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Output Response with LQR and LQT Methods on RS PRO 834-7641 DC Motor for Optimization.

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ABSTRACT

Technological developments occur very quickly, and in the manufacturing process, various methods are applied by each developer. One method commonly used in technology creation is system optimization. System optimization is an approach used to achieve the best results on a particular technology. There are various methods for system optimization, such as SISO, MISO, SIMO, MIMO, and Noise. In this context, we will explore system optimization using SISO, MISO, SIMO, and MIMO circuits using the RS PRO 834-7641 DC Motor as a plant. The RS PRO 834-7641 DC motor is one of the plants that is easily accessible in the control system. The LQR optimal control method, which is state space based, is used in this system. The LQR controller has two main parameters, namely the weight matrices Q and R, which must be determined to create optimal control actions. In addition, the Linear-Quadratic Tracker (LQT) method is used as the main solution for tracking problems in linear systems. LQT is designed to design optimal control so that a linear control system can track a preset reference trajectory.

Key Word : *DC RS PRO 834-7641, LQR, LQT, system optimization*

I.INTRODUCTION

The challenge of optimal control has become a significant focus of attention today, especially due to increasing demands for high-performance systems [2]. The concept of optimization in control systems involves balancing the selection of performance indices and engineering to achieve an optimal control system, taking into account existing physical constraints. In dealing with optimal control of a system, the goal is to find decision-making rules for the control system that can minimize the difference between the system's behavior and its ideal behavior [1][3].

LQR is an optimal control method in systems that uses a state space approach [3]. The LQR controller requires determining two main parameters, namely the weight matrices Q and R, in order to produce optimal control actions according to requirements. Examples of applications of the LQR method involve speed regulation in induction motors, frequency control in generator power plants, and applications in drones[4].

By using LQR, the system will maintain the state at zero from the set point that has been set. This allows the system to remain stable even when interference or noise occurs. The LQR method uses a DC motor plant which is included in the datasheet [5]. To see the step response, the datasheet is entered into a MATLAB script and then simulated using MATLAB Simulink software [6]. The DC motor used is the BN-42 type, which has values for moment of inertia, motor constant, damping ratio, resistance and inductance.

System optimization involves various types of circuits, including SISO (single input single output), SIMO (single input multiple output), MISO (multiple input single output), MIMO (multiple input multiple output), noise, LQR, LQT, and others[7][8]. In this research, the author uses a closed loop control system to evaluate the response of a DC motor type RS PRO 834-7641 with first order mathematical modeling as a plant in a system. The simulation was carried out using the LQR and LQT methods on a DC motor type RS PRO 834-7641. LQR (Linear-Quadratic Regulator) is a state space control method that requires information from the entire system. To achieve optimal gain values, weighting of the Q and R values in LQR is required [9][10]. Meanwhile, LQT (Linear-Quadratic Tracker) is the main method for tracking problems in linear systems[11]. LQT is designed to design optimal control so that a linear control system can track a predetermined reference trajectory. Optimal control is achieved by minimizing a specified quadratic value function. LQT consists of feedback and feed-forward parts which are calculated using the Algebraic Riccati Equation (ARE)[12].

In this research, the author uses Simulink to produce a system simulation built using the LQR and LQT methods. Simulink is a graphical extension of Matlab which is used to model and simulate a system. In the Simulink environment, the system is represented as a block diagram, including elements such as transfer functions, summing junctions, as well as including virtual input and output devices such as function generators and oscilloscopes.

Mathematical modeling is a method for describing a complex system in the form of a mathematical model. Thus, it is hoped that the formulated mathematical model can explain the complex situation being observed. The author carried out calculations by referring to the RS PRO 834-7641 DC motor datasheet to produce a 1st order mathematical model which was used as a plant transfer function. This transfer function is a mathematical representation of the relationship between the input and output of the control system components.

II.METHODOLOGY

2.1 Research Stages

1. Literature Study

   Reference searches are carried out to make it easier for writers to compose papers, where references function as the writer's literature and also increase understanding of the problems discussed in the paper. Apart from that, references are also used as the main reference in the process of preparing a paper [13].

