

3-phase Alternating Current (ac) Induction Motor Sequential Controller: an Instructional Apparatus



Evangelita A. Anino

Abstract: *Technology education would require high quality, effective laboratory instruction which involves manipulation of instructional apparatuses. Instructional apparatuses provide students to experience the real field of work. However, due to its inadequacy in the electrical technology laboratory, the instructors experienced difficulty of providing the skills to the students particularly on motor control which involves complex designing and installation that needs a skillful and technically-knowledgeable person. In the interest of alleviating this problem, the researchers design an instructional apparatus that address the needs of the electrical technology students. This study aimed to assemble and assess the performance of the 3-Phase Alternating Current (AC) Induction Motor Sequential Controller and find out its effectiveness as an instructional apparatus. Moreover, it finds out its acceptability level in terms of performance, convenience of use, safety, assembly and cost. This was conducted in Bohol Island State University–Calape, Bohol in the Academic Year 2015-2016 for the improvement of instruction in electrical technology. The respondents of the study were the third year students of Bachelor of Science in Industrial Technology, major in Electricity and Technical Experts from BISU system. This study made use of experimental methods of research specifically one group pre-skill test and post-skill test design in developing the apparatus and testing its effectiveness in enhancing the skills of the students. The descriptive design was used in determining the acceptability level of the apparatus supplemented with observation guide to measure its performance level. The result of the study revealed that students' performance using the apparatus was increased by 52.24%. The acceptability level of the apparatus was rated very high by the respondents, obtaining the average weighted mean of 3.62. The result showed that the apparatus is suitable to be utilized in the electrical technology as a tool for instruction. The researchers highly recommend utilizing the apparatus as a tool for instruction in electrical technology laboratories.*

Keywords: *electrical technology, experimental research, instructional apparatus, sequential controller*

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* Correspondence Author

Evangelita A. Anino, Instructor, College of Technology and Allied Sciences, Bohol Island State University – Calape Campus, San Isidro, Calape, Bohol, Philippines. E-mail: vhangie_an@yahoo.com

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I. INTRODUCTION

People desire to experience convenient living. Hence, the use of scientific knowledge from the brilliant human resources paves the way to innovations and technology advancement. One product of innovations is the Alternating Current (AC) Induction motor that facilitate modern tool for country's development through driving the mechanical machineries.

The most common type and widely used AC induction motor in industrial application is the 3-Phase AC induction motor. Due to its unlimited application in industries, motor control poses a significant impact. It reduces power consumption and brings the motor to operate on its specific purpose. In addition, it provides protection of the motor, machines being driven and to the operator as well. Motor control designing and installation is complex which needs a skillful and technically-knowledgeable person to adhere to the requirements of the technological change. Institutions have a big role in enhancing the knowledge of a person. Learning of students will be developed depending on the quality of education being input to them. However, due to the inadequacy of instructional apparatuses present in the electrical technology shops, the instructors experienced difficulty in providing the theoretical input to learners.

According to the Thorndike's Learning Theory of Exercise states that "practice makes perfect" which means that regular repetition of a response strengthens its connection with the stimulus (Maheshwari, 2012)[6]. An instructor is tasked to provide the students better learning experiences that are useful tools to motivate them to become competitive in the field of industry. The availability of instructional apparatus in the technology laboratory is helpful for the students to practice repeatedly. It is a better way of providing the students the opportunity to strengthen the stimulus and to achieve the desired competencies.

Furthermore, Friedrich Froebel's theory emphasizes that learning comes through self- activity (Curtis, 2015)[1]. It is a great and fundamental principle in education that would give the students opportunity to engage into actual operation that would result to acquisition of knowledge through self- activity and actual hands-on activities. Using technology devices in teaching has been proven to be an effective tool in conceptualizing ideas through demonstration of the actual process. Giving instruction would be more convenient with the aid of instructional apparatus because it will be easier to explain a topic if done through actual hands-on.



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In response to the given statements, the researchers intend to design, assemble and assess the 3-Phase Alternating Current Induction Motor Sequential Controller. This apparatus is integrated with circuit breakers, and halogen lights that will protect against short circuits. It has measuring instruments for voltage and current running in the circuit, magnetic starters, relays, pilot lights for output display, push buttons that stop and start the operation, buzzer that will alarm the operator for motor overloading and the AC induction motors which are being controlled.

Moreover, the apparatus utilizing the timers to make the sequential operation of the motors automated.

The apparatus will be a great factor in the development of the students' competencies. It can perform the motor control actual operation for the students to be able to immediately interpret the problem, understand and observe the functions in each device, and learn how it works into a circuit.

The researchers believe that the assembly of the 3-Phase Alternating Current Induction Motor Sequential Controller is beneficial to the students in gaining in-depth understanding on motor control operations. This will give the students insight that multiple induction motors can be controlled in one location and in an easy way. Moreover, students were able to understand that automation is a step beyond mechanization, where humans are provided with machines to help them with their jobs (Tejano, 2019)[8].

II. OBJECTIVES

The main purpose of this study was to assemble and assess the performance level of the 3-Phase Alternating Current Induction Motor Sequential Controller; determine the level of effectiveness of the controller as an instructional apparatus; determine the acceptability level of the controller in terms of performance, convenience of use, safety, and cost; and determine if there is a significant difference in the results of pre-skill test and post-skill test rating of the students using the instructional apparatus.

III. METHODS

A. Design

The study used the experimental design in the assembly of the 3-Phase AC Induction Motor Sequential Controller. Several trial-and-errors were conducted upon assembling the apparatus to ensure its 100% functionality. A one group pre-skill test and post-skill test design was employed for testing its effectiveness in enhancing the technical skills of the students.

Moreover, descriptive method was used to determine the acceptability level of the apparatus. A questionnaire was employed to the electrical technology students and technology experts supplement with the observation guide to gather the necessary data.

B. Environment and Participants

The study was conducted in Bohol Island State University - Calape Campus. It is one of the six campuses of Bohol Island State University that offers technology courses including the Bachelor of Science in Industrial Technology major in Electricity. This course offers Industrial Motor Controller and Industrial Electronic subjects where the Motor Control topic has been taken up. Motor control in this field of specialization

is essential, because this is more applicable in the industry. There were 45 respondents in the study which includes 30 third year students of Bachelor of Science in Industrial Technology, major in electricity and 15 technology experts from BISU system.

C. Instruments

The researcher formulated a questionnaire, scoring rubric and the observation guide as tools in gathering the data in assessing the effectiveness and validate the performance of the apparatus. The observation guide was utilized to measure the performance level of the 3-Phase AC Induction Motor Sequential Controller; the rubric was used to assess the level of effectiveness of the apparatus; and the questionnaire was used to measure the acceptability of the apparatus in terms of performance, convenience of use, safety, assembly of parts, and costs.

IV. RESULTS AND DISCUSSION

Data were gathered and tabulated which was supported with tables that illustrates the responses in the performance of the 3-Phase Alternating Current Induction Motor Sequential Controller, effectiveness of the controller as an instructional apparatus and the acceptability level as perceived by the electrical technology students and technology experts.

The construction of the 3-Phase Alternating Current Induction Motor Sequential Controller was based on the specified design and already applied for Utility Model.

The ladder diagram (Figure 1) of the 3-Phase Alternating Current Induction Motor Sequential Controller control circuit is a set of connections of the devices for the automatic sequential operation of the 3 units Alternating Current (AC) induction motors.

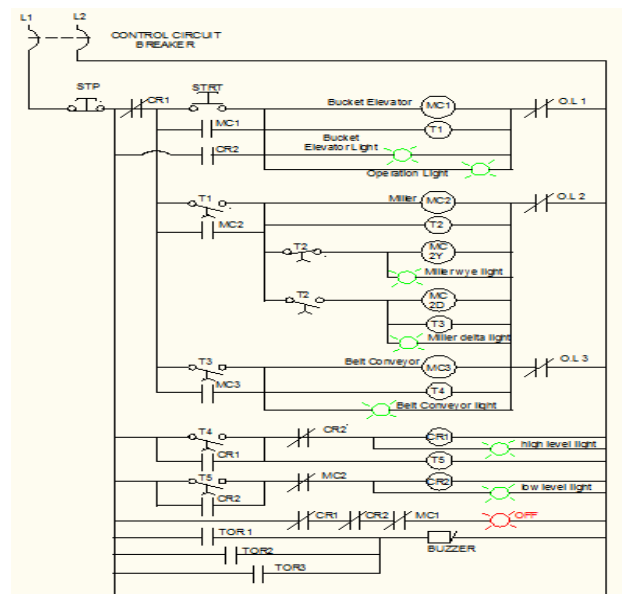


Fig 1. Ladder Diagram of 3-Phase AC Induction Motor Sequential Controller Control Circuit

