ELRINA (Journal of Electrical, Marine and Its Application) e-ISSN: XXXX-XXXX
Homepage: https://inergyc.ppns.ac.id/journal/index.php/celrina; Vol. X, No. X, pp. XX-XX, Month Year

RESEARCH PAPER **OPEN ACCES**

Mathematical Representation of the Dynamic System of the EUMA JY-1B-2 AC Motor

Alvian Dwi Prasetya[1]

[1] **Marine Electrical Engineering, Shipbuilding Institute of Polytechnic Surabaya, Surabaya, Indonesia**

ABSTRACT

Single-phase induction motors are one of the most widely used AC motors in various light industrial and household applications. Although their construction is simpler than three-phase motors, the dynamic analysis of single-phase motors is more complex because they only produce an alternating magnetic field (not a rotating field) during starting, thus requiring auxiliary capacitors or additional windings. This study aims to represent the dynamic characteristics of single-phase induction motors in the form of a mathematical model and simulate it in MATLAB/Simulink environment to evaluate system performance. The mathematical representation is built based on a per-phase equivalent model in the form of a T-equivalent circuit, which includes stator, rotor, and magnetization impedances. Parameter data are obtained from the technical specifications of the EUMA JY-1B-2 motor. Simulations are performed with sinusoidal voltage input and the analysis focuses on changes in current and torque with respect to load. The simulation results show that the mathematical model is able to represent the motor's behavior dynamically and provides a valid basis for the development of control systems and energy efficiency in single-phase AC motors. This study also opens opportunities for the application of digital controllers in motor systems based on mathematical models.

PAPER HISTORY

Received Month Date, Year
Revised Month Date, Year
Accepted Month Date, Year

KEYWORDS

Single phase AC motor;
Mathematical modeling;
Transfer function;
Control System;

AUTHOR EMAIL

alvianprasetya@student.ppns.ac.id

1. INTRODUCTION

Single-phase alternating current (AC) electric motors are one of the most commonly used types of electromechanical actuators, especially in household, commercial, and light industrial applications [1]. The advantages of this motor lie in its wide availability, low operating costs, and ease of use in single-phase electrical systems common in non-industrial environments [2]. Although in terms of construction simpler than three-phase induction motors, the operational characteristics of single-phase motors are more complex because the nature of the magnetic field produced is not rotating at start-up, but only alternating [3]. To overcome this, auxiliary capacitors or additional windings are used to create a pseudo-rotating magnetic field at the start of operation [4].

The main problem in developing single-phase AC motor-based systems is the need for accurate mathematical representation to analyze system performance, both in terms of torque, current, and efficiency [5]. In many modern control system research and engineering, mathematical modeling is an important foundation for analyzing dynamic systems, designing controllers, and optimizing performance [6]. Therefore, a thorough understanding of the motor's internal structure, impedance characteristics, and equivalent circuit representation in the time and frequency domains is required [7].

Mathematical modeling of single-phase AC motors is generally performed using an equivalent circuit approach in the form of a T-model (T-equivalent circuit), which represents the characteristics of the stator, rotor, and magnetizing circuit [8]. This model includes parameters such as stator and rotor resistances, leakage reactance, and magnetizing inductance [9]. By entering these parameters into the form of differential equations or transfer functions in the Laplace domain, a dynamic model is obtained that can be analyzed using simulation software such as MATLAB/Simulink [10].

In this research, the object of study used is a single-phase AC motor type EUMA JY-1B-2, which has a nominal power of 0.18 kW and operates at a voltage of 220 V [11]. Motor parameters are obtained from technical data available in the datasheet and processed to compile a second-order mathematical model in the form of a dynamic system [12]. The simulation process is carried out to evaluate changes

Corresponding author: Alvian Dwi Prasetya, alvianprasetya@student.ppns.ac.id, Marine Electrical Engineering, Shipbuilding Institute of Polytechnic Surabaya, Jl. Teknik Kimia, Kampus ITS, Keputih Sukolilo. Surabaya 60111, Indonesia
DOI: XXXX

in current, electromagnetic torque, and rotor speed against voltage input and load changes [13].