2. Making Mathematical Models

   In this step, the author carries out mathematical calculations to theoretically support the results of the literature study that has been collected. The author will produce a mathematical model which will then be integrated into the circuit created[14].

3. Circuit Creation

   The LQR circuit and LQT circuit were created using a DC motor plant RS PRO 834-7641 and assisted by MATLAB software [15]. This process involves implementing a mathematical model into a control system to understand and analyze the system's response [16].

4. Results and Discussion

   This section contains the results of the circuit that has been created using MATLAB. Displays an overview of the circuit and the wave results produced by the scope. The discussion involves a comparison between the results of the LQR circuit and LQT circuit with the RS PRO 834-7641 DC motor plant.

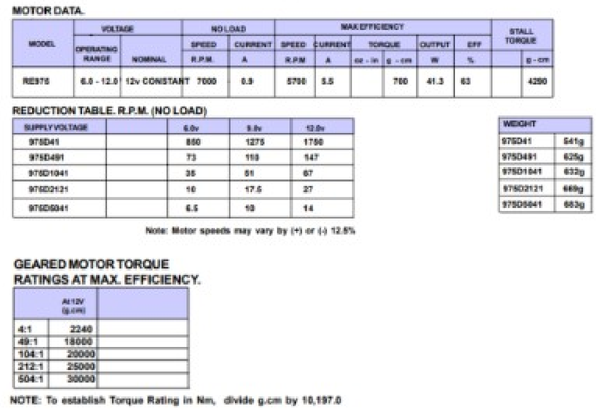
5. Drawing Conclusions

   This stage involves drawing conclusions based on the results and discussions that have been carried out. Several important points were conveyed by the author as a summary or findings from the research that has been carried out.

2.2 Problem Solving Methods

1. RS PRO 834-7641 DC Motor Modeling

Figure 1. DC Motor RS PRO



MOTOR DATA.

MODEL	VOLTAGE		NO LOAD		MAX EFFICIENCY						STALL TORQUE	
	OPERATING RANGE	NOMINAL	SPEED	CURRENT	SPEED	CURRENT	TORQUE		OUTPUT	EFF		
			R.P.M.	A	R.P.M	A	oz - in	g - cm	W	%		g - cm
RE975	6.0 - 12.0	12v CONSTANT	7000	0.9	5700	5.5		700	41.3	63		4250

REDUCTION TABLE. R.P.M. (NO LOAD)

SUPPLY VOLTAGE		6.0v	9.0v	12.0v
975D41		850	1275	1750
975D491		73	110	147
975D1041		35	51	67
975D2121		16	17.5	27
975D5041		6.5	10	14

Note: Motor speeds may vary by (+) or (-) 12.5%

WEIGHT	
975D41	541g
975D491	625g
975D1041	632g
975D2121	669g
975D5041	683g

GEARED MOTOR TORQUE RATINGS AT MAX. EFFICIENCY.

	At 12V (g.cm)	
4:1	2240	
49:1	18000	
104:1	20000	
212:1	25000	
504:1	30000	

NOTE: To establish Torque Rating in Nm, divide g.cm by 10,197.0

Figure 2. Datasheet Motor DC

2. Specification

1. Motor = Motor DC RS PRO 834-7641
2. τ = 1,8 N/m
3. No load current = 900 mA = 0,9 A
4. Rated Current = 5500 mA= 5,5 A
5. Voltage = 12V
6. Speed = 14,97 m/s
7. Reduction Ratio = 1:49

- Order 1

General form of 1st order transfer function [15]

$$G(s)=\frac{K}{\tau s+1}$$

Order 1 DC motor

Based on the DC motor datasheet, the 1st order equation is obtained:

