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Design of Physics Teaching Aids on Arduino Uno-based parallel Series Circuits

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Abstract

This study aims to develop arduino-based parallel series circuit teaching aids to facilitate students in understanding the concepts of Ohm's Law. The method used in this research is to use *research* and development procedures (*Research and Davelopment*) with Nieveen's description. The design of teaching aids in this study uses the help of Arduino Uno R3 so that measurements can be made automatically. The props designed by researchers use a 30 ampere acs712 current sensor. Based on the results of the data obtained, the relationship between the voltage and the current produced is directly proportional. This is evidenced when the series circuit given a voltage of 6 volts produces a current of 1.82 A, when given a voltage of 7.6 volts produces a current of 2.08 A, and when given a voltage of 9.25 volts produces a current of 2.34 A. Likewise, in parallel circuits, the relationship between voltage and current is also directly proportional. When the voltage given is 6 volts, it produces a current of 1.04 A, when the voltage is 7.6 volts, it produces a current of 1.30 A, when the voltage is 9.25 volts, it produces a current of 1.56 A. Based on these data, it can be interpreted that the greater the voltage given, the greater the current that will be generated. Thus, the research and development of arduino-based parallel series circuit teