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Design of a One-Phase Induction Motor Forward and Reverse Trainer for The Electrical Motor Control Practicum Course

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Abstract

The Electrical Motor Control course is a crucial in learning about electric drive systems. However, the lack of representative often becomes an obstacle in the learning process. One phase forward reverse motor demonstration tool has never been present in the Electric Motor Control Practical. This study aims to design a forward and reverse single-phase induction motor trainer to be used as a learning medium in the Electrical Motor Control practicum. The research adopts a research and development (R&D) method using the Borg and Gall model, which includes the stages of problem identification, literature review, planning, product design, expert validation, and product revision. The validation instruments used in this study involved media experts and subject matter experts, with two experts in each field evaluating the feasibility of the forward and reverse single-phase induction motor trainer design. Based on the validation results, the material experts gave a score of 94% and the media experts gave a score of 86%, both of which fall into the "highly feasible" category for use in the Electrical Motor Control practicum course. It can be concluded that the developed single-phase forward-reverse induction motor trainer is suitable for use as a learning medium and has the potential to increase the effectiveness of Electric Motor Control practicums.

Keywords*: Forward and Reverse, Electric Motor Control Practicum, Single-Phase Induction Motor.*

Abstrak

Mata kuliah pengendalian motor listrik merupakan salah satu kompetensi penting dalam dalam pembelajaran sistem penggerak listrik. Namun, keterbatasan alat peraga yang representatif sering menjadi kendala dalam proses pembelajaran. Penelitian ini bertujuan untuk merancang alat peraga forward dan reverse motor listrik induksi satu phasa yang dapat digunakan sebagai media pembelajaran dalam praktikum pengendalian motor listrik. Penelitian ini menggunakan metode research and development dengan model yang digunakan borg and gall yang mana tahapan yang dipakai yaitu identifikasi masalah, studi literatur, planning, perancangan produk, validasi ahli, product revision dalam desain alat peraganya, Instrumen validasi alat penelitian yang dilakukan oleh peneliti adalah validasi ahli media dan validasi ahli materi masing masing sejumlah dua ahli untuk menguji kelayakan hasil dari desain alat peraga forward dan reverse motor induksi satu phasa. Berdasarkan presensate nilai yang diperoleh dari ahli materi yaitu 94% dan ahli media memperoleh nilai 86% termasuk dalam kategori sangat layak untuk digunakan dalam mata kuliah Praktikum Pengendalian Motor Listrik. Dapat disimpulkan bahwa trainer motor induksi satu fasa maju-mundur yang dikembangkan ini layak digunakan sebagai media pembelajaran dan berpotensi meningkatkan efektivitas praktikum Pengendalian Motor Listrik.

Kata kunci: Fasa Maju dan Mundur, Praktikum Kontrol Motor Listrik, Motor Induksi Satu Fasa

Introduction

The advancement of technology in the modern era has driven various innovations in the field of education[1]. One significant innovation that supports the learning process is the use of instructional media or teaching aid. Teaching aids are a set of tools that are intentionally designed, created, or arranged to assist students in understanding concepts or principles in learning more effectively [2]. Through the use of teaching aids, abstract concepts can be visualized, enabling students to more easily grasp the core of the lesson. Teaching aids help learners understand concepts in a more concrete and digestible manner [3]. With visual or physical representations, students are able to build a stronger understanding of the concepts being taught. In addition, teaching aids can enhance interaction between teachers and students, as well as encourage active student participation in the learning process [4]. Currently, there is no trainer specifically designed for the forward and reverse flow of single-phase induction motors in electrical engineering. Therefore, the development of new teaching aids is urgently needed to effectively support the Electric Motor Control practicum and meet the needs of on-the-job learning. Thus, the use of teaching aids in education functions not only as a tool to support instruction, but also as a means of creating more engaging, interactive, and meaningful learning experiences for students. It can be concluded that teaching aids can improve children's sensorimotor skills, reduce reliance on verbal-based instruction, enhance teacher-student interaction, and help students maintain better focus during learning [5].