Where τ = K.i

$$K=\frac{T}{i}=\frac{1,8}{5,5}=0,32$$

order 1 motor dc :

$$G(s)=\frac{K}{\tau s+1}=\frac{0,32}{1,8+1}$$

- Program Script Matlab LQR

```
% OPTIMASI SISTEM LQR PADA MOTOR DC
clear; clc;
% Model Motor DC
J=0.00000242 ; b=0.1 ; K=0.0167 ; R=0.343 ; L =0.00018 ;
```

```
% J = Momeninesia, b = Rasioredam,
K= konstanta, R= resistansi, L=
% Induktansi

A = [-b/J K/J; -K/L -R/L];
B = [0; 1/L];
C = [1 0];

AA = [ A zeros(2,1); -C 0];-
BB = [B;0];

% Pole Placement
J = [-3 -4 -5];
K = acker(AA,BB,J)
KI = -K(3);
KK = [K(1) K(2)];

% Matrix LQR
Q = [1 0 0;
   0 1 0;
   0 0 1000];
R = [1] ;

K_lqr = lqr(AA,BB,Q,R)
KI2=-K_lqr(3);
KK2=[K_lqr(1) K_lqr(2)];
```

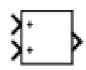
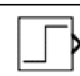
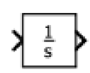
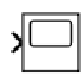
- Program Script Matlab LQT

```
clear
clc

%parameter sistem MSD
m=2;
k=8;
b=6;
%Matriks pada state
A=[0 1;k/m -b/m];
B=[0;1/m];
C=[1 0];
%bobot
Q=[1 0;0 1];
R=10;
[S,eig,G] = care(A,B,G) %riccati
0=A'S+SA-SB(inv R)B'S+Q
Kx=inv(R)*B'*S %feedback Gain Kx
Kr=(Kx*(inv(A))*B-
eye(1))*(inv(C*(inv(A))*B))
Ahat=[0 1 0;-k/m -b/m 0;1 0 0]
Bhat=[0;1/m;0]
%bobot hat
Qhat=[1 0 0;0 1 0;0 0 1];
Rhat=6;
[Shat,eighat,Ghat] =
care(Ahat,Bhat,Qhat) %Riccati
0=A'S+SA-SB(inv R)B'S+Q
Khat=inv(Rhat)*Bhat'*Shat
Kw=Khat(;,3)
```

3. Tools Simulink

Table 1. Simulink Tools

	Add
	Step
	Random Number
	Gain
	Integrator
	Scope

2.3 Optimal control LQR (Linear Quadratic Regulator)

Linear Quadratic Regulator (LQR) is a method applied in modern control theory[16]. System analysis uses a state space approach in this method[17]. Due to its simple approach, this method can be applied to multi-input multi-output systems. The general state space equation for the system is written as follows:

$$x = AX + Bu$$

In principle, the LQR method looks for a control signal u that minimizes the performance index J.

$$J=\int \left(X^T Q_x ¿ + U^T R_a \right) dt ¿$$

LQR finds the optimal input control law u*. Constraints arising from the Q and R matrices aim to minimize the performance index. The optimal closed loop control law is defined as:

$$u^{¿}=-Kx$$

Where K represents the optimal feedback gain matrix. The gain matrix functions to minimize the performance index[18]. This determines the optimal closed-loop pole placement to minimize that index. The feedback gain matrix K depends on the matrices A, B, Q, and R [19]. The feedback gain matrix K is obtained by solving the Algebraic Riccati Equation (ARE), where P is a symmetric and positive definite matrix which is a solution of ARE and is defined as:

$$A^T P+PA-PBR^{-1}B^T P+Q=0$$
$$K=AX-BK_x=(A-BK)x$$

substitution (8) and (9)

$$x=AX-BKx=(A-BK)x$$

2.4 Optimal control LQT (Linear Quadratic Regulator)

Linear Quadratic Tracker (LQT) involves the usual state feedback of a linear dynamical system along with additional feedforward control terms [20]. The feedforward control term depends on the reference signal vector, r(t). The vector r(t) is expressed as:

$$r(t)=¿ \quad (9)$$

A reference voltage signal, Vref, that varies over time. The Linear Quadratic Tracker (LQT) scheme minimizes the quadratic performance index to produce optimal control decisions, which can be formulated in the following equation:

