Simulation Model of Servo Motor by Using Matlab

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***Abstract*—The research aims to develop documented empirical data to obtain a high-accuracy and effective system according to a principal system as a model that represents the system for all expected cases and different working conditions. The current works are simulating a servo motor that works with specifications as a mathematical representation of it down to its representation with a transformation function. The simulation is done for different cases, the first is without a controller, and the other is an operation simulation with a conventional controller that is with a PID controller. The results, through response and accuracy, prove the preference of PID controller systems in the speed of response and high accuracy with the change or different conditions of the system, i.e., working with linear systems. A simulation is being conducted to verify the use of control systems to improve the performance of servo motors. Algorithms of control systems are developed according to designs based on prior experience. Speed and position control are the most common and used in many applications, which created the need to choose them. To overcome fluctuations and obtain a quick response and a high-precision system used, control systems, as the results proved. The research contribution is developing a design for the user control systems also checking them in simulation with the servo motor system using MATLAB. They test them in the servo motor control as well to test their performance experimentally.**

Keywords—Servo Motor; PID Controller; Transfer Function; Matlab

I. INTRODUCTION

Electric motors are used in many homes, industrial, military, and other systems [1-3]. Electric motors have properties that depend on the selection of the type of motor for the appropriate application [4-6]. The performance of the motor depends on the system in which it is part [7-9]. The appropriate design must be chosen for each part to obtain the best performance and the highest efficiency. Control systems have been proven by experiments the need for it within many industrial applications due to the effect it has when it is part of the system. It is classified into a traditional, expert, and optimum. Conventional improves the performance of linear systems is widely used because it is simple and cheap compared to others [10-14]. The expert relies on previous experiences in its design and is used with linear systems, and its performance is better than the traditional one [15-18].

Electric motors are used in many applications such as elevators, jacks, cars, trains, printers, home appliances, industrial, civil, military systems, and others such as robots. It can be used in different applications such as underwater welding and in other places that are dangerous to humans, such as the operation of mine -removal, explosive dismantling, and others [19-21]. An electric motor was chosen within the specifications. It will be mentioned later and represented mathematically by a conversion function and simulation. There are three cases, including what are its results without controllers again and again with a conventional controller and a third with expert systems [22-25]. The simulation results prove the importance of using controllers to improve the performance of the system's work efficiently and accurately with high response. The current simulation aims to identify the capabilities of the computer program Matlab as a computer program. Previous experiences and the current time periods have proven the possibility of simulating different systems. Through work, a special model must be developed, and according to the researchers' specialization, it is necessary to identify the possibilities of its use first, the accuracy of working with it and taking its results into account. Electric motors of various types have been simulated using the Matlab program. PID controller to compare with different systems such as linear systems. The results confirmed the previous statement that traditional power systems improve the performance of cell systems. The results also confirmed the need for expert systems to improve the performance of linear systems.

The difference between the current work and previous works is the emphasis on the one hand on the capabilities of the computer program to simulate engine-based systems in different applications by representing them mathematically. The operation for comparing the different cases to get the best performance. In order to obtain the appropriate design that enables the operation of a highly efficient and responsive system, Fast and high accuracy in performance. The steps will also be indicated later in the research papers. The limits of the research included understanding the process of operating the engine in different ways and working conditions. Also, the research contribution is designing algorithms of control theories, including traditional. The operation of control systems to control the engine was also implemented.

Section 2 includes mathematical representation by adopting the phase diagram and under the title functional and sporty model of the servomotor system. Section 3 includes computer simulation models to be adopted in conducting the appropriate tests, and under the title, Servo Motor (SM) system simulation model using Transfer Function (TF). Section 4 includes the results of computer simulation of the proposed tests and, under the title, SM system simulation results using TF.

II. FUNCTION AND MATHEMATICAL MODEL OF SERVOMOTOR SYSTEM

A motor is a machine that converts electrical energy into mechanical energy. The motor consists of a fixed part and a fixed rotating part, which contains electrical energy. It is represented by current and voltage, and the rotating part has kinetic energy. It is represented by torque and speed. Fig. 1 represents a motor system [26-31], where Ra is armature resistance, La is inductance, $Vb(t)$ is back EMF, Ea is the input voltage, θm is the angular Position.

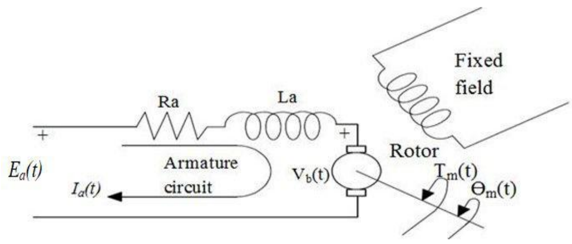

Fig. 1. Servomotor system

Fig. 2 and Fig. 3 shows a diagram of the electric motor control algorithm with sensors and position control devices for the rotor and speed according to the required application. It is frequently adopted in various applications such as industrial, military, home, etc.