In the Electrical Motor Control Practicum, one of the essential aspects of learning is the understanding and mastery of electric motor control systems. Single-phase electric motors are vital components in various industrial and domestic applications. Therefore, a thorough understanding of how these motors operate and how they are controlled is crucial for students [6]. Currently, the Electrical Engineering Education Study Program still has limited availability of trainers specifically designed for single-phase induction motor forward and reverse training. The available trainers are generally general in nature and do not fully meet the learning needs of the Electric Motor Control practical material. Therefore, the development of new, more specific and contextual teaching aids is very necessary to increase the effectiveness of the learning process and support the achievement of student competencies in the field of electric motor control [7]. A single-phase electric motor is a type of motor that utilizes a single phase of alternating current (AC) power to produce mechanical rotation. These motors are widely used in a variety of applications, particularly in household appliances such as fans, washing machines, and water pumps, as well as in light commercial applications and some small-scale industries that do not require high power output[8]. The forward and reverse control method, commonly referred to as bidirectional motor control, is one of the most frequently used techniques for controlling induction motors in various production machines, ranging from small-scale to large-scale industries [9]. This system enables the motor to rotate in two directions—forward and reverse—thus providing flexibility in operating equipment and machinery that require periodic or demand-based changes in rotational direction [10].

In the Electrical Motor Control Practicum, mastery of motor control circuit configurations—including the forward and reverse system—is one of the core

competencies that students are expected to achieve [11]. A single-phase forward-reverse motor is a type of electric motor capable of rotating in two different directions: forward and reverse{Formatting Citation}. This is achieved using a drive system powered by a single-phase electrical source. In more complex industrial applications, the forward and reverse system is often integrated with automation technologies, such as sensors and programmable logic controllers (PLCs) [12]. These integrations enable the motor's direction of rotation to be switched automatically based on pre-programmed operational conditions, thereby increasing the efficiency and precision of industrial processes [13].

Based on the results of observations, a forward-reverse single-phase motor trainer has not yet been available in the Electrical Motor Control Practicum. Therefore, the researcher intends to design a forward-reverse single-phase motor trainer that can be utilized in the Electrical Motor Control course.

Method

a. Research Design

This study aims to design a forward-reverse single-phase motor trainer to be used as a learning aid in the Electrical Motor Control Practicum. In this research, the researcher will apply the Research and Development (R&D) method, which is a research approach used to produce a specific product and test its effectiveness [14]. The R&D method encompasses several development models, and the researcher has chosen the Borg and Gall development model, which consists of six stages, as illustrated in the figure below [15].

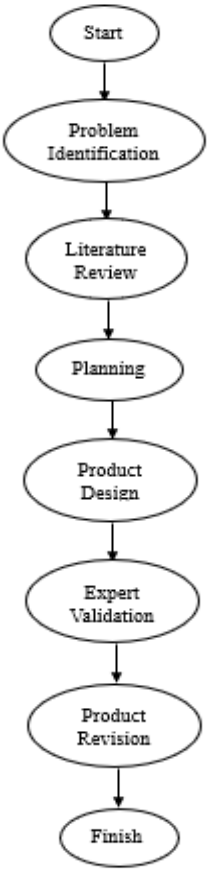

Figure 1. Borg and Gall Development Model Flowchart

b. Tools and Components

The tools and components that will be used to construct the forward and reverse single-phase induction motor trainer are as follows [16]:

a) Contactor
b) Timer
c) Relay
d) Push-on and push-off buttons
e) Single-phase Miniature Circuit Breaker (MCB)
f) Single-phase induction motor
g) Wiring
h) Control panel

c. Validation Sheet

A validation sheet is a document or instrument used to evaluate the validity of a product, research instrument, or research results. The purpose of validation is to ensure that the designed product aligns with the intended objectives in order to obtain the desired data or outcomes [17]. Thus, a validation sheet assists researchers in confirming that the instruments used in the study possess adequate quality to achieve the research goals. In this study, the researcher will utilize validation sheets from both subject matter experts and media experts [18].

d. Data Analysis Techniques

The researcher's data analysis technique employs descriptive statistics with a quantitative approach. The data in this study are analyzed using frequency analysis, which involves examining the occurrence of specific values within a variable and presenting these values as absolute numbers or percentages of the total [19]. In this research, the validation sheets will be directly distributed to the relevant experts. The formula used to calculate the percentage of expert responses regarding the design of the tool is as follows [20].

$$Persentage = \frac{\text{Total Score Obtained}}{\text{Maximum Possible Score}} \text{X}100 \ldots\ldots\ldots\ldots\ldots\ldots 1)$$

Result and Discussion

a. Results of the Forward and Reverse Single-Phase Induction Motor Trainer Design

The power and control circuit layouts of the forward and reverse single-phase induction motor trainer are illustrated in Figures 2 and 3 below.