$$J=\frac{1}{2}\int_0^T ¿¿ \quad (10)$$

The state (Q) and control (R) weighting matrices are intermediate weighting matrices, respectively. These matrices are chosen in such a way; Q = QT ≥ 0 and R = RT > 0. Due to the quadratic nature of the cost function, the control signal is correlated with the quadratic variation of the equation. Therefore, if the state variation is large, minimization occurs, and as a result, the convergence rate becomes faster. The optimal affine control decision is evaluated via the mathematical expression shown in,

$$d(t)=-Kx(t)+K_{ff}v_{ref}(t) \quad (11)$$
$$K=R^{-1}B^T P \quad (12)$$
$$K_{ff}=R^{-1}B^T ¿ \quad (13)$$

The gain vector, K, plays a role in relocating system poles to synthesize an optimal controller. Obtaining the optimal vector depends on the positive definite symmetric matrix, P, as explained in equation (12). The matrix P for a given system can be obtained by solving the Algebraic Riccati Equation, as shown in.

$$A^T P+PA-PBR^{-1}B^T P+H^T QH=0 \quad (14)$$

2.5 Simulation System Matlab

2.5.1 Linear Quadratic Regulation (LQR) Motor DC RS PRO 834-7641

The first order circuit is used to see the output response of the RS PRO 834-7641 DC motor without any influence from optimization methods and noise.

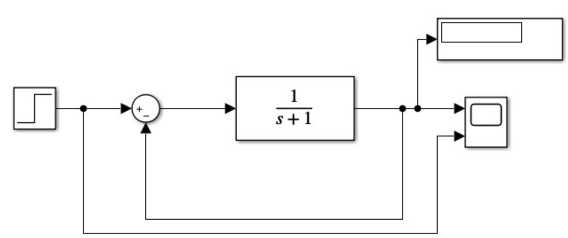


Figure 2. Linear Quadratic Regulation (LQR) Motor DC RS PRO 834-7641

The diagram in Figure 2.4 depicts a first order circuit for a DC motor with one input and one output. The input used is the step type. The transfer function in this circuit includes first order RS PRO 834-7641 DC Motor modeling. The output response is displayed on the scope to visualize the response results.

2.5.2 Linear Quadratic Regulation (LQR) Motor DC RS PRO 834-7641

The LQR block diagram for the DC Motor RS PRO 834-7641 is used to evaluate the output response of the DC motor when the LQR optimization method is applied via the Matlab Simulink tool.

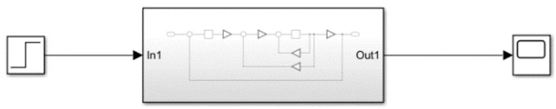


Figure 3. LQR Motor DC RS PRO 834-7641

2.5.3 Linear Quadratic Regulation (LQR) Motor DC RS PRO 834-7641 With Noise

The LQR block diagram for the RS PRO 834-7641 DC Motor with noise is used to observe the output response of the DC motor when the LQR optimization method and additional noise are applied in the Matlab Simulink environment.

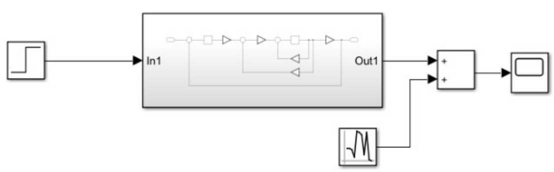


Figure 4. LQR Motor DC RS PRO 834-7641With Noise

2.5.4 Linear Quadratic Tracker (LQT) Motor DC RS PRO 834-7641

The LQT DC Motor RS PRO 834-7641 circuit is used to determine the response results of a DC motor if a DC motor is added using the LQR Matlab Simulink optimization method.

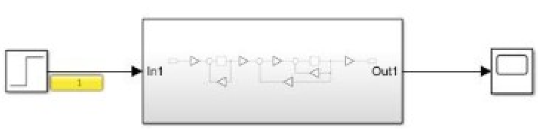


Figure 5. LQT Motor DC RS PRO 834-7641

2.5.5 Linear Quadratic Tracker (LQT) Motor DC RS PRO 834-7641 With Noise

The LQT block diagram for the RS PRO 834-7641 DC Motor with noise is used to observe the output response of the DC motor when the LQT optimization method and additional noise are applied in the Matlab Simulink environment.

