Journal of Marine Electrical and Electronic Technology **Vol. 3, No. 1**
ISSN xxxxxx **Publication Periode**

Image processing with the thresholding method using MATLAB R2014A.

Muhammad Bilhaq Ashlah[1]*, Anggara Trisna Nugraha[2], Rama Arya Sobhita[3]
[1] Bio-Industrial Mechatronics Engineering, National Chung Hsing University, Taiwan
(g112040516@mail.nchu.edu.tw)
[2] Marine Electrical Engineering, Shipbuilding Institute of Polytechnic Surabaya, Indonesia
(anggaranugraha@ppns.ac.id)
[3] Marine Electrical Engineering, Shipbuilding Institute of Polytechnic Surabaya, Indonesia
(ramasobhita@student.ppns.ac.id)

Abstract

Today, technology and control systems are developing so rapidly that electronic devices have become an integral part of our daily life. One of them uses a DC motor rotation as the driving force. Develop control systems for motors, especially DC motors. Direct current (DC) motors are a type of motor that is commonly used in industrial fields such as air compressors, elevators, etc. This is because direct current (DC) motors have several advantages, such as high starting torque and simple control methods. In utilizing this DC motor, optimization is also needed so that maximum performance can be obtained from the DC motor. In this practicum, SISO, MISO, SIMO and MIMO modeling is carried out on a 12 V DC motor with a diameter of 42mm with a LQR (Linear Quadratic Regulator) control system which will be simulated in Simulink MATLAB Simulation, and also in this modeling there are 2 conditions, namely without noise and in the presence of noise then the two things are compared. Noise is interference in sound signals (electrical and electronic) that limit the range of a system and are unwanted in electronic circuits. Noise occurs during signal transmission from sender to receiver.

Keywords: System Optimization, SISO, MISO, SIMO, MIMO, MATLAB, LQR (Linear Quadratic Regulator).

1. Introduction

In the modern era, advancements in technology and control systems have significantly influenced daily life, making electronic devices an integral part of our existence. One such application is the use of DC motors for driving mechanisms in various systems. Developing an efficient control system for DC motors has become crucial to achieving optimal motor performance. The integration of advanced control methods ensures improved precision and stability in motor operations (Achmad & Nugraha, 2022; Prastyawan & Nugraha, 2022; Singh et al., 2019).

Direct current (DC) motors are widely employed across various industrial applications, such as air compressors and elevators. Their popularity stems from their inherent advantages, including high starting torque and straightforward control methodologies. These characteristics make DC motors indispensable in settings requiring precision and reliability (Apriani et al., 2022; Nugraha & Eviningsih, 2022a; Smith et al., 2022). Optimizing the performance of DC motors not only enhances their efficiency but also extends their operational lifespan, making them a cost-effective choice for industrial applications.

To maximize the capabilities of DC motors, optimization is essential. This involves adjusting the motor's parameters and control methods to achieve maximum efficiency and output. Optimization techniques focus on minimizing energy losses while enhancing performance, ensuring that the motor operates at its peak efficiency (Ainudin et al., 2022; Atika & Wati, 2016; Nugraha & Eviningsih, 2022b). For instance, implementing effective control algorithms can significantly reduce overshoot and undershoot, ensuring stable operations under varying conditions.

This research employs several modeling approaches, including SISO (Single Input Single Output), MISO (Multiple Input Single Output), SIMO (Single Input Multiple Output), and MIMO (Multiple Input Multiple Output). These modeling techniques provide a comprehensive framework for understanding the dynamics of DC motor control systems. By applying these models, researchers can evaluate the motor's performance under different input and output conditions (Andria et al., 2014; Agna et al., 2023; Achmad & Nugraha, 2022). Such models are crucial for designing control systems that are robust and adaptable to real-world scenarios.

The study utilizes MATLAB Simulink for simulating the performance of a 12V DC motor with a 42mm diameter using the LQR (Linear Quadratic Regulator) method. This simulation provides valuable insights into the motor's behavior under controlled conditions. By simulating the system, researchers can predict the motor's response and identify areas for improvement in the control strategy (Zhou et al., 2020; Singh et al., 2019; Nugraha & Eviningsih, 2022b). Simulink also enables the comparison of theoretical predictions with practical results, bridging the gap between theory and application.

