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Review Article

A Review: Real Time Speed and Position Control of DC Motor with PID and Fuzzy Logic

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Abstract

With the increasing technology, different types of motors have been widely used in many different fields in recent years: Especially due to the increase in industrial applications, the use of motors with many different features has increased significantly in different fields. In this context, Direct Current (DC) motor is one of the most preferred and used motor types. With the rapid development of power electronics and microelectronics technology, the brushless DC motor usage area has expanded considerably. Brushless DC motor has many advantages such as small volume, light weight, high efficiency, energy saving, easy speed adjustment, simple structure, reliable operation and easy maintenance. Nowadays, since brushless DC motor is widely used in industrial control processes, DC motor control has become an important problem.

In this study, it is aimed to develop a system for position and speed control of a Direct Current (DC) motor. Although there are various control methods for DC motor position and speed in the literature, PID control algorithm and Fuzzy Logic are used in this project. The system consists of two main parts. These are; the software part where the information is received and processed and the electronic circuit part that works on the basis of this software. The software part was realized in MATLAB environment. The written codes were tested on the system in real time with the control card and the system was tested on the system. A rule table was created for the system in order to use membership functions in fuzzy logic operation. The change of the error in the created rule table was observed. In addition, PID control application was realized on the system and the results of overshoot, rise time, settling time and steady state errors were observed.

As a result of the project work, the position and speed control of the DC motor, which is one of the widely used motor types in industrial applications, has been realized in real time. It is considered to have a very important place in terms of both academic and industrial projects, since the work is a very important circuit equipment in the industrial sector and the work is tested in real time and high success is achieved. Especially motor control, which is one of the indispensable and most important parameters of the automation sector, shows that it is a potential study that allows application in the industry in this field.

Keywords: DC Motor Control, DC Motor Speed Control, DC Motor Position Control, PID Control, Fuzzy Logic Control.

Introduction

A DC motor is defined as any class of rotary electric motor that converts direct current electrical energy into mechanical energy. The most common variety is based on the forces generated by magnetic fields. Almost all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current in a section of the motor. DC motors were the first type of motor to be widely used because they could be powered from existing direct current lighting power distribution systems. The speed of a DC motor can be controlled over a wide range by using a variable supply voltage or by varying the

strength of the current in the field windings. Small DC motors are widely used in tools, toys and appliances. The universal motor can run on direct current but is a lightweight brushed motor used for portable power tools and appliances. Larger DC motors are currently used to drive electric vehicles, elevators and lifts, and drives for steel rolling mills. The development of power electronics has made it possible to replace DC motors with AC motors in many applications.

In recent years, DC motors and drive systems, one of the machines that convert electrical energy into mechanical energy, have been used in many branches of industry [1]. DC motors are compatible with many applications such as production vehicles, industrial robots, etc. DC motors are available in a wide range of sizes and prices. Their prices are very cheap compared to Alternating Current (AC) motors. DC motors are also compatible with very simple and stable control methods. Another advantage is high efficiency and high starting torque for sudden load increases [2]. Many years ago, most of the servo motors used for position control were powered by Alternating Current (AC). Since AC motors are difficult to control and their nonlinearity is dominant, DC motors are preferred in many applications. On the other hand, the brushes and commutator inside the DC motor make maintenance difficult and increase the cost [3]. As a result of the studies carried out due to such problems, brushless DC motors have emerged. Today, brushless DC motors have started to replace conventional DC motors. Nowadays, DC motor speed, position control is realized and also DC motor control methods vary [4]. Some of them are conventional PI, PID, fuzzy logic based, nonlinear, adaptive variable structure, model reference adaptive control, artificial neural networks, feed-forward computed moment control [5-6]. PID control technique is widely used in the control of dynamic systems. 85% of dynamic controls are based on PID control [7]. The reason for its widespread use is its simple structure. However, despite the simplicity of its structure, the disadvantages of this control method are that it requires a mathematical model and does not give successful results in nonlinear systems.