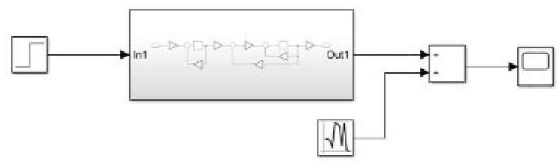


Figure 6. LQT Motor DC RS PRO 834-7641With Noise

III. RESULT & DISCUSION

3.1 LQR Circuit

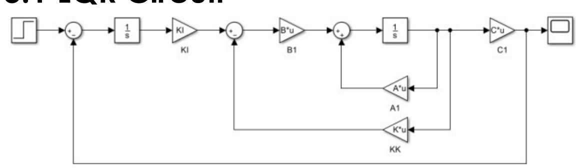


Figure 7. LQR circuit

3.2 Subsystem LQR Without Noise

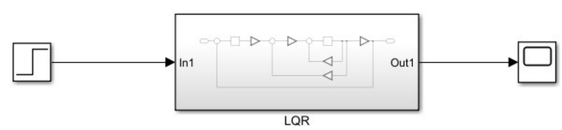


Figure 8. Subsystem LQR Without Noise

3.3 Subsystem LQR with Noise

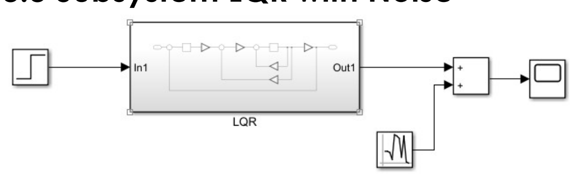


Figure 9. Subsystem LQR With Noise

3.4 First Order Response Results for DC Motor RS PRO 834-7641

The first order response graph shows that the motor response has a significant output away from the targeted set point. The orange wave line represents the motor response, while the blue line shows the desired set point, namely 0.5. The motor response only reaches 0.07, which is quite a big difference from the set point. The RS PRO 834-7641 DC motor exhibits linear characteristics, indicated by the lack of ripple in the signal. The motor response reaches steady state at 2 seconds, which can be considered relatively slow in the context of optimization.

Figure 10. Response Results for DC Motor RS PRO 834-7641

3.5 RS PRO 834-7641 DC Motor Response Results using the LQR Method

The response results from the LQR circuit show that the 37-GB500 motor response graph has an output that is consistent with the desired set point value. This set of points has a value of 0.5. The motor response managed to reach the set point at 1.2 seconds without any overshoot or undershoot. The motor response of the RS PRO 834-7641 DC Motor with the application of the Linear Quadratic Regulation (LQR) method outperforms the motor response of the order model.

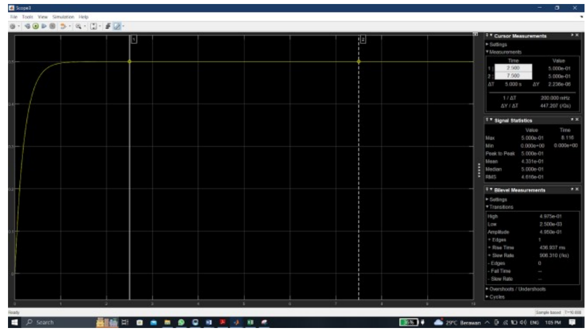


Figure 11. DC Motor Response Results using the LQR Method

3.6 Comparison Results of RS PRO 834-7641 DC Motor Response with LQR Method and Without Method

Response output compared with the LQR method and without the method. Different graphs are created based on the response results. The orange wave shows the desired set point, the blue wave shows the motor response without using the LQR method, and the yellow wave shows the motor response using the LQR method. It can be seen that, when compared with no method, the motor response using the LQR method has a higher response rate. The motor response becomes faster to reach the steady state value and corresponds to the set point.