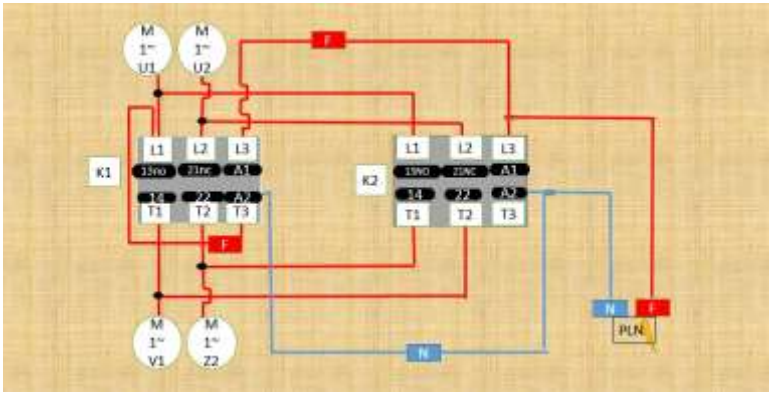

Figure 2. Single-Phase Induction Motor Power Circuit

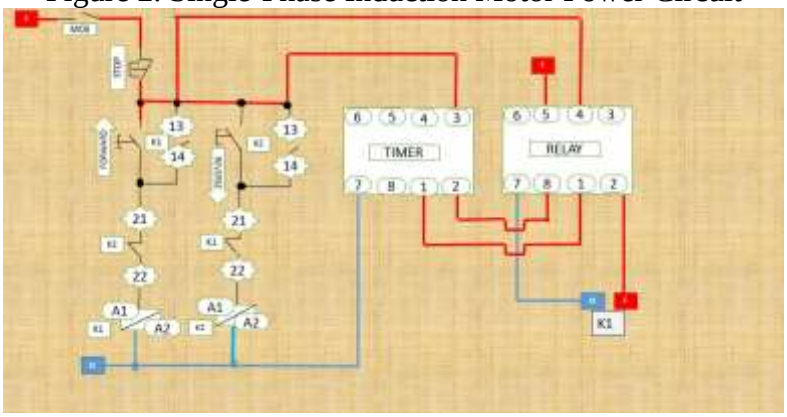

Figure 3. Forward and Reverse Control Circuit for Single-Phase Induction Motor

Based on Figure 2, which illustrates the motor power circuit, and Figure 3, showing the forward and reverse control circuit for the single-phase induction motor, a tangible design of the forward and reverse single-phase induction motor trainer can be realized, as depicted in the image below.

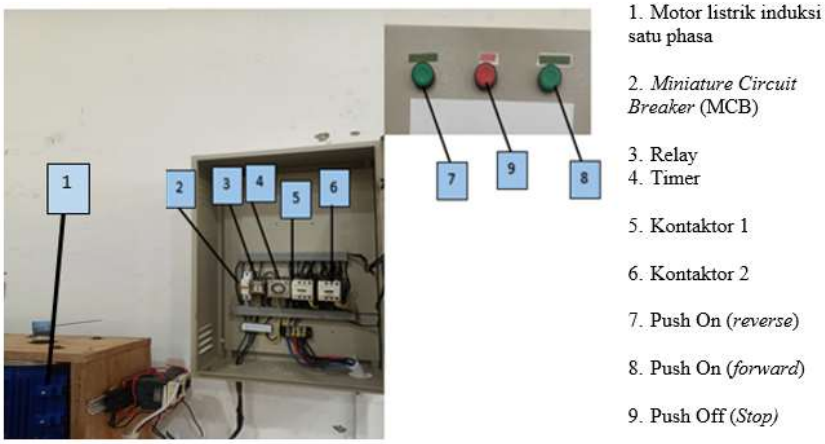

Figure 4. The Layout Design of the Forward and Reverse Single-Phase Induction Motor Trainer

The forward and reverse control of a single-phase induction motor works by altering the phase sequence of the motor's power supply, allowing it to rotate in either direction depending on the configuration of the control circuit. Based on this working principle, the researcher designed a trainer that enables the motor to operate alternately in forward and reverse directions through a properly assembled power and control circuit. The trainer is built into a compact control panel box, making it easier for students to observe and understand the flow of electrical control signals during the Electrical Motor

Control Practicum course. This trainer functions as an instructional tool, specifically supporting the topic of forward and reverse motor control, and is intended to help instructors demonstrate the concept clearly and practically using a small-scale, hands-on learning device.

b. Results of Validation by Subject Matter Experts and Media Experts for the Forward and Reverse Single-Phase Induction Motor Trainer Design

The validation results were obtained from the validation sheets completed by four selected experts who assessed the feasibility of the forward and reverse single-phase induction motor trainer. These experts consist of two subject matter specialists and two media specialists, all of whom are lecturers with expertise in their respective fields.