Figure 1. *An image of different types of DC motors*

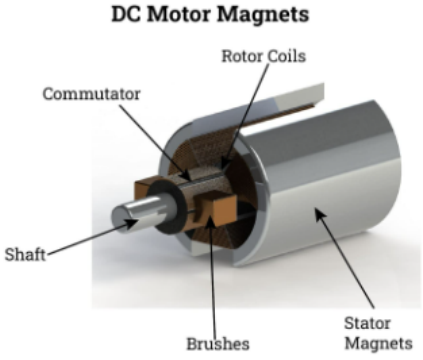

Figure 2. *DC motor image*

Today, with the development of technology, DC motors have been widely used in many fields, especially in industry, automation and robotics. DC motors, which are designed with different power and speed values, can be divided into two as brushed and brushless according to their structure. The design of brushed DC motors is much older than the design of brushless DC motors. The main advantages of brushed DC motors over brushless DC motors are as follows.

- Easy to find
- Affordable price
- Easier design of control and driver circuits

The most important advantage of brushless DC motors is their very high efficiency. Considering the advantages of DC motors above, the fact that they are affordable and easy to find can be stated as an important parameter for companies and researchers. In addition, the easy design of the control of DC motors provides a flexible and fast opportunity. This is considered to be a prominent advantage according to the area where it will be used in industrial areas.

Materials and Methods

Material

In this study, a 4-stage method was adopted.

1) Conceptual Design
2) Software Design
3) Hardware Design
4) Integration

In the conceptual design phase, methods used for similar purposes in the literature were investigated. The path to be followed in the study was determined. In this context, a comprehensive analysis of articles for a comprehensive literature study for DC motor control was investigated. In addition, the suitability of the control method to the hardware and the methods adopted in hardware architectures designed for similar purposes in the literature were investigated. The conceptual design phase will continue continuously from the beginning to the end of the study, taking into account the current literature, and it is aimed to make the necessary improvements in the study and to make the necessary optimizations in the designed system. The software design phase is carried out in parallel with the hardware architecture design. At this stage, research activities were carried out to improve the performance of the control process. Then, the algorithm obtained was tried to be adapted to the hardware architecture without loss of performance and continuous optimization studies were carried out. PID and Fuzzy Logic Control studies were tested in real time on the system to be developed and their success rates were analyzed.
In the hardware design phase, the hardware architectures developed in the hardware design phase were utilized to design the hardware for the DC Motor experimental setup system. Sensors, data acquisition cards, etc. to be used for data acquisition were designed in accordance with the system. While doing these works, possible changes on the software were tried to be determined. At this stage, a continuous optimization study was carried out following the design and a continuous synchronization was made with software development studies. Apart from this, necessary improvement studies were carried out by using methods such as determining the limits of the algorithm to be realized, performing iterative operations, etc. methods to be used in the design phase. The integration phase consists of the design of the interface software and hardware that will enable the designed software and hardware architecture to communicate with the computer to be used in the system. The PID and Fuzzy Logic control methods used were tested on the hardware in real time and the results were interpreted. As a result of the project work, an interface software and hardware that can communicate with peripheral components has been designed.