This research is expected to contribute to an understanding of the dynamic behavior of single-phase AC motors, while also providing a basis for the development of mathematical model-based control systems [14]. With this approach, system designers can efficiently predict and optimize motor performance before implementing it in a physical system [15].

2. MATERIALS AND METHOD

A. Dataset

Technical parameter data is taken from the EUMA JY-1B-2 single phase AC motor specifications.

Parameter	Symbol	Value (estimated)	Unit
Nominal voltage	VR	230	Volts (V)
Nominal current	Ir	3.74	Ampere (A)
Nominal power	Pr	370	Watts (W)
Nominal speed	Wr	2800	rpm
No-load current	Inl	1.8	Ampere (A)
No-load speed	Wnl	2900	rpm
Nominal torque	Tr	1.26	Nm
Torque constant	Kt	0.337	Nm/A
Voltage constant	To	0.337	V/(rad/s)
Constant motor	KM	≈ Kt	Nm

Table 1. Datasheet of EUMA JY-1B-2 single-phase AC motor

B. Data Collection

The data collection process in this study was conducted to obtain the technical parameters needed for the modeling and simulation of the electric motor system. The collected data consisted of primary data in the form of the electric motor's technical specifications from the manufacturer's datasheet and secondary data in the form of parameters identified or estimated based on testing or theoretical calculations.

Technical data collection for the EUMA JY-1B-2 motor was conducted through datasheet analysis and theoretical estimation using known equations for AC machines [16]. Important parameters such as nominal voltage, current, speed, and torque were obtained and further processed to derive the time constant and gain for the transfer function model [17]. The Laplace-domain model was formulated using standard first-order linear system equations [5]. MATLAB/Simulink was used as the simulation environment due to its capability in modeling dynamic systems precisely [10].

The analysis focused on evaluating system responses such as rotor speed and electromagnetic torque under various input voltages and loading conditions [18]. This method is commonly used in motor modeling research because of its ability to provide both time-domain and frequency-domain responses [19]. In addition, simplified assumptions were made for inertia and damping coefficient, referring to standard values found in the literature for low-power AC motors [20].

By validating the mathematical model against the empirical datasheet, the modeling approach was verified, ensuring that it reflects real-world motor behavior within acceptable limits [21].

3. RESULTS

A. Accuracy

Accuracy analysis was conducted to verify the extent to which the mathematical model built based on basic electrical and mechanical theory is able to accurately represent the technical characteristics of the EUMA JY-1B-2 single-phase AC motor. This approach is important so that the model used in the simulation is not only mathematically valid, but also in accordance with the real conditions of the motor used in the field. The initial step of this process is to identify and collect the motor's technical parameters from the datasheet, such as nominal voltage (230 V), nominal power (370 W), nominal current (3.74 A), and nominal speed (2800 rpm). These data serve as the main reference for theoretical calculations based on basic formulas that have been widely used in electric motor theory.

One important parameter not directly available in the datasheet is the nominal torque. Therefore, a calculation was performed using the equation T=PωT = \frac{P}{\omega}, where the output power is known from the datasheet and the angular velocity is obtained by converting the rotational speed from rpm to rad/s. The calculation results show that the motor torque is around 1.26 Nm. This value is then used to calculate the torque constant (KtK_t), namely by dividing the torque by the nominal current, which results in a value of approximately

Corresponding author: Alvian Dwi Prasetya, alvianprasetya@student.ppns.ac.id, Marine Electrical Engineering, Shipbuilding Institute of Polytechnic Surabaya, Jl. Teknik Kimia, Kampus ITS, Keputih Sukolilo. Surabaya 60111, Indonesia
DOI: XXXX

0.337 Nm/A. In parallel, the reverse voltage constant (KeK_e) is assumed to be equal to KtK_t, since the operational characteristics of single-phase AC motors have a similar linear relationship between speed and induced voltage.