The power circuit schematic diagram (Figure 2) of 3-Phase Alternating Current Induction Motor Sequential Controller is a representation of power circuit.

It indicates the wiring connections between the devices and the motor control designs. The apparatus has terminals of 3-Phase AC induction motors.

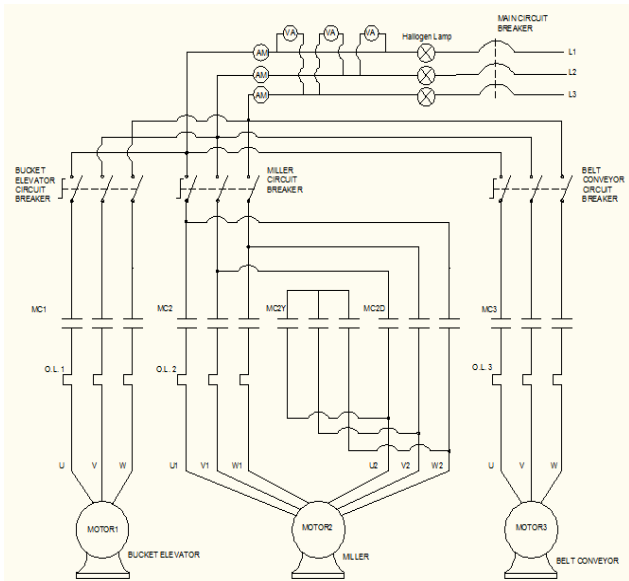


Fig 2. Schematic Diagram of the 3-Phase AC Induction Motor Sequential Controller Power Circuit

A. The Performance Level of 3-Phase Alternating Current (AC) Induction Motor Sequential Controller

The 3-Phase Alternating Current Induction Motor Sequential Controller was 100% functional to simulate the automatic sequential operation of the 3-Phase AC induction motor. Basic Concept of Electricity emphasizes that electric circuit is an unbroken loop of conductive material that allows electrons to flow continuously without beginning or ending. Any break anywhere in a circuit prevents electrons to flow throughout the circuit (Kuphaltdt, 2010)[4]. This concept is relevant to the study in completing or breaking the circuit by another circuit. The apparatus is designed to energize the magnetic starter by the other magnetic starter, thus it makes the starting of the induction motor sequential. This accomplished through the use of the electromechanical devices design according to the purpose.

The protection devices installed were activated protecting the apparatus and the students from erroneous connections. The protection requirements is emphasizes in the 2008 National Electrical Code, Article 110.10, which states that the over current protective devices, the total impedance, the component short-circuited ratings, and the other characteristics of the circuit to be protected shall be selected and coordinated to permit the circuit protective devices used to clear a fault to do so without extensive damage to the electrical components of the circuit (Murphy, 2012)[7]. The article is related to the study in terms of the protective devices installed in the apparatus which are selected and coordinated accurately to prevent any damage to the components when line faults occur. Halogen lamps which are installed in series with the main breaker, function as additional protection of the apparatus. This will serve as a load therefore absorbed the high current produced when short circuit occurs in the control or power circuit. The halogen lamps will correct the line fault preventing the motor and other devices to damage.

The 3-Phase Alternating Current Induction Motor Sequential Controller was also functional to operate on other

electromechanical devices exposed on the board to cater other motor control operation.