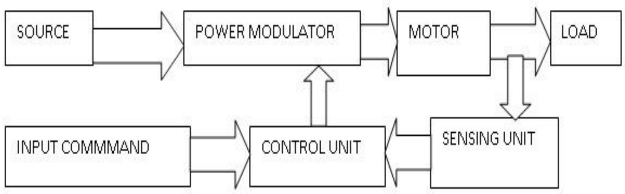

Fig. 2. Block diagram of an electric drive [32-39]

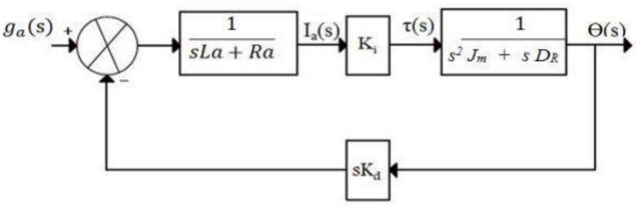

Fig. 3. Block diagram of SM

By using Kirchhoff Voltage Law (KVL), the equations of the electrical system are

$$Ea(s) = Ia(s)Ra + Vb(s) \tag{1}$$

$$Ia(s) = \frac{Ea(s) - Vb(s)}{Ra} \tag{2}$$

$$\frac{\theta m(s)}{Ea(s)} = \frac{Kt}{JmRas^2 + s(BRa + KtKb)} \tag{3}$$

$$\frac{\theta m(s)}{Ea(s)} = \frac{0.121}{0.00006286 * 2.23 * s^2 + s(0.0000708 * 2.23 + 0.121 * 0.121)}$$

$$\frac{\theta m(t)}{Ea(t)} = \frac{863.189}{s^2 + 105.58s} \tag{4}$$

The parameters of the servo motor can be written as in Table 1.

TABLE I. PARAMETERS OF SERVO MOTOR

Parameters	***KT***	***KP***	***Ra***	***B***	***Jm***
Value	0.121	0.121	2.23	0.0000708	0.0000628
Units	N.m/A	V/(rad/s)	Ω	N.m/(rad/s)	Kg.m^2

III. SIMULATION MODEL OF SM SYSTEM BY USING TRANSFER FUNCTION

There are two states of this simulation 1st without a controller, 2nd with PIDC. The first it a Simulation model of SM without a controller

In this section, a simulation model of SM without a controller that by using the model as shown in Fig. 4.

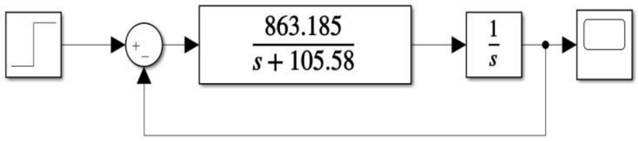

Fig. 4. Simulation model of SM without controller

The second is a Simulation model of SM with PID controller. In this section, a simulation model of SM with PID controller that by using the model as shown in Fig. 5.

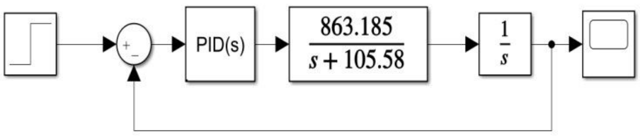

Fig. 5. Simulation model of SM with PID controller

IV. SIMULATION RESULTS OF SM SYSTEM BY USING TRANSFER FUNCTION

There are two states of this simulation, 1st without a controller and the 2nd with PIDC. By using the simulation model as shown in Fig. 6.

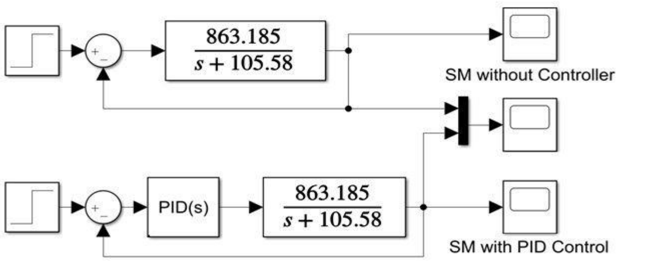

Fig. 6. Simulation model of SM without a controller and with PID controller

First is the Simulation result of SM without a controller. In this section, the simulation result of SM without a controller by using the model as shown in Figs. (7-10). In Fig. 7, the simulation result of SM with PIDC shows the rise time equal 8.385ms. In Fig. 8, the simulation result of SM without a controller shows the rise time equal to 2.247ms. In Fig. 9, the simulation result of SM with PIDC shows the Settling Time equal 3.181ms, overshoot equal 0.501%, and Undershoot equal 0.0748%. In Fig. 10, the simulation result of SM without a controller shows the Settling Time equal -, Overshoot equal 9.341%, and Undershoot equal -0.178%.