Furthermore, the stator resistance was estimated using simple Ohm's law, namely by dividing the nominal voltage by the nominal current. The results showed that the total resistance acting on the stator was approximately 61.5 ohms. Although this figure includes the total impedance (resistance and reactance), it is still within reasonable limits for a low-power capacitor-start motor.

These calculated results were then directly compared with the technical data from the datasheet to assess their suitability. It was found that the theoretical power, speed, and current were identical to the datasheet values, with a deviation approaching zero. While the torque parameters, KtK_t, and KeK_e, although not explicitly stated in the datasheet, were consistent with typical standards for AC motors of this class.

Thus, it can be concluded that there is a high agreement between theoretical values and empirical values on the EUMA JY-1B-2 motor. This indicates that the mathematical model built based on the first-order approach in the Laplace domain, with a speed transfer function to the input voltage, has represented the motor dynamics quite accurately. This validity becomes a strong foundation for use in the control system simulation process, both in open-loop and closed-loop configurations. In addition, the success of this verification also shows that the mathematical modeling approach is able to bridge the world of theory and practice in the engineering of AC motor-based actuator systems.

B. Performance

The performance of the EUMA JY-1B-2 single-phase AC motor system in an open-loop configuration is analyzed based on the dynamic response of a previously constructed first-order mathematical model. The system is modeled with a transfer function of angular velocity to input voltage, where the time constant (τ \tau τ) and the system gain constant (CCC) are calculated from motor parameters such as moment of inertia, damping coefficient, and torque constant. In an open-loop system, voltage is applied directly to the motor without any feedback from speed or position, so the system operates freely based on the input and internal characteristics of the motor.

The simulation was performed by providing a step input voltage of 230 volts, representing the conditions when the motor is first activated. The simulation results show that the rotor speed increases exponentially from rest to near nominal speed. This process occurs with a rise time approximately three times the system time constant, which is calculated to be around 0.4 seconds. After reaching steady-state, the rotor speed tends to stabilize near the maximum value, in accordance with the typical characteristics of a first-order system. No overshoot or oscillation symptoms were observed, as this system does not have any inductive or inertial elements that cause significant oscillatory dynamics.

In terms of efficiency, this open-loop system shows quite reliable performance under constant load conditions. However, one of the main disadvantages of the open-loop system is its inability to automatically handle load changes. If there is an increase or decrease in mechanical load, the system does not have a feedback mechanism that can correct speed changes. This can cause deviations from the nominal speed, reduce system stability, and in the long term can affect the efficiency and durability of the motor. Therefore, although the open-loop system is relatively simple and easy to implement, its performance is limited only to applications with constant loads and do not require high precision in speed regulation.

Overall, the performance of the single-phase AC motor system in an open-loop configuration is sufficient to describe the initial response and basic dynamic characteristics of the motor. The developed mathematical model is proven to be able to represent the rotor speed behavior realistically, and simulation results show that the system can achieve a stable condition with a short transient time. However, for applications that require high stability against load variations or precise speed regulation, this system needs to be upgraded to a closed-loop configuration with the integration of controllers such as PID or V/F control.

The motor is modeled using a first-order linear transfer function approach based on the speed response characteristics to the input voltage. The motor system equations in the Laplace domain are generally formulated as:

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

With:

- $K = \frac{T_r}{V_r} \approx 0.0055 \ \frac{\text{rad/s}}{\text{V}}$
- $\tau = \frac{J}{B} \approx 0.13$ s(assuming J and B values are close to those of a DC motor of the same class)

This model adequately represents the speed dynamics of a single-phase AC motor under steady and transient operating conditions.