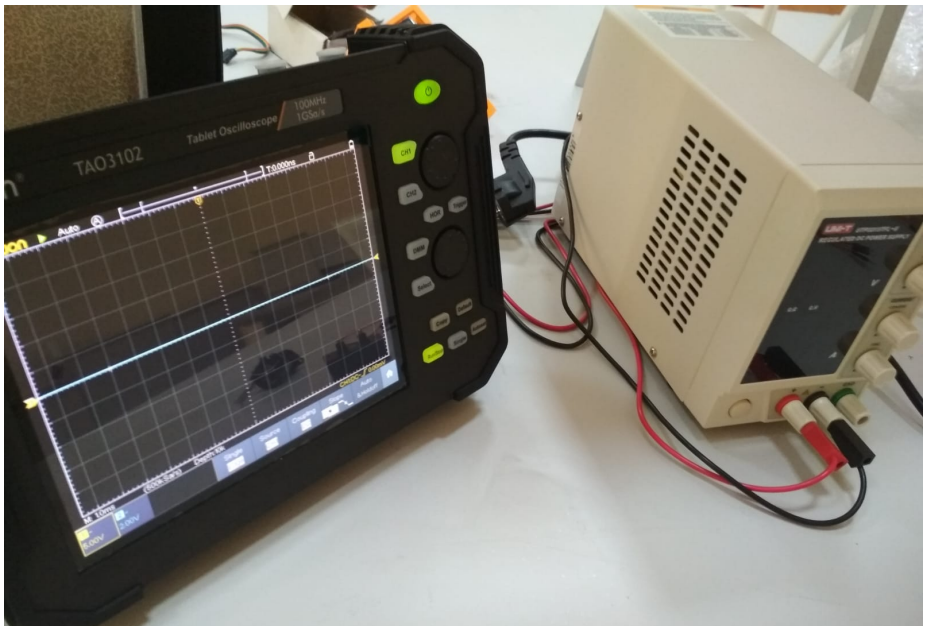

Figure 3. *Power supply and oscilloscope forming the test setup*

Figure 4. *Image of the power supply that makes up the test setup*

After the testing and calibration procedures of the power supply have been tested, the image of the system being put together is shown in Figure 4.

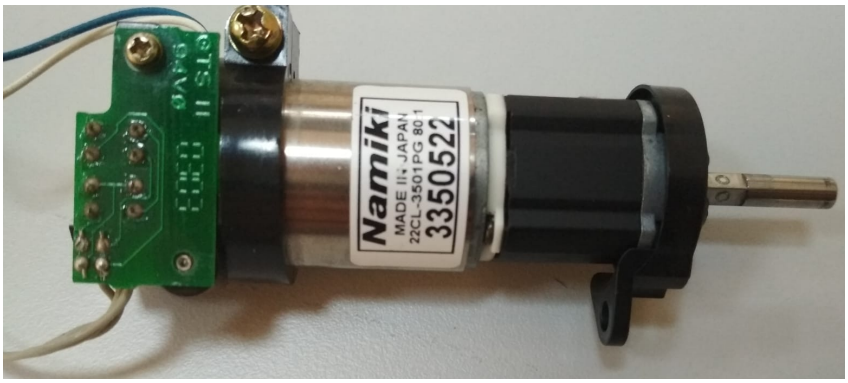

Figure 5. *DC motor constituting the test setup*

After the literature studies and the examination of the DC motors used in similar projects, the DC motor image that constitutes the test setup taken within the scope of the project is shown in Figure 5.

Figure 6. *DC motor driver that constitutes the test setup*

The image of the DC motor driver, which was preferred after the literature studies and the examination of the DC motor drivers used in similar projects, and which constitutes the test setup taken within the scope of the project, is shown in Figure 6.