B. The Level of Effectiveness of the 3-Phase Alternating Current (AC) Induction Motor Sequential Controller: An Instructional Apparatus

Table 1. Pre-Skill Test and Post-Skill Test Result of the Students (n = 30)

Rang e	Descriptio n	Pre-Skill Test			Post-Skill Test		
		f	%	Ran k	f	%	Ran k
3.25-4.00	Excellent	0	00.00		19	63.33	1
2.50-3.24	Very Good	0	00.00		11	36.67	2
1.75-2.49	Good	9	30.00	2	0	00.00	
1.00-1.74	Needs Improvement	21	70.00	1	0	00.00	
Average Rating		1.60 Needs Improvement			3.35 Excellent		

Table 1 shows the frequency and percentage of the students’ performance on pre-skill test and post skill test in using the 3-Phase AC Induction Motor Sequential Controller. There were 21 out of 30 or 70% of the student’s performance on pre-skill test were described as “Needs Improvement”. While only 9 or 30% were described as “Good”. Likewise, none were described “Excellent” and “Very Good”. The result of the pre-skill test obtained the average rating of 1.60 which is described as “Needs Improvement”.

The post-skill test performance of the students got an average of 3.35 which was described as “Excellent”, where 19 out of 30 students or 63.33% of their performance rated “Excellent” and 11 or 36.67% were described as “Very Good”. The result revealed that the apparatus is an effective tool for the acquisition of learning competencies in electrical technology and also essential in improving the skills of the students.

Table 2. Difference between the Pre-Skill Test and Post-Skill Test Results of the Students.

Diffe rence	t compu ted value	t tabular value	Descrip tion	Interpre tation
	At 0.05 level of significance, df 29			
Pretest and Posttest	-20.34	2.045	Significa nt	Reject Null Hypothe sis

Table 2 presents the difference between the pre skill test and post skill test of the students. The data illustrated that students got a higher rating on post-skill test than of the pre-skill test. The computed t-value was -20.34, with an absolute tabular value of ± 2.045 at 0.05 level of significance. It showed that there was a significant difference in the performance of the students taking pre skill test and post skill test. Thus, the null hypothesis was rejected. This proved that the use of the 3-Phase Alternating Current Induction Motor Sequential Controller is essential for the improvement of the students’ skills and retention of knowledge.

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This is supported by the Experiential Learning Theory of John Dewey, which states that “Education must be conceived as continuing reconstruction of experience; the process and goal of education are one and the same thing” (Kolb and Kolb, 2005)[3]. The apparatus offered hands on experience of the students on motor control designing, installation and troubleshooting thus, providing them a retention of knowledge and skills improvement. It will also increase self-confidence of the students and strengthen the interest to the course, will consciously and willingly participate in laboratory and industrial studies (Erdal and Halliyev, 2008)[2].

Table 3. Acceptability Level of the 3-Phase AC Induction Motor Sequential Controller

Acceptability Level			
5.1 Performance	WM	Desc	Rank
As a gadget: it			2
1 has protection devices for short circuit	3.76	VH	
2.has protection and alarm device for motor overloading	3.89	VH	
3.simulates the automatic sequential operation	3.65	VH	
4.has the ability for multi-function operation	3.71	VH	
Average:	3.75	VH	
As an instructional apparatus, it			
1. increases the performance of the students on pre-skill test to post-skill test	3.79	VH	
2. facilitates the teaching and learning process for a more comprehensive motor control lesson.	3.87	VH	
3. enhances the student’s skills in troubleshooting the motor control circuit.	3.70	VH	
4. enhances the ability of the students in motor control designing.	3.69	VH	
5. makes the students more skillful in motor control.	3.61	VH	
6. improves the knowledge of the students on how the motor control is constructed and connected.	3.73	VH	
Average:	3.73	VH	
Average:	3.74	VH	
5.2. Convenience of use : The gadget is/has:			3
1.Provided with terminals exposed to operator for easy operation.	3.51	VH	
2.Provided with roller to move from one place to another.	3.89	VH	
3.Parts and terminals are properly label for identification	3.30	H	
4.has installed parts accessible to the operator.	3.80	VH	
Average:	3.63	VH	
5.3. Safety, The apparatus has			1
1.a circuit breaker and halogen lamp that protect against short circuit.	3.96	VH	
2.manual switch that serves to its purpose.	3.81	VH	
3.parts and accessories are properly installed.	3.95	VH	
4.terminals that are properly insulated.	3.77	VH	
5.conductors that are properly connected and insulated.	3.93	VH	
6.a trainer structure that is well polished	3.89	VH	
7.wiring connections that are properly enclosed.	3.85	VH	
Average:	3.88	VH	
5.4. Assembly of parts			4
1. Installed parts are intact and immovable.	3.35	H	
2. Parts are properly labeled.	3.26	H	
3. Parts can be assembled and dismantled.	3.45	VH	
4. The wirings are in proper location.	3.55	VH	
5. Installed parts are accessible and visible to the operator	3.30	H	
6. Parts are installed according to the technical plan	3.59	VH	
Average:	3.42	VH	
5.6. COST			