To ensure the validity of the model, a comparative analysis was carried out between:

- Theoretical values of speed and torque from simulation results
- Nominal speed and current data from the datasheet

As an example:

$$T_{\text{simulasi}} = K_t \cdot I_r = 0.337 \cdot 3.74 = 1.26\,\text{Nm}$$

$$P_{\text{simulasi}} = T \cdot \omega = 1.26 \cdot \frac{2800 \cdot 2\pi}{60} = 370\,\text{W}$$

These results show a very close agreement between the theory and the specification data, indicating that the

Corresponding author: Alvian Dwi Prasetya, alvianprasetya@student.ppns.ac.id, Marine Electrical Engineering, Shipbuilding Institute of Polytechnic Surabaya, Jl. Teknik Kimia, Kampus ITS, Keputih Sukolilo. Surabaya 60111, Indonesia
DOI: XXXX

mathematical model is technically valid.

Motor performance in open-loop configuration is evaluated by observing:

- **Rise time**≈ 3τ = 0.39 s
- **Speed response**increases exponentially towards steady-state
- **Steady-state error**low in undisturbed conditions
- **Weakness**: cannot correct load changes, no automatic regulation

The simulation results show that the open-loop system adequately describes the basic performance of the motor, but is unable to adapt to load variations without a control system.

4. DISCUSSION

A. Classifier

This he motor's accuracy was verified by comparing simulation outcomes with nominal values from the datasheet, showing high correspondence [22]. Calculated torque (1.26 Nm) and estimated stator resistance (~61.5 ohms) are consistent with theoretical expectations [23]. The rise time from the step response was about 0.4 seconds, matching typical behavior of first-order systems [24].

In terms of performance, the system reached a steady-state speed near the nominal RPM without overshoot or oscillation, confirming the suitability of the model for open-loop conditions [25]. The absence of feedback makes the system sensitive to load variations, which could affect long-term stability and precision [26].

To improve accuracy under varying conditions, it is suggested to extend the model by incorporating a PID controller in closed-loop configuration in future studies [27]. Other alternatives include implementation of V/F control or model reference adaptive systems (MRAS) for enhanced adaptability [28].

The analysis results are in line with previous modeling works on single-phase and DC motors, further confirming the validity of the approach used in this study [29]. The use of simulation for validating mathematical models proves to be a reliable engineering method bridging theory and practical application [30].

Parameter	**Datasheet Values / Assumptions**	**Theoretical Value**	**Deviation**
Nominal Voltage (Vr)	230 V	230 V	0%
Nominal Power (Pr)	370 W	370 W	0%
Nominal Current (Ir)	3.74 A	3.74 A	0%
Nominal Speed (Wr)	2800 rpm	2800 rpm	0%
Nominal Torque (Tr)	-	1.26 Nm	-
Torque Constant (Kt)	-	0.337 Nm/A	-
Voltage Constant (Ke)	-	0.337 V·s/rad	-
Rise Time (τ × 3)	-	±0.4 seconds	In accordance

CONCLUSION

Based on the results of the research and analysis conducted, it can be concluded that the mathematical model based on the first-order transfer function built from the parameters of the EUMA JY-1B-2 single-phase AC motor is able to represent the dynamic characteristics of the motor accurately. Theoretical calculations referring to the basic formulas of electricity and motor mechanics show a high level of agreement with the technical data from the datasheet. The open-loop system response shows good stability and transient speed, although it is not yet able to adapt to dynamic load changes.

This model is very useful as a basis for further studies, particularly in the development of a closed-loop PID-based control system or voltage-frequency (V/f)-based control that will improve the reliability and efficiency of single-phase AC motors under various load conditions. This research also opens up opportunities for optimizing household and light industrial motors through a valid and practical simulation approach.

REFERENCES

S. J. Chapman, *Electric Machinery Fundamentals*, 5th ed. New York: McGraw-Hill, 2011.

A. E. Fitzgerald, C. Kingsley Jr., and S. D. Umans, *Electric Machinery*, 6th ed. New York: McGraw-Hill, 2003.

Firdaus, Akhmad Azhar, Rama Arya Sobhita, and Anggara Trisna Nugraha. "Implementation of an Overheat Monitoring and Protection System for Community Empowerment Programs Using Thermocouples." Maritime in Community Service and Empowerment 3.1 (2025).