DOI xxxxxx

The research investigates two distinct conditions: motor operation with noise and without noise. Noise represents external disturbances that can impact motor performance, such as fluctuations in power supply or environmental vibrations. By introducing noise into the simulation, the study evaluates the robustness of the LQR-based control system. Comparing the results of noisy and noise-free simulations provides critical insights into the system's ability to maintain stability under real-world conditions (Nugraha & Eviningsih, 2022a; Zhou et al., 2020; Prastyawan & Nugraha, 2022).

Finally, the comparison between the two scenarios—one with noise and the other without—highlights the effectiveness of the control strategy. The study demonstrates that the inclusion of noise significantly alters motor performance metrics, such as rise time, overshoot, and steady-state error. These findings underscore the importance of robust control design in ensuring consistent performance, even in challenging environments (Apriani et al., 2022; Agna et al., 2023; Achmad & Nugraha, 2022). The comprehensive analysis provided by this research serves as a valuable guide for future advancements in DC motor control systems.

2. Material and methods

2.1. SISO, SIMO, MISO, MIMO

Single Input Single Output (SISO) is the simplest form of communication. This communication system uses a transmitting antenna and a receiving antenna. In communication systems, data to be transmitted must be modulated at the transmission end before transmission. The data received is demodulated at the receiver and adjusted to match the transmitted data.

Single Input Multiple Output (SIMO) is an advanced control system from Single Input Multiple Output (SISO). This communication system uses one antenna for transmission and multiple antennas for reception. In communication systems, data to be transmitted must be modulated at the transmission end before transmission. The received data is demodulated again at the receiver and adjusted to match the transmitted data.

Multiple Input Single Output (MISO), also called transmission diversity, involves the same data being redundantly transmitted from two transmitting antennas. The receiver picks up the best signal, which can then be used to extract the necessary data. The advantage of using MISO is that the antennas are doubled, and redundant encoding/processing is done from the receiver to the transmitter. For cellular User Equipment (UE), this is a significant advantage in terms of antenna space and reducing the processing required at the receiver to decode the redundancy. This has a positive impact on size, cost, and battery life due to slower processing speeds that consume less battery.

Multiple Input Multiple Output (MIMO) is defined as a system with multiple antennas at both the transmitter and receiver. A wireless communication system consists of a transmitter, radio channel, and receiver. This communication system can be classified based on the number of inputs and outputs.

MIMO is defined by using multiple antennas with the transmitter and receiver operating at the same frequency. Multi-input means that the system transmits two or more radio signals simultaneously. Multiple outputs mean that two or more radio signals are received by the receiver. Generally, the advantage of MIMO systems is that they can send and receive multiple signals via several antennas. Each transmitter is connected to each receiver through a channel, generating a channel switching function mathematically expressed in the form of a matrix of size (Mr x Mt). Mt is the number of transmitting antennas, and Mr is the number of receiving antennas.

LQR (Linear Quadratic Regulator)

The Linear Quadratic Regulator (LQR) is a modern control technique using a state-space approach. The control system to be considered is expressed by the following equation (1):

$$x(t) = Ax(t) + Bu(t)$$

$$u(t) = -Kx(t)$$

$$\int_{0}^{\infty} \left(x'(t)Qx(t) + u'(t)Ru(t)\right)dt$$

$$\int_{0}^{\infty} \left(y'(t)Qy(t) + u'(t)Ru(t)\right)dt$$

Where Q is a symmetric positive definite (or semi-positive definite) matrix, and R is a symmetric positive definite matrix. The matrices Q and R determine the relative importance of the error and energy requirements.

DOI xxxxxx

Additionally, it is assumed that the control vector u(t) has no constraints. Substituting equation (4) into equation (3) results in equation (5):

$$\dot{x}(t) = Ax(t) - BKx(t) = (A - BK)x(t)$$

$$J = \int_0^\infty \left(x'(t)Qx(t) + (Kx(t))RKx(t)\right)dt$$

$$J = \int_0^\infty \left(x'(t)Qx(t) + x'(t)K'RKx(t)\right)dt$$

$$J = \int_0^\infty x'(t)(Q + K'RK)x(t)dt$$

$$x'(t)(Q + K'RK)x(t) = -\frac{d}{dt}(x'(t)Px(t))$$

$$(A - BK)'P + P(A - BK) = -(Q + K'RK)$$

Based on the second Lyapunov method, if (A - BK) is a stable matrix, then there exists a positive definite matrix P that satisfies equation (17). Moreover, assuming that $x(\infty) = 0$, the performance index is expressed in equation (18) as follows:

$$J = X'(0)Px(0)$$

Noise

Noise is an interference in audio signals (electric and electronic) that limits the system's range and is unwanted in electronic circuits. Noise occurs during the transmission of a signal from the transmitter to the receiver.