1. Total cost of the apparatus P 66,139.00	3.41	VH	5
Average :	3.41	VH	
Average :	3.62	VH	

Table 3 presents the tabulation of data in which “safety” ranked as highest. This acquired the weighted mean of 3.88 and described as very high. It means that the apparatus was properly equipped with protection devices and designed to provide safety to users.

Safety was given emphasis in the Philippine Electrical Code. This code is established for safeguarding the persons, buildings and its contents from hazards that may arise from the use of electricity (Leoncio, 2014)[5]. The code is related on the study in terms of the selection and installation of the devices in the apparatus which were based on the standards mandated by the Code to protect the users and the devices, and prevent from hazards.

The performance of the apparatus as a gadget and as an instructional apparatus was described as “very high”, which obtained an average weighted mean of 3.74. This shows that the apparatus can operate to its maximum level of efficiency without any failure in the operation. Also, it provides better understanding and increases the level of knowledge as perceived by the respondents. The convenience of use acquired an average of 3.63 and described as “very high”. This means the apparatus is appropriate for instruction and convenient to operate as perceived by the respondents.

The assembly of parts acquired the average weighted mean of 3.42 and described as “very high”. This means that the parts installed on the apparatus are accessible and visible. Cost was described as “very high” having the average weighted mean of 3.41; however it was ranked the lowest. The apparatus was higher in cost due to the quality of materials being used by the researchers. This is to provide better quality performance of the apparatus during the operation.

The overall weighted mean of the 3-Phase AC Induction Motor Controller was 3.62 and described as “Very High”. This shows that the respondents strongly believed that the apparatus is appropriate to be utilized in the electrical laboratory as a tool for instruction.

V. FINDINGS

Based on the result of the data obtained, the following are the findings: the 3-Phase AC Induction Motor Sequential Controller was 100% functional to simulate the automatic sequential operation of the 3-Phase AC induction Motor and the devices installed were activated protecting the apparatus and the students from erroneous connections; the students could understand better on the discussion with the aid of the apparatus, since they obtained the highest average rating of 3.35 in post-skill test, described as “excellent”, while only 1.60 average rating in pre-skill test, described as “needs improvement”; and the apparatus was highly acceptable by the respondents obtaining the average weighted mean of 3.62 in terms of performance, convenience of use safety, assembly and cost.



VI. CONCLUSION

Based on the study's findings, the researcher concluded that there is a significant difference in the performance of the students in the pre-skill test and post-skill test using the 3-Phase Alternating Current (AC) Induction Motor Sequential Controller. The apparatus serves as an effective tool for delivering instruction in electrical technology laboratory and provides the students in-depth understanding on motor control operation. Moreover, the apparatus was highly acceptable since it can operate to its highest level of efficiency with guaranteed safety to the students.

VII. RECOMMENDATION

Based on the data and findings, the following recommendations are given:

Utilize the 3-Phase Alternating Current Induction Motor Sequential Controller in delivering the instruction on industrial motor control; introduce the apparatus as PLC-based to electrical technology as a tool for instruction; and construct instructional apparatuses that can imitate the actual functions of the machines found in the industry.

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AUTHORS PROFILE



Evangelita A. Anino was born in Bohol, Philippines in 1981. Graduated Master of Science in Industrial Technology major in Electrical Technology from Bohol Island State University-Main Campus in 2016. A full-time instructor in the College of Technology and Allied Sciences of BISU- Calape Campus. She is also an active member of the Institute of Integrated Electrical Engineers of the Philippines (IIEE).