3.7 RS PRO 834-7641 DC Motor Response Results LQR Method with Noise

The results of the LQR control system in the presence of disturbances show that the yellow signal experiences deformation before being affected by the disturbance. The signal experiences a lot of distortion and creates duplication of the noise in the signal. The resulting signal is no longer linear and is far from stable at a predetermined set point.

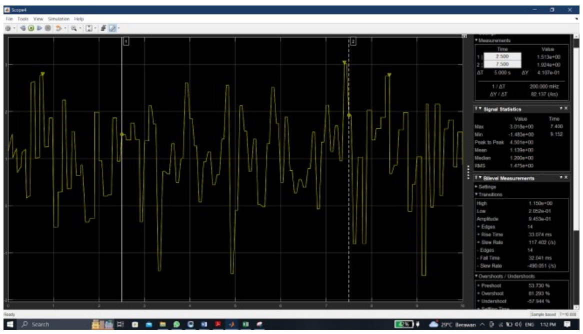


Figure 12. DC Motor Response Results LQR Method with Noise

3.8 RS PRO 834-7641 DC Motor Response Results using the LQT Method

The output of the LQT circuit response shows that the 37-GB500 motor response graph has an output that is parallel to the desired set point value. This set of points has a value of 0.5. The motor response managed to reach the set point at 1.2 seconds without any overshoot or undershoot. The response of the RS PRO 834-7641 DC Motor using the Linear Quadratic Tracker (LQT) method is superior to the motor response of the first order model.

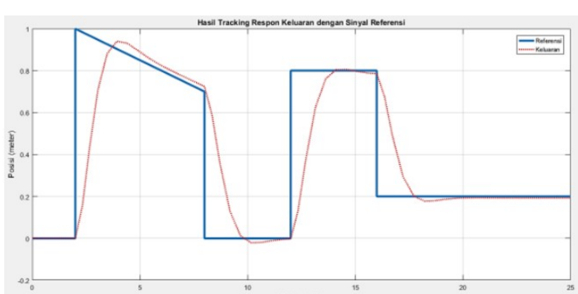


Figure 13. DC Motor Response Results using the LQT Method

3.9 RS PRO 834-7641 DC Motor Response Results with LQT Method and Without Method

The comparison response output between the application of the LQT method and without its use shows differences in the response graph. The orange color wave represents the desired set of points, the blue color reflects the motor response without the application of the LQT method, and the yellow color wave reflects the motor response with the application of the LQT method. In Figure 3.3, it can be seen that the motor response using the LQT method has better performance compared to the response without applying any method. Apart from having a response that corresponds to the set point, the motor response also reaches steady state values more quickly.

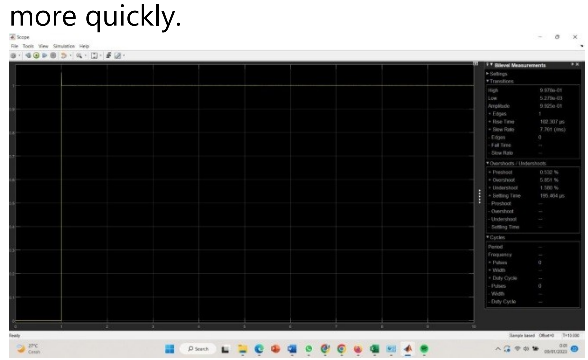


Figure 14. DC Motor Response Results with LQT Method and Without Method

3.10 RS PRO 834-7641 DC Motor Response Results LQT Method with Noise

The results of the LQT circuit response in the presence of noise show that the yellow signal undergoes a change in shape before the noise is added. The signal shape experiences a lot of ripple and reflects the shape of the input noise signal. The resulting signal is no longer linear and is far from the steady state condition at the predetermined set point.