Figure 7. *DC motor test setup*

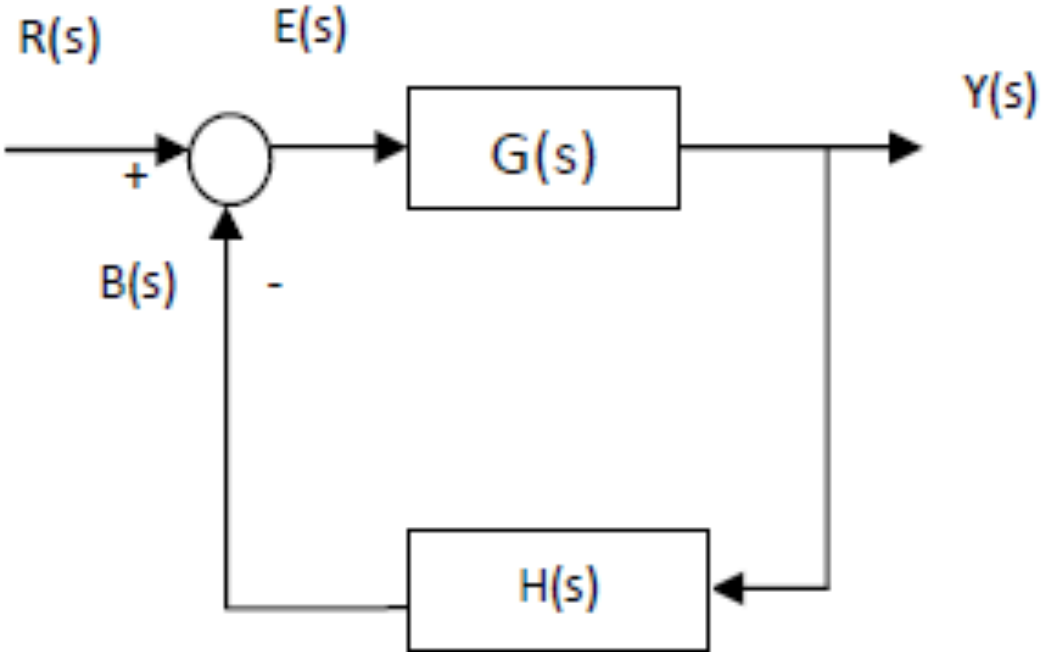

Figure 8. *Block diagram of a general closed loop control system*

After carefully examining the data sheets of the products received within the scope of the study, after the necessary electrical connection and soldering process, the test setup is shown in Figure 7.

The block diagram of a basic control system with feedback in control applications is shown in Figure 8. The basic principle logic of control operations in control applications is as above.

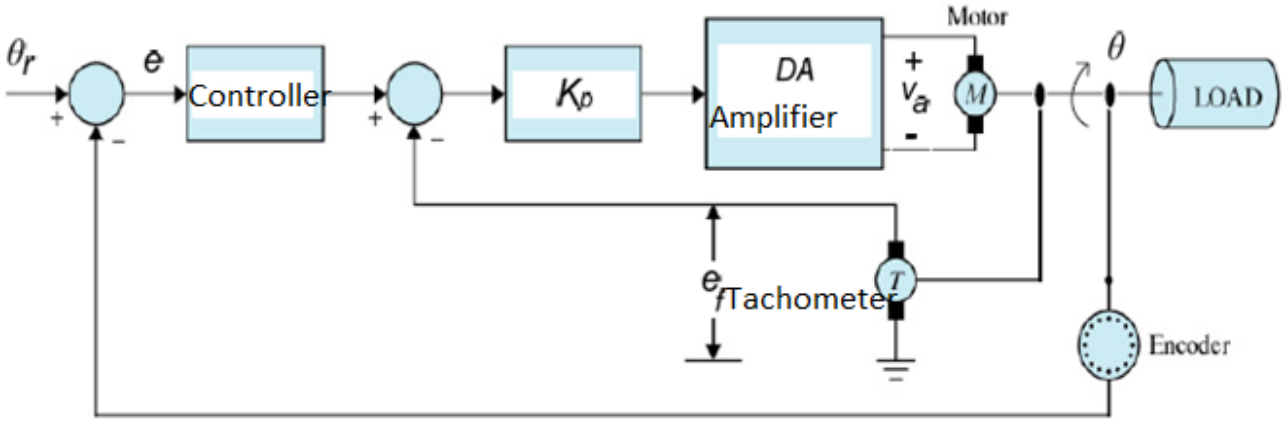

Figure 9. *Control system with speed and position sensors*

An example of a block diagram for the speed control circuit in a DC motor control system is given in Figure 9. As can be seen in the block diagram above, the speed-position control system is depicted by this block diagram.