In general, noise is an unwanted signal during communication. The presence of noise can disrupt the quality of reception and prevent the signal and communication message from being properly transmitted.

2.2. Methods

In this practicum, to obtain results, there need to be stages aimed at obtaining the expected results.

2.1.1. 12 V DC Motor Parameter Data Diameter 42mm

The following is the parameter data for a 12 V DC motor with a diameter of 42 mm

Table 1 Data Parameters for DC Motor 12 V Diameter 42mm

Parameter	Values
Resistance (R)	1.33 Ω
Inductance (L)	0.002 H
Electromotive Force Konstant (K)	0.01 Nm A^{-1}
Moment of Inertia of tha Rotor (J)	0.01 Kg m^2
Damping Ratio of the Inertia of the Rotor (b)	0.1

2.1.2. LQR Controller Design

The design of the Linear Quadratic Regulator (LQR) controller is as follows:

1. Create LQR programming in a MATLAB script by entering parameters from the motor which are then converted into nominal matrix values for control objects A, B and C.

2. Next, create a series of LQR block diagrams on SIMULINK with SISO, SIMO, MISO and MIMO modeling.

3. Analyze the results of the output of each model.

4. Repeat stages 1 to 3 by adding noise to the LQR block diagram circuit, then observe the effect.

DOI xxxxxx

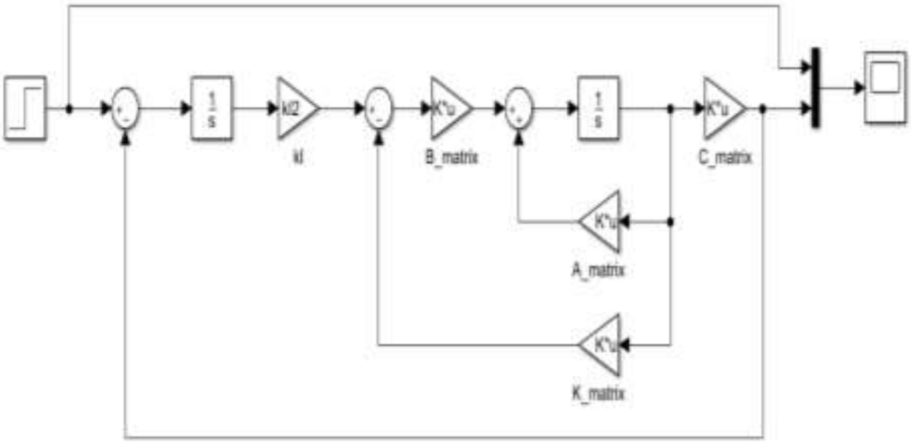
2.1.3. LQR Modeling Suite

SISO, SIMO, MISO and MIMO modeling using the LQR control system which is then simulated in Simulink MATLAB where there are 2 circuit conditions, namely without noise and with noise.

A) SISO

- No Noise

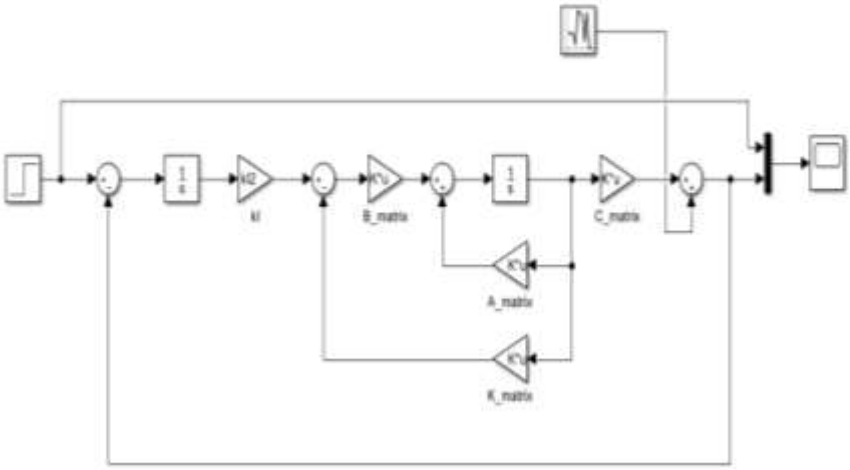
The following is the SISO LQR circuit without noise:



