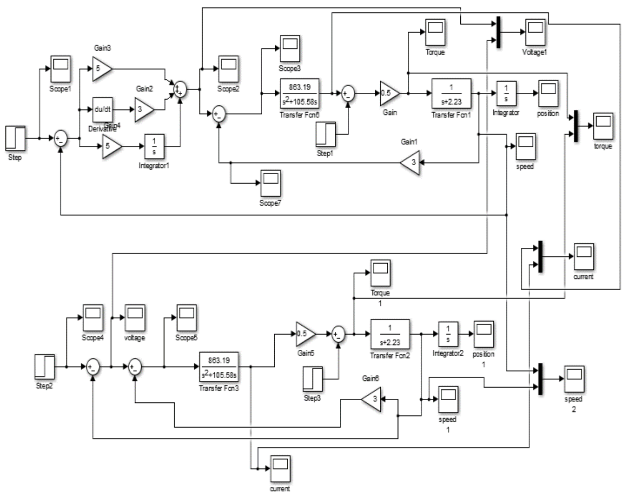

Fig. 3. The simulation model with and without PID controller at constant speed

III. SIMULATION MODEL TO SPEED CONTROL OF DCSM

The simulation model of DCSM is implemented by using Math Lab program [43-46], this type of traditional controllers has advantages using to improve the work and performance of operation for machines to get better results, especially in the field of control, so this paper proposes two models when DCSM operates at no load [47-54], the first model refers to speed control at constant value of speed while second model deals with variable speed at multi conditions. Fig. 3 indicates to simulation model for each with and without PID controller whereas Fig. 4 shows the model at variable speed at different conditions.

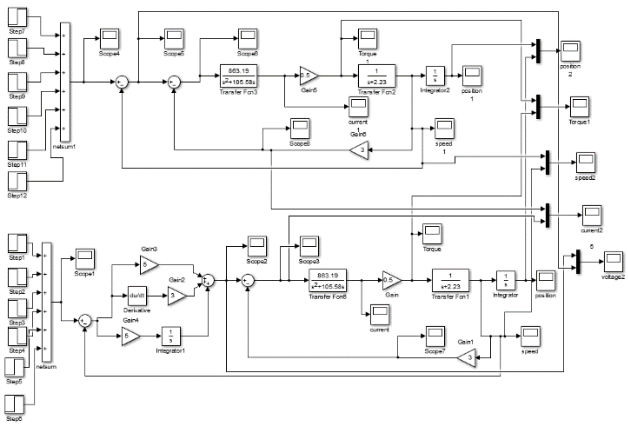

Fig. 4. The simulation model with and without PID controller at variable speed

IV. SIMULATION RESULTS AND DISCUSSION

In this part, the results will be discussed. These results also are in two cases, first case deals with speed control for DCSM with constant speed with and without PID controller while the second case at a variable speed in different conditions.

A. Simulation results at constant speed

When speed constant the Simulink response of PID controller for speed control of DCSM at no load that can be shown in the Figures. Fig. 5 refers to characteristics of speed whereas Fig. 6 indicates the torque of motor while other characteristics can be shown in Figs. 8, 9 and 10 respectively.