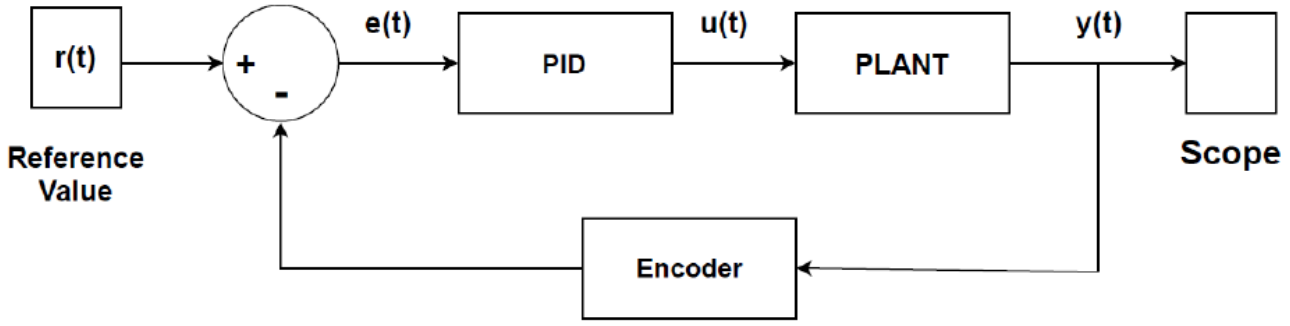

Figure 10. *PID Control Method Block Diagram*

The block diagram of the PID control method proposed in the study is given in Figure 10. It is a visual representation of the block diagram of the control mechanism proposed for the study.

Results and Discussion

The studies conducted within the scope of this study consist of four stages. These are; a detailed literature review, which is considered as a conceptual concept, was conducted. As a result of the literature review, as a result of the examination of similar studies for the proposed project, deficiencies that would reduce the possible performance results were identified. In the conceptual design phase, methods for similar purposes were investigated in the literature. The path to be followed in the project study was determined. In this context, for a comprehensive literature study for DC motor control, graduate theses in the YÖK thesis archive were examined, articles were analyzed extensively and similar topics abroad were investigated in detail. In addition, the suitability of the control method to the hardware and the methods adopted in hardware architectures designed for similar purposes in the literature were investigated. The conceptual design phase will continue continuously from the beginning to the end of the project and it is aimed to make the necessary improvements in the project by taking into account the current literatures and to make the necessary optimizations in the designed system.

The software design phase is carried out in parallel with the hardware architecture design. At this stage, research activities were carried out to improve the performance of the control process. Then, the obtained algorithm was tried to be adapted to the hardware architecture without loss of performance and continuous optimization studies were carried out. PID and Fuzzy Logic Control studies were tested in real time on the system to be developed and their success rates were analyzed. In the hardware design phase, the hardware architectures developed in the hardware design phase are utilized for the DC Motor experimental setup system. Sensors, data acquisition cards, etc. to be used for data acquisition were designed in accordance with the system. While doing these works, possible changes on the software were tried to be determined. At this stage, a continuous optimization study was carried out following the design and a continuous synchronization was made with software development studies. Apart from this, necessary improvement studies were carried out by using methods such as determining the limits of the algorithm to be realized, performing iterative operations, etc. methods to be used in the design phase.

The integration phase consists of the design of the interface software and hardware that will enable the designed software and hardware architecture to communicate with the computer to be used in the system. The PID and Fuzzy Logic control methods used were tested on the hardware in real time and the results were interpreted. As a result of the project work, an interface software and hardware that can communicate with peripheral components has been designed. As a result of the studies carried out, the success of the proposed work was tested on the experimental setup created in real time. Based on the performance results obtained, it was determined that the speed and position control of the DC motor was successfully realized with the proposed control approaches. It is thought that this study has the potential to be an important study for both academic and industrial applications, especially for automation studies.

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