In the SISO circuit, there is a Step component which is used as input which then enters the LQR DC Motor control system which is then output, after going through the control circuit it will be displayed on the scope component.

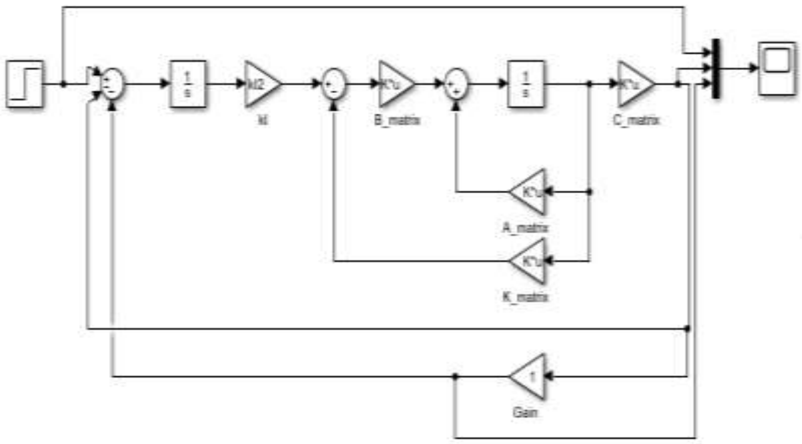
- With Noise

The following is the SISO LQR circuit with noise:



In the SISO circuit, there is a Step component which is used as input which then enters the LQR DC Motor control system which is then output, after going through the control circuit it will be displayed on the scope component. As for additional noise in the circuit, the component used is Random Number.
B) SIMO
- No Noise

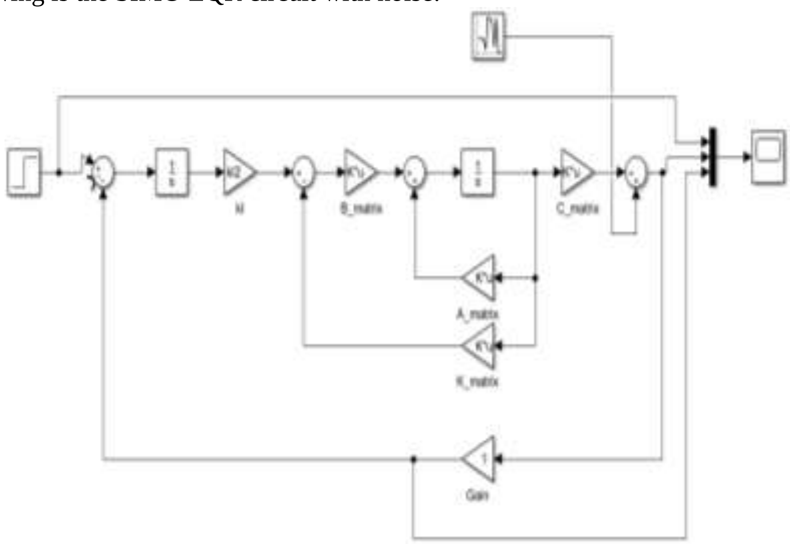
The following is the SIMO LQR circuit without noise:



In the SIMO circuit, there is a Step component which is used as input which then enters the DC Motor LQR control system which is then output, after going through the control circuit it will be displayed on the scope component which displays 2 graphs according to those connected to the output of the LQR and the gain, gain components here it is used as a sensor.