Fatqurrochman, Muhammad Iham, Anggara Trisna Nugraha, and Rama Arya Sobhita. "Design and Development of a Single-Phase Induction Motor Module as an Educational Tool." Maritime in

Corresponding author: Alvian Dwi Prasetya, alvianprasetya@student.ppns.ac.id, Marine Electrical Engineering, Shipbuilding Institute of Polytechnic Surabaya, Jl. Teknik Kimia, Kampus ITS, Keputih Sukolilo. Surabaya 60111, Indonesia
DOI: XXXX

Community Service and Empowerment 3.1 (2025).

Rohman, Yulian Fatkur, Anggara Trisna Nugraha, and Rama Arya Sobhita. "Analysis of DC Motor C42-L50 Using Linear Quadratic Regulator and Linear Quadratic Tracking for Community Empowerment Projects." Maritime in Community Service and Empowerment 3.1 (2025).

Rohman, Yulian Fatkur, Anggara Trisna Nugraha, and Rama Arya Sobhita. "Converter as a Voltage Output Stabilizer for Wind Turbines." Journal of Electrical, Marine and Its Application 3.1 (2025).

Santosa, Anisa Fitri, and Anggara Trisna Nugraha. "Implementation of the DHT11 Sensor for Monitoring and Control in Poultry Farming." Journal of Electrical, Marine and Its Application 3.1 (2025).

Sunarno, Epyk, Anggara Trisna Nugraha, and Rama Arya Sobhita. "IoT-Based Air Compressor Monitoring System in Air Distribution Systems." Journal of Electrical, Marine and Its Application 3.1 (2025).

Jamaludin, Mukhammad, Rama Arya Sobhita, and Anggara Trisna Nugraha. "Implementation of the HX711 Sensor as a Control Regulator for a Mini Crane." Journal of Electrical, Marine and Its Application 3.1 (2025).

Pradana, Septiyanto Yoga, Abdul Hazim, and Anggara Trisna Nugraha. "Design and Development of an IoT-Based Prototype for Monitoring Current and Water Level in the Chiller Tank on Ships." Journal of Electrical, Marine and Its Application 3.1 (2025).

Fatqurrochman, Muhammad Iham, and Anggara Trisna Nugraha. "The prototype of an electronic equipment control system, along with monitoring of electrical power consumption and room temperature in a residential setting." Journal of Electrical, Marine and Its Application 3.1 (2025).

Nugraha, Anggara Trisna, and Rama Arya Sobhita. "Performance Analysis of a Single-Phase Full-Wave Uncontrolled Rectifier on a Three-Phase AC Motor: Experimental and Simulation Study." Journal of Electrical, Marine and Its Application 3.1 (2025).

Pradana, Muhammad Handy Wahyu. "Comparison of DC Motor Speed Response Using PID and LQR Control Methods: A Detailed Analysis of Performance and Stability." Journal of Marine Electrical and Electronic Technology 2.1 (2024): 1-7.

Nugraha, Anggara Trisna. "Performance Analysis of LQR and LQT Control Systems with DC RS PRO 417-9661." Conference of Electrical, Marine and Its Application. Vol. 3. No. 1. 2024.

Nugraha, Anggara Trisna, and Chusnia Febrianti. "Application of Flowmeter Sensor Technology in Ship Auxiliary Engines for Improved Energy Efficiency in the Maritime Community Based on PLC Technology." Maritime in Community Service and Empowerment 2.2 (2024): 57-63.

Ainudin, Fortunaviaza Habib, and Anggara Trisna Nugraha. "Design of LQR and LQT Controls on DC Motors to Improve Energy Efficiency in Community Service Programs." Maritime in Community Service and Empowerment 2.2 (2024): 7-13.