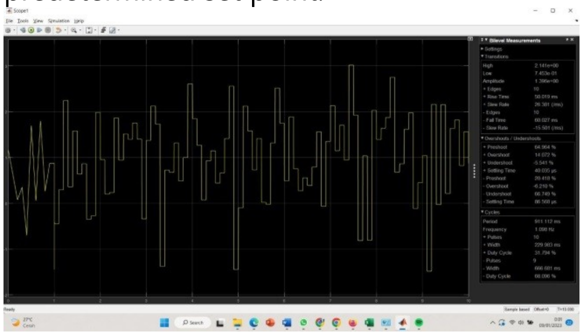


Figure 15. DC Motor Response Results LQT Method with Noise

IV. CONCLUSION

From the simulation results on the RS PRO 834-7641 DC Motor in several series, it can be concluded that the two methods, namely Linear Quadratic Regulation (LQR) and Linear Quadratic Tracker (LQT), have a significant influence on the motor response. A striking difference can be seen in the form of signal output between circuits using LQR, LQT and first order methods. However, it should be noted that when noise is added to the circuit, there is a lot of ripple in the signal. This research only focuses on comparative analysis of signal output results using the LQR and LQT methods.

V. REFERENCE

1.Acknowledgement

research, especially those that fund your research. Include individuals who have helped you with your studies: Advisors, Financial supporters, or perhaps other supporters such as Proofreaders, Typists, and Suppliers who may have provided materials.

Researchers realize that without support from various parties, the preparation of this community service journal would never be realized. So on this occasion the researcher would like to express many thanks to the various parties who have participated.

2. Reference

[1] Ayu, D., Sari, K., Wijaya, F. D., & Ali, H. R. (2022). Optimization of Hybrid Power Plant System in Enggano Island. 11(2), 154–160.

[2] Baedlowi, B., Rahim, A. R., & Aminin, A. (2020). OPTIMASI SISTEM BUDIDAYA POLIKULTUR DENGAN PENENTUAN KOMPOSISI ORGANISME YANG BERBEDA ANTARA BANDENG (C. chanos), UDANG VANAME (L. vannamei), DAN RUMPUT LAUT (G. verucoss). Jurnal Perikanan Pantura (JPP), 3(2), 57. https://doi.org/10.30587/jpp.v3i2.1952

[3] Daeng Rahmatullah, & Belly Yan Dewantara. (2021). Optimasi DOCR Pada Sistem Distribusi Loop dengan Pembangkit Tersebar Menggunakan Algoritma Modified Particle Swarm Optimastion (MPSO). J-Eltrik, 1(1), 10. https://doi.org/10.30649/je.v1i1.10

[4] Fadhli, M., & Soim, S. (2020). Komparasi dan Optimasi Model Propagasi Pada Sistem Komunikasi Seluler Di Kota Palembang. Jurnal Nasional Teknik Elektro, 9(2), 92. https://doi.org/10.25077/jnte.v9n2.773.2020

[5] Ferdiansyah, I., Sudiharto, I., Sunarno, E., & Muhammad, M. G. (2021). Desain SPWM Single Phase Full Bridge Inverter pada Sistem Uninterruptible

Power Supply 500W. Jurnal Arus Elektro Indonesia (JAEI), 7(1), 10–16. https://jurnal.unej.ac.id/index.php/E-JAEI/article/view/23438/9857

[6] Findari, W. S., & Nugroho, Y. A. (2019). Jurnal Manajemen Industri dan Logistik A NTRIAN PADA LAYANAN KESEHATAN OPTIMIZATION OF QUEUE SYSTEM IN THE PUBLIC HEALTH SERVICES USING A Fenomena mengantri sering terjadi dalam fasilitas pelayanan umum , termasuk fasilitas sistem , data perpindahan antar. Jurnal Manajemen Industri Dan Logistik, 03, 14–22.