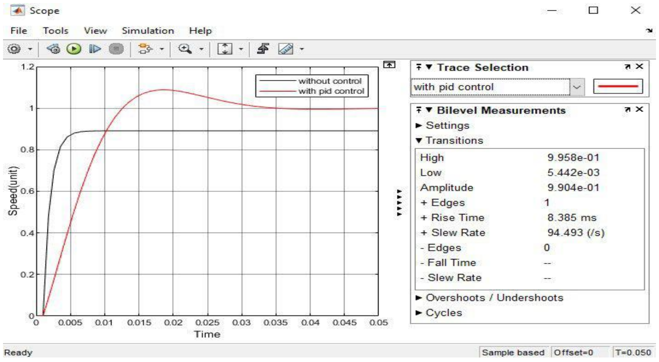

Fig. 7. Rise Time with PIDC

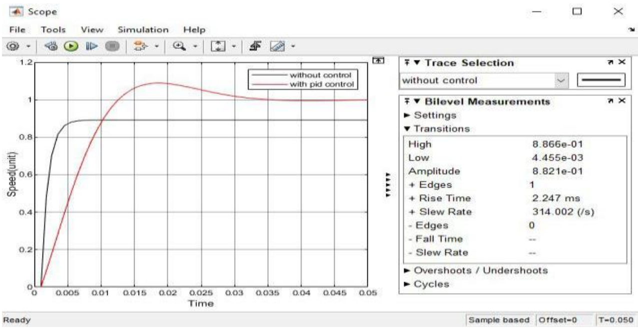

Fig. 8. Rise Time without Control

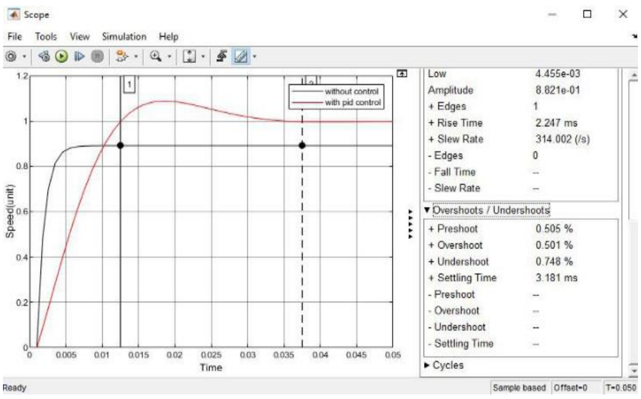

Fig. 9. Settling Time, Overshoot, and Undershoot without Control

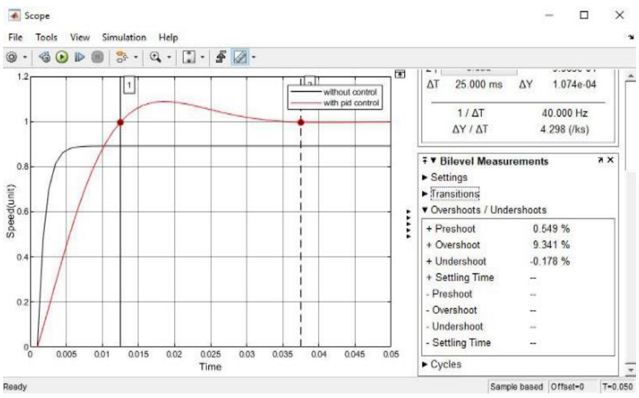

Fig. 10. Settling Time, Overshoot, and Undershoot with PIDC

V. CONCLUSION

It is proposed to implement an electric motor control system within the specifications used in the simulation above. The simulation was conducted for this proposed model to verify the validity of the system. Control systems are with an electric actuator to overcome changes in working conditions through control using classic PID controllers. It starts the process of controlling the actuation of the actuator to improve the work of the system. This is achieved by adapting it according to the suitability of appropriate control parameters to the position of the control system capable of modifying the shape of the objective value for feeding. This indicates that the ambient pattern and system can be used to control multiple points. The work simulation results confirm the idea that the motor has better control performance with classic PIDC to impress control characteristics. Engine function simulation and simulation were performed using the MATLAB (SIMULINK) software package.

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