1) Validation Results from Subject Matter Experts on the Design of the Forward and Reverse Single-Phase Induction Motor Trainer

Table 1. Validation Results from Subject Matter Experts

Aspect	Statement Criteria	Value Criteria	
		V1	V2
1. Learning Objectives	- The trainer helps students understand forward and reverse concepts	5	5
	- Students comprehend the working principle of single-phase induction motors	4	4
	- Students can apply control and power systems using the trainer	4	4
	- Students can change the motor rotation direction to forward and reverse	5	5
	- Students recognize the difference between single-phase and three-phase motor systems	4	5
	- Students are able to assemble forward and reverse circuits	5	4
	- Students grasp and apply forward-reverse concepts in practice	5	4
2. Content	- The trainer clearly presents forward and reverse concepts	4	4
	- It turns abstract theory into hands-on experience	5	4
	- The trainer demonstrates the motor's working principle	5	4
	- It shows both control and power circuits	4	5
3. Teaching Methods and Time Allocation	- The trainer supports discussion and problem-based learning	5	4
	- It makes teaching more time-efficient	5	5
4. Benefits	- Students better understand the Electric Motor Control Practicum	5	5
	- It enhances students' knowledge of single-phase motors	5	4
	- It improves practical skills in forward-reverse motor operation	5	5
	- The trainer boosts student motivation	5	5
	- It supports the overall learning process in practicum	5	5
Quantity		**85**	**81**
Percentage		**94%**	**90%**

2) Validation Results of Media Experts for the Design of the Forward and Reverse Single-Phase Induction Motor Trainer

Table 2. Results of Media Expert Validation

Indicator	Statement Criteria	Value Criteria V1	Value Criteria V2
1. Media Form	- The components of the trainer are clearly visible	5	4
	- The trainer is easy for students to understand	4	3
	- The trainer includes a main component: a single-phase induction motor	5	4
	- This forward and reverse single-phase motor trainer serves as a medium for students during practical sessions	5	5
	- The trainer is able to present the theoretical concepts of forward and reverse operation	5	5
2. Overall Appearance	- The design of the trainer is visually appealing to students	4	3
	- The precise layout of the trainer's components adds to its attractiveness	4	3
	- The trainer has a simple appearance, making it easier for students to understand how forward and reverse work on a single-phase induction motor	5	4
	- Students can comprehend the concept of forward and reverse through this trainer	5	4
3. Practicality	- The tools and materials used in this trainer are easily accessible	5	4
	- The initial cost of the trainer is relatively affordable	4	3
	- The tools and materials used in the trainer are simple	5	4
	- The tools and materials are easy for students to understand in terms of function	5	4
	- The trainer is durable for long-term use	4	4
	- The tools and materials used are appropriate and safe for use	5	4
4. Technical Aspects	- The forward and reverse single-phase induction motor trainer functions properly	5	5
	- The operation of the trainer is easy to understand	5	4
	- The trainer operates manually	5	4
5. Media Quality	- The trainer has high marketability	4	3
	- The maintenance cost of the trainer is relatively low	5	4
	Quantity	**94**	**78**
	Percentage	**94%**	**78%**

After analyzing the assessment results from the validators using statistical calculations, the researcher obtained an average percentage score of 86%. Based on the eligibility criteria listed in Table 3.4, the Forward and Reverse Single-Phase Induction Motor Trainer is categorized as "Highly Feasible" for use in the Electric Motor Control practicum course. The researcher has implemented the suggestions provided by the expert validators, including organizing the wiring and adding labels to each component used in

the design of the trainer, in order to make it neater and easier to understand. Below are images showing the trainer before and after the validators' suggestions were applied.

Figure 5. The Trainer Before Revision

Figure 6. The Trainer After Revision

This study employs the Research and Development (R&D) method using the Borg and Gall development model. The purpose of this teaching aid is to help students better understand the operation of forward and reverse single-phase induction motors. The teaching aid designed by the researcher is constructed in the form of a simple control panel box to facilitate student comprehension during the learning process in the Electrical Motor Control Practicum course. This teaching aid is specifically developed as an instructional medium for the forward and reverse motor control topic within the Electrical Motor Control Practicum. To assess the feasibility of this teaching aid for student use, the researcher utilized validation instruments comprising material validation and media expert evaluation. Feedback and suggestions were requested from lecturers who are experts in their respective fields to evaluate the teaching aid's suitability.