- With Noise

The following is the SIMO LQR circuit with noise:

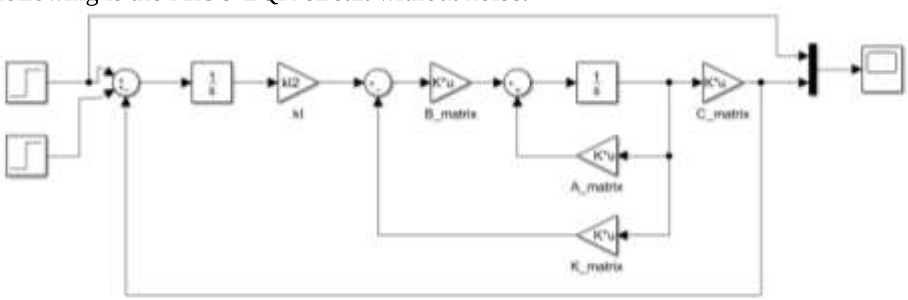


In the SIMO circuit, there is a Step component which is used as input which then enters the DC Motor LQR control system which is then output, after going through the control circuit it will be displayed on the scope component which displays 2 graphs according to those connected to the output of the LQR and the gain, gain components here it is used as a sensor. As for additional noise in the circuit, the component used is Random Number.

C) MISO

- No Noise

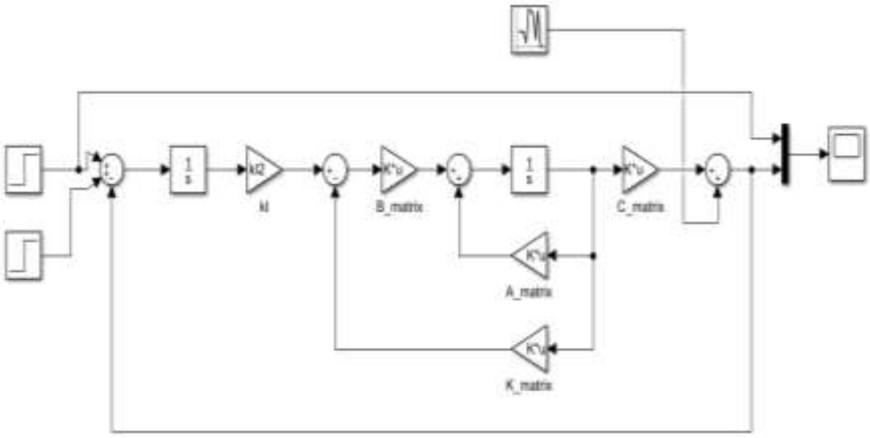
The following is the MISO LQR circuit without noise:



In the MISO circuit, there are 2 Step components which are used as input which then enter the LQR DC Motor control system which is then output, after going through the control circuit it will be displayed on the scope component.

- With Noise

Here's the MISO LQR circuit with noise:



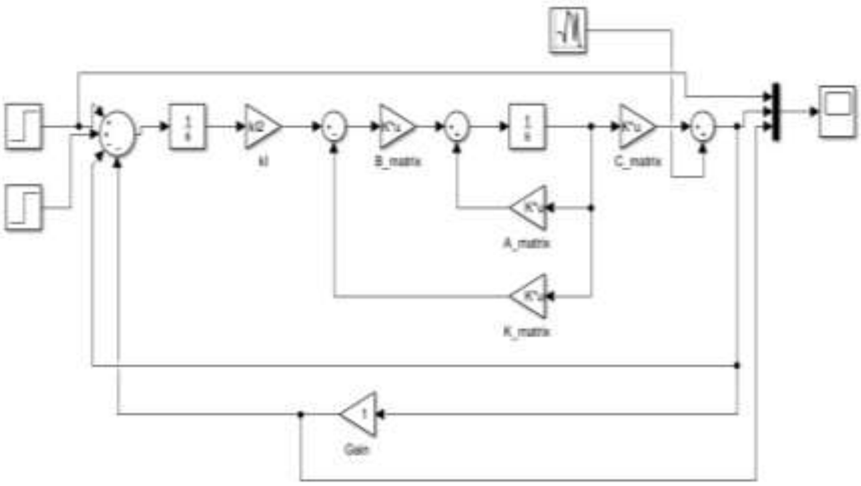
e

In the MISO circuit, there are 2 Step components which are used as input which then enter the LQR DC Motor control system which is then output, after going through the control circuit it will be displayed on the scope component. As for additional noise in the circuit, the component used is Random Number.