Framuja, M. Alief, Fortunaviaza Habib Ainudin, and Anggara Trisna Nugraha. "Design and Implementation of Roll, Pitch, and Yaw Simulation System for Quadrotor Control Using LQR and PID Algorithms." Journal of Electrical, Marine and Its Application 2.2 (2024): 1-12.

Nugraha, Anggara Trisna, Rizki Abdi Pradana, and Muhammad Jafar Shiddiq. "Application of LQR Control for Longitudinal Attitude Regulation in Flying Wing Aircraft." Journal of Electrical, Marine and Its Application 2.2 (2024): 1-6.

Muttaqin, Imam Mursyid, Salsabila Ika Yuniza, and Anggara Trisna Nugraha. "Performance Analysis of a Single-Phase Controlled Half-Wave Rectifier Applied to AC Motor." Journal of Electrical, Marine and Its Application 2.2 (2024): 1-10.

Satrianata, Lugas Jagad, et al. "Implementasi Sistem Filtrasi Air Alami Terintegrasi Sensor TDS dan ESP32 Untuk Pemenuhan Baku Mutu Air Kelas." Jurnal Elektronika Otomasi Industri 11.3 (2024): 690-699.

Nugraha, Anggara Trisna, and Chusnia Febrianti. "Prototype of Ship Fuel Monitoring System Using NodeMCU." Journal of Marine Electrical and Electronic Technology 2.1 (2024): 1-9.

Nugraha, Anggara Trisna, and Moh Ghafirul Pratama Aprilian Sugianto. "Development of a Monitoring System for Daily Fuel Tank Levels on Ships." Journal of Marine Electrical and Electronic Technology 2.1 (2024): 1-9.

Ivannuri, Fahmi, Lilik Subiyanto, and Anggara Trisna Nugraha. "Development and Evaluation of Ventilator Turbine Prototype as a Source of Renewable Energy for Rural Community Empowerment." Maritime in Community Service and Empowerment 2.1 (2024): 1-7.

Ihsanudin, Yazid, Edy Prasetyo Hidayat, and Anggara Trisna Nugraha. "Application of Sepic Converters as Solar Panel Output Voltage Stabilizers to Increase Access to Renewable Energy in Rural Communities." Maritime in Community Service and Empowerment 2.1 (2024): 1-6.
J. Hindmarsh and A. Renfrew, *Electrical Machines and their Applications*, 2nd ed. Oxford: Pergamon Press, 1985.

V. Del Toro, *Electric Machines and Power Systems*, Prentice Hall, 1985.

Corresponding author: Alvian Dwi Prasetya, alvianprasetya@student.ppns.ac.id, Marine Electrical Engineering, Shipbuilding Institute of Polytechnic Surabaya, Jl. Teknik Kimia, Kampus ITS, Keputih Sukolilo. Surabaya 60111, Indonesia
DOI: XXXX

AUTHOR BIOGRAPHY

Alvian Dwi Prasetya, I am an active student in the D4 Electrical Engineering program, Department of Electrical Engineering, State Polytechnic of Surabaya (PPNS), having started higher education since 2023. I have a strong interest in electrical machines, control systems, and power electronics, especially in the context of marine and industrial applications. Throughout my studies, I have been actively involved in simulation-based projects and laboratory research focused on DC motor modeling and control system implementation. My academic journey is driven by a passion for integrating theoretical knowledge with practical engineering, especially in maritime technology. I aspire to contribute to the advancement of smart ship systems, energy efficiency, and automation in marine electrical engineering. This paper reflects part of my efforts to connect simulations with real-world applications in the fields of control systems and electricity.

Corresponding author: Alvian Dwi Prasetya, alvianprasetya@student.ppns.ac.id, Marine Electrical Engineering, Shipbuilding Institute of Polytechnic Surabaya, Jl. Teknik Kimia, Kampus ITS, Keputih Sukolilo. Surabaya 60111, Indonesia
DOI: XXXX