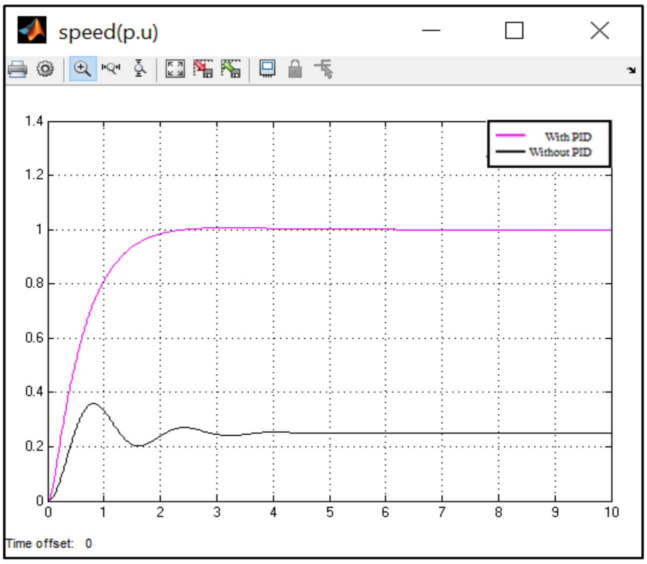

Fig. 5. speed control of DCSM

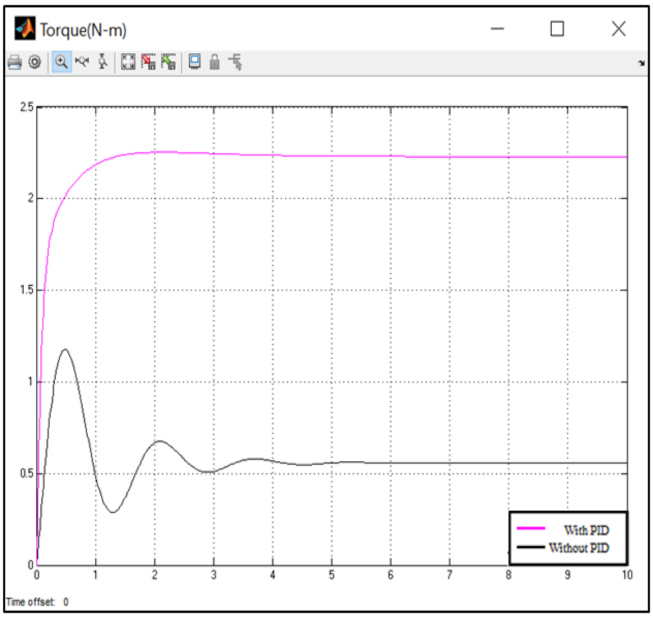

Fig. 6. Torque characteristic of DCSM

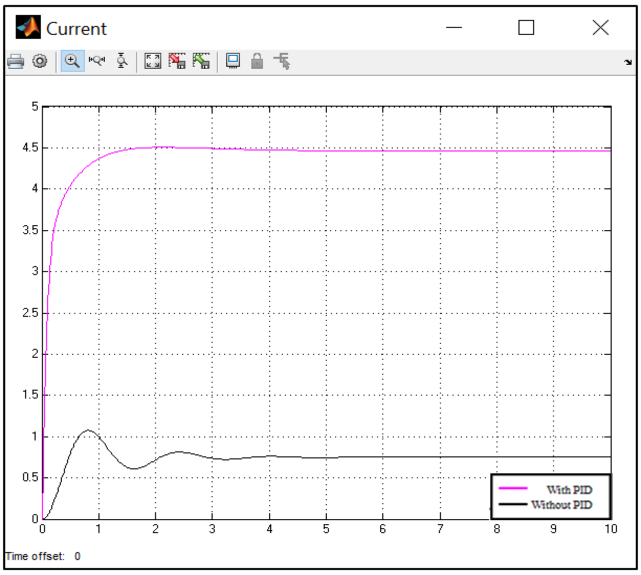

Fig. 7. The Current

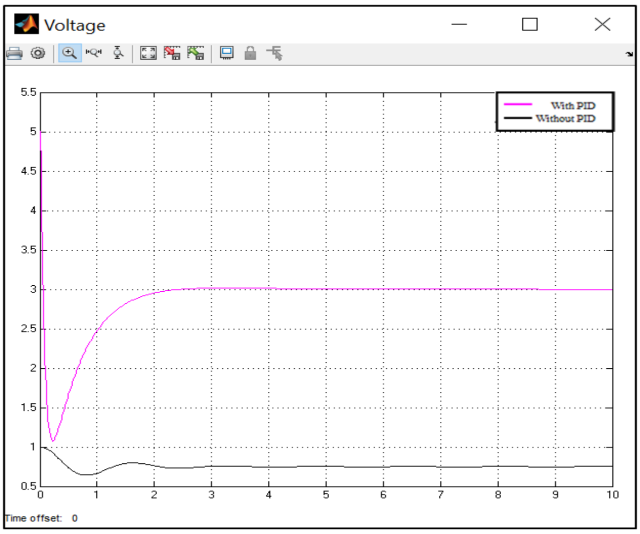

Fig. 8. The Voltage

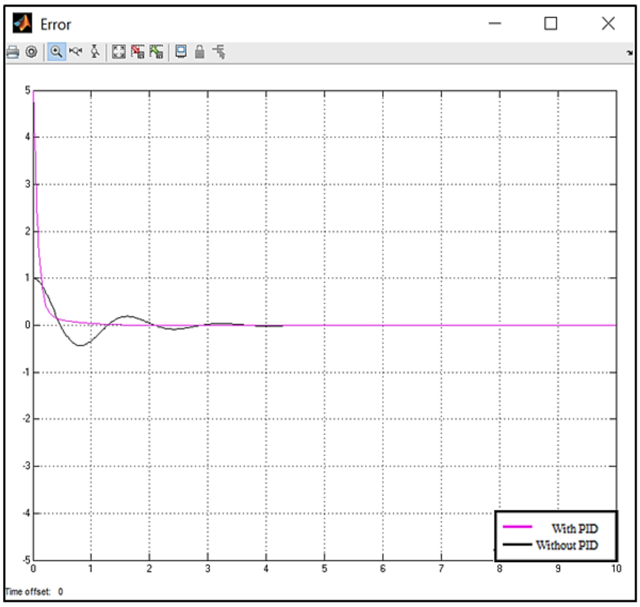

Fig. 9. Error of system

B. Simulation results at variable speed

In this section, the results are obtained at variable speed in three condition, first condition when the motor rotates at a clockwise direction, the second condition when the motor breaks and third condition when the motor returns rotating in opposite clockwise direction as available in Table 2.

TABLE II. CONDITION OF OPERATION FOR DCSM

Conditions of operation for DCSM	**Time (sec)**
Rotates at a clockwise direction	0-5
Break	5-10
Rotate opposite clockwise direction	10-15
Break	15-20
Rotates at a clockwise direction	20-25

Simulink responses and the characteristics of DCSM at above conditions can be shown in Fig. 10 – 15.