[7] Haris, A. (2020). Optimasi Sistem Irigasi Lahan Tada Hujan menggunakan Algoritma Ant Colony Optimization berbasis Tenaga Surya. Petir, 14(1), 45–51. https://doi.org/10.33322/petir.v14i1.1064

[8] Jefi, J.-, Joddy, A. M., & Solecha, K. (2020). Optimasi Sistem Informasi Penggajian Karyawan Berbasis Website. Jurnal Infortech, 2(2), 184–189. https://doi.org/10.31294/infortech.v2i2.9164

[9] Khotama, R., Santoso, D. B., & Stefanie, A. (2020). Perancangan Sistem Optimasi Smart Solar Electrical pada Pembangkit Listrik Tenaga Surya (PLTS) dengan Metode Tracking Dual Axis Technology. Jurnal Ecotipe (Electronic, Control, Telecommunication, Information, and Power Engineering), 7(2), 78–84. https://doi.org/10.33019/jurnalecotipe.v7i2.1887

[10] Kosanke, R. M. (2019). 済無 No Title No Title No Title. 7(5).

[11] Prakarsa, M. T., Wahyuni, D., Rachman, N., & Mujahidin, I. (2019). Optimasi Sistem Komunikasi Dari Ht Dengan Hp Dalam Pelaksanaan Tugas Operasi Tni Ad Menggunakan Metode Dtmf. JASIEK (Jurnal Aplikasi Sains, Informasi, Elektronika Dan Komputer), 1(1). https://doi.org/10.26905/jasiek.v1i1.3150

[12] Priyantono, M. B., Ahnan, M., Widhianto, M. A., & ... (2022). Optimasi Sistem Pelabelan Topik Skripsi menggunakan Algoritma Naive Bayes dengan Pendekatan Design Thinking. ... (Jurnal Edukasi Dan ..., 8(1), 168–174. https://jurnal.untan.ac.id/index.php/jepin/article/view/50702%0Ahttps://jurnal.untan.ac.id/index.php/jepin/article/viewFile/50702/75676592958

[13] Rahmasari, M. E. P. (2020). Review Artikel : Optimasi Sistem KCKT untuk Analisis Kafein dan Epikatekin.

[14] Ramadan, B. S., Safitri, R. P., Cahyo, M. R. D., & Wibowo, Y. G. (2019). Optimasi Sistem Pengangkutan Sampah Kecamatan Jati, Kabupaten Kudus, Jawa Tengah. Jurnal Presipitasi : Media Komunikasi Dan Pengembangan Teknik Lingkungan, 16(1), 8.

https://doi.org/10.14710/presipitasi.v16i1.8-15

[15] Saf, M. R. A., Usti, S. D., & Nugroho, E. S. (2020). Optimasi Penggunaan Google Apps for Education (GAFE) Melalui Sistem Informasi Penjadwalan Terintegrasi. Prosiding Seminar Nasional ..., 2, 147–154. http://tunasbangsa.ac.id/seminar/index.php/senaris/article/view/155

[16] Saputra, D. I., Yusuf, C., & Fakhri, Z. (2020). Optimasi Kendali Pada Sistem Node Nirkabel Berbasis Algoritma Fuzzy Logic Controller - PI. Seminar Nasional Teknologi Dan Riset Terapan, 49–57.

[17] Mu'in, Misbakhul, et al. "ANALISIS ALIRAN DAYA DAN CAPASITOR PLACEMENT PADA SISTEM KELISTRIKAN PT BLAMBANGAN BAHARI SHIPYARD DENGAN SOFTWARE ETAP." Jurnal 7 Samudra 8.1 (2023).

[18] Amrullah, Muhammad'Ubaid, et al. "RANCANG BANGUN MONITORING KUALITAS AIR TAMBAK UDANG VANAME DENGAN KONTROL PADDLE WHEEL BERBASIS MIKROKONTROLLER." Jurnal 7 Samudra 8.2 (2023): 117-122.

[19] Pangestu, Nanda Dwi, et al. "PERANCANGAN SMART PROTECTION PADA MOTOR KINCIR AERATOR TAMBAK UDANG MENGGUNAKAN LOGIKA FUZZY." Jurnal 7 Samudra 9.1 (2024): 1-8.

[20] Hidayana, Elmi, et al. "UTILIZATION OF BAGASSE WASTE FOR BIO-OIL EXTRACTION FROM SUGARCANE JUICE VENDORS IN BANYUWANGI REGENCY." Jurnal Cakrawala Maritim 7.1 (2024): 43-51.