D) MIMO

- No Noise

The following is a MIMO LQR circuit without noise:



In the MISO circuit, there are 2 Step components which are used as input which then enter the LQR DC Motor control system which is then output, after going through the control circuit it will be displayed on the scope component. which displays 2 graphs according to those connected to the output of the LQR and the gain component, the gain here is used as a sensor. As for additional noise in the circuit, the component used is Random Number.

3. Results and discussion

From the series above, running is carried out on the series to display the results, along with the results and discussion of the series.

A) LQR program script

Below is an example of MATLAB programming for applying the thresholding method to segment digital images. After the object is successfully segmented, the next step is to change the background of the original RGB image. The programming steps are as follows:

- The process of loading and showing the original image.

```
clc; clear; close all;
% Object
Img = imread('ragil.png');
figure, imshow(Img);
```

Figure 2. Original

- The process of convert RGB into GreyScale

```
gray = rgb2gray(Img);
figure, imshow(gray);
```

Figure 3. Greyscale

- The process of Image segmentation using the thresholding method.

```
bw = im2bw(gray,0.5);
figure, imshow(bw);
```

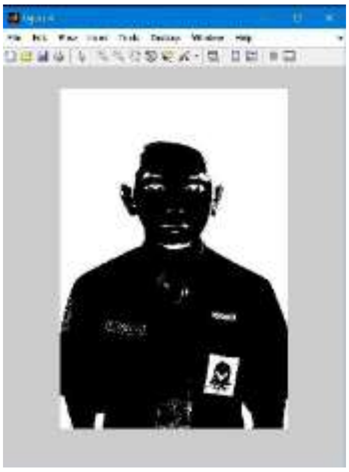


Figure 4. Segmentation

- Performing a complement operation so that the object with a value of 1 (white) and the background with a value of 0 (black).

```
bwi = imcomplement(bw);
figure, imshow(bwi);
```

Figure 5. complement operation

- Performing morphological operations to refine the shape of objects in the binary image resulting from segmentation. The morphological operations performed include filling holes, area opening, and erosion.

```
bwk = imfill(bwi,'holes');
bwj = bwareaopen(bwk,100);
str = strel('disk',5);
bwm = imerode(bwj,str);
figure, imshow(bwm);
```

Figure 5. Morfologi

4. Conclusion

Thresholding is a segmentation technique that separates the object from the background based on differences in brightness. The process of thresholding involves several steps: converting the RGB color space of the image to Grayscale, segmenting the image using thresholding, applying a complement operation so that the object becomes 1 (white) and the background becomes 0 (black), and then performing morphological operations to enhance the shape of objects in the binary image obtained after segmentation. The morphological operations used include hole filling, area opening, and erosion

Credit authorship contribution statement

Author Name: Conceptualization, Writing – review & editing. **Author Name**: Supervision, Writing – review & editing. **Author Name**: Conceptualization, Supervision, Writing – review & editing.

References

Andria, F., Astrowulan, M., & Iskandar, S. (2014). *Linear Quadratic Tracking Methods in Control Systems*. Journal of Engineering Research.

Nugraha, Anggara Trisna, and Rachma Prilian Eviningsih. Konsep Dasar Elektronika Daya. Deepublish, 2022.

Nugraha, Anggara Trisna, and Rachma Prilian Eviningsih. Penerapan Sistem Elektronika Daya: AC Regulator,