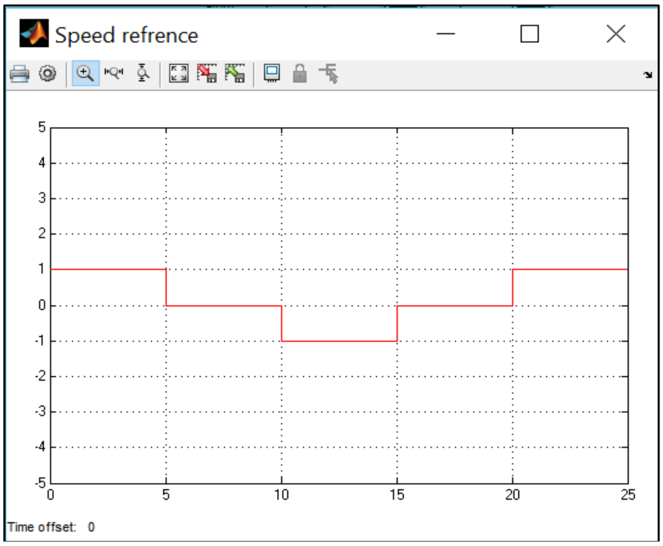

Fig. 10. reference speed of DCSM

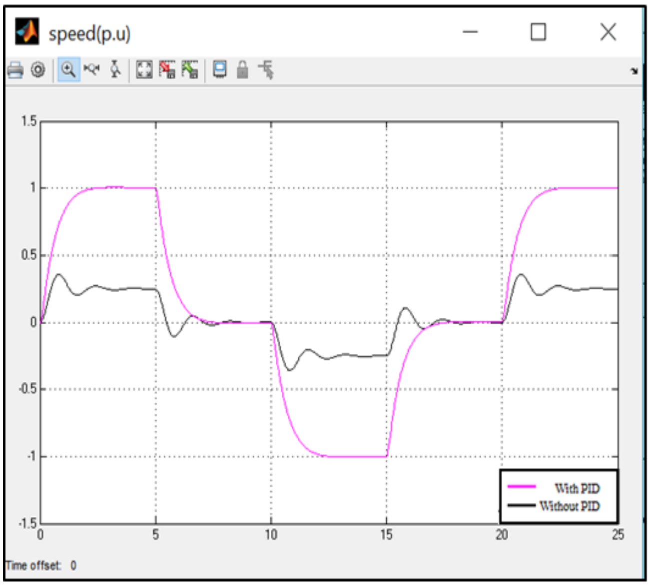

Fig. 11. speed control of DCSM

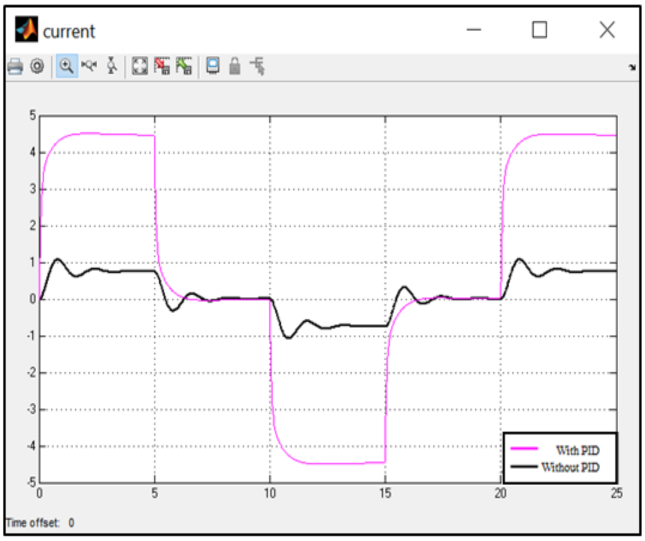

Fig. 12. The current

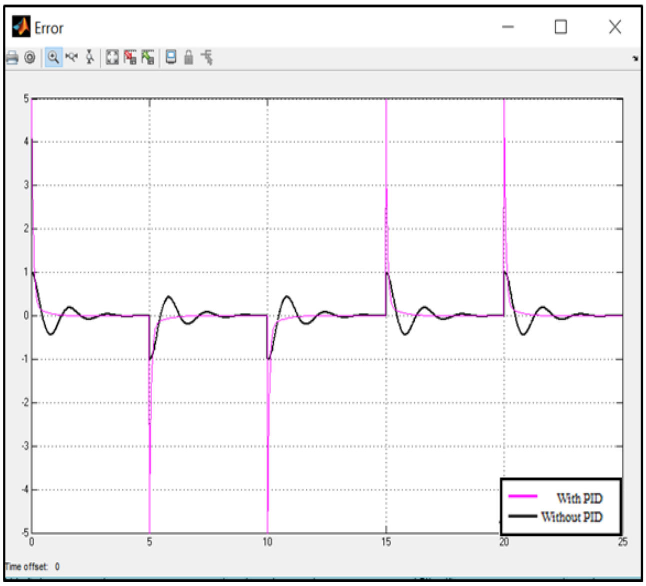

Fig. 13. The Error of system

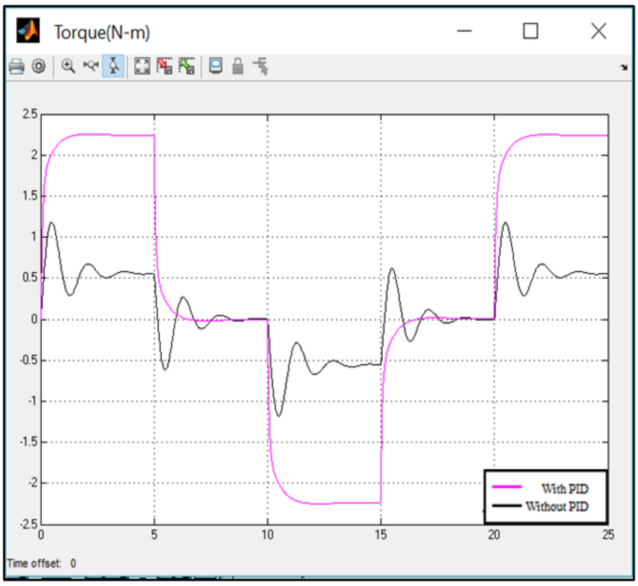

Fig. 14. Torque of DCSM

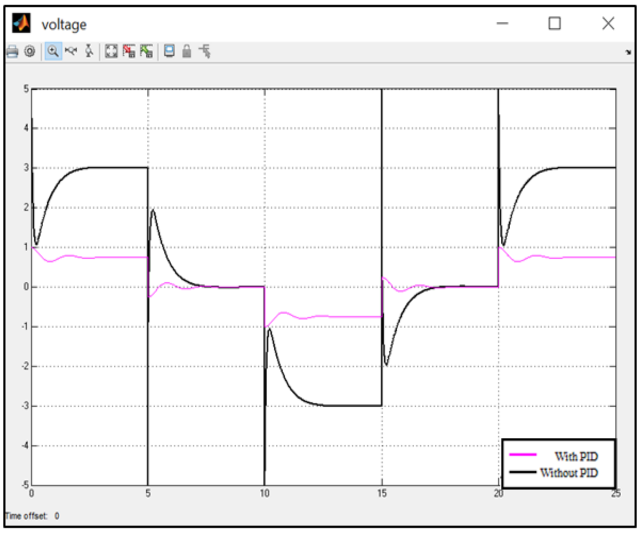

Fig. 15. The voltage

The simulation results indicate obtaining better results for each speed control and Simulink response of DCSM when using PID control by minimize in ever shoot in order to develop and improve performance of DCSM to obtain good simulation results.

V. Conclusion

In this simulation, the process of designing and implementing a conventional control unit was conducted to control the speed of the motor. A model was built that simulates the electric motor in two cases at no load with constant speed and with variable speed. Simulation results Possibility to improve the performance of the motor by setting the conventional control unit for all the proposed conditions and given in your results section.

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