Based on the results of the material expert validation, both validators assessed that the content presented in this trainer adequately covers relevant fundamental concepts, is clear, and is easy for students to understand. Furthermore, the trainer is considered effective in bridging the gap between theory and practice, thereby facilitating students'

understanding of the working principles of forward and reverse single-phase induction motors

Meanwhile, the results of the media validation show that, in terms of the physical form and general appearance of the trainer, both validators gave a satisfactory assessment. This evaluation indicates that the trainer's design meets good standards in terms of appearance, dimensions, and ease of use. The validators also noted that the form of the trainer is appropriate for practicum needs, thereby supporting students in understanding the concept of forward and reverse motor control more effectively

The results of the feasibility assessment for the forward and reverse single-phase induction motor teaching aid can be seen in the following figure.

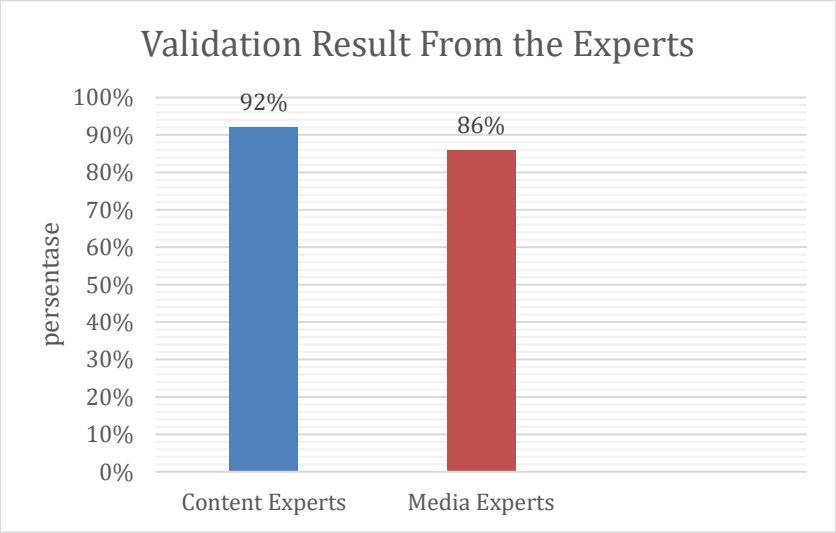

Figure 7 Graph of Expert Validation Results

Material validation, as shown in the graph of expert validation results in Figure 4.6, indicates that the average percentage score given by the two subject matter experts for the teaching aid is 92%. This score falls within the "very feasible" category according to the percentage feasibility calculation formula for teaching aids. This assessment reinforces that the teaching aid can effectively assist students in understanding the concepts of forward and reverse operation of single-phase induction motors. Although the validation results show a very high level of validity, the subject matter experts still provided several suggestions and recommendations as guidance for further refinement of the teaching aid [21]. The media validation results, conducted by two media experts, yielded an average percentage score of 86%, which falls within the "very feasible" category. The feasibility percentage was calculated using the formula.

In this case, the total score given by the validators was compared against the maximum possible score, then converted into a percentage. Based on the interpretation criteria for teaching aid feasibility, a score between 81%–100% is categorized as "very feasible." Therefore, the 86% result indicates that the designed teaching aid meets the feasibility standards and is appropriate for use in the Electrical Motor Control Practicum learning process.

The combined results from both material and media validations confirm that the design of the forward and reverse single-phase induction motor teaching aid is classified as “Very Feasible,” with a material validation score of 92% and a media validation score

of 86%, according to the Teaching Aid Feasibility Percentage Category Table. The teaching aid design for the forward and reverse motor control practicum in the Electrical Motor Control course has undergone thorough validation by both subject matter and media experts. The overall average validation percentage from these expert evaluations is 89%, indicating that the forward and reverse single-phase induction motor teaching aid is highly suitable for implementation as a practical learning medium in the Electrical Motor Control Practicum course.

Conclusion

Based on the discussion above, the conclusions are as follows the forward and reverse single-phase induction motor teaching aid was designed in the form of a simple control box that integrates key components such as two contactors, a timer, a relay, and push on/off buttons, all arranged according to a specific control circuit. This configuration allows the single-phase induction motor to operate alternately in both forward and reverse directions. The design of this teaching aid not only supports lecturers in delivering the concepts of forward and reverse motor control in a concrete and demonstrative way, but also enhances students' understanding by providing a more interactive, innovative, and engaging learning experience in the Electrical Motor Control Practicum course. Based on the validation results, the teaching aid received a percentage score of 92% from subject matter experts and 86% from media experts. These scores fall within the "Highly Feasible" category, indicating that the tool is well-suited for implementation in the Electrical Motor Control Practicum and meets the required standards for effective learning media.

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