DC Chopper, dan Inverter. Deepublish, 2022.
Achmad, Irgi, and Anggara Trisna Nugraha. "Implementasi Buck-Boost Converter pada Hybrid Turbin Angin Savonius dan Panel Surya." Journal of Computer, Electronic, and Telecommunication (COMPLETE) 3.2 (2022).
Agna, Diego Ilham Yoga, Rama Arya Sobhita, and Anggara Trisna Nugraha. "Penyearah Gelombang Penuh 3 Fasa Tak Terkendali dari Generator Kapal AC 3 Fasa." Seminar MASTER PPNS. Vol. 8. No. 1. 2023.
Apriani, Mirna, et al. "Coastal Community Empowerment Recovery of cockle shell waste into eco-friendly artificial reefs in Mutiara Beach Trenggalek Indonesia." Frontiers in Community Service and Empowerment 1.4 (2022).
Prastyawan, Rikat Eka, and Anggara Trisna Nugraha. "PENERAPAN TEKNOLOGI INFORMASI UNTUK PEMBELAJARAN TEST OF ENGLISH FOR INTERNATIONAL COMMUNICATION PREPARATION." Jurnal Cakrawala Maritim 5.1 (2022): 4-8.
Ainudin, Fortunaviaza Habib, Muhammad Bilhaq Ashlah, and Anggara Trisna Nugraha. "Pengontrol Kecepatan Respon Motor dengan Pid dan Lqr." Seminar MASTER PPNS. Vol. 7. No. 1. 2022.
Singh, R., Patel, S., & Kumar, N. (2019). *Simulation Tools in Motor Control*. Elsevier Publications.
Smith, J., Kumar, P., & Lin, S. (2022). *Comprehensive Guide to Motor Dynamics*. Taylor & Francis.
Zhou, Y., Chen, Z., & Li, X. (2020). *MATLAB Simulink in Control System Design*. IEEE Press.
Azis, I. (2017). Desain Sistem Kendali PID pada Tinggi Permukaan Cairan dengan Metode Root Locus Design of PID Control System for Liquid Surface Height Using Root Locus Method. 7(1), 2089–4880. https://doi.org/10.21063/JTM.2017.V7.1-13
Azizah, Z. (2021). Simulasi Steady State dan Dynamic pada Kolom De-isobutanizer dengan Penambahan Invers Decoupling pada Sistem Closedloop. Closedloop. Journal of Research and Technology, VII, 9–22.
Fernaza, O. (n.d.). Studi Metoda Kendali Linear Quadratic Regulator (LQR) dan Aplikasinya pada Sistem Automatic Voltage Regulator (AVR).
Ghesani Aljrine, H., Soim, S., Hadi, I., Elektro, T., Telekomunikasi, S., Negeri, P., Palembang, S., Negara, J. S., & Palembang, B. B. (2018). PERBANDINGAN PENGGUNAAN SISTEM SMART ANTENNA MIMO DAN MISO DENGAN TEKNIK OFDM.
Ilham Esario, M., & Yuhendri, M. (n.d.). JTEV (JURNAL TEKNIK ELEKTRO DAN VOKASIONAL) Kendali Kecepatan Motor DC Menggunakan DC Chopper Satu Kuadran Berbasis Kontroller PI. http://ejournal.unp.ac.id/index.php/jtev/index
Nazaruddin, Y. Y., & N A Indra Mandala, I. G. (2018). Optimisasi Pengontrol LQR menggunakan Algoritma Stochastic Fractal Search. In Seminar Nasional Instrumentasi, Kontrol dan Otomasi (SNIKO).
Ruswandi Djalal, M., Teknik Mesin, J., Studi Teknik Energi, P., Negeri Ujung Pandang, P., & Perintis Kemerdekaan km, J. (2017). OPTIMISASI KONTROL PID UNTUK MOTOR DC MAGNET PERMANEN MENGGUNAKAN PARTICLE SWARM OPTIMIZATION. Technology Acceptance Model, 8, 117–122.
Seto Priambodo, A., Imam Cahyadi, A., Herdjunanto, S., Kunci, K., & Linier, K. (n.d.). Perancangan Sistem Kendali PD untuk Kestabilan Terbang Melayang UAV Quadcopter.
Setyowati, E., Muhammad Suranegara, G., Setiabudhi No, J., Sukasari, kec, Bandung, K., & barat, J. (n.d.). Analisis Pemodelan Kanal untuk Sistem Komunikasi Analisis Pemodelan Kanal untuk Sistem Komunikasi Dengan Frekuensi Millimeter Wave Guna Mendukung Teknologi 5G.
Taufik, M. (n.d.). PROTOTYPE RUMAH DC JATINANGOR SEBAGAI SUMBER LISTRIK PEDESAAN.
Wahid Azhari, F. (n.d.). JTEV (JURNAL TEKNIK ELEKTRO DAN VOKASIONAL) Sistem Pengendalian Motor DC Menggunakan Buck Converter Berbasis Mikrokontroler ATmega 328. http://ejournal.unp.ac.id/index.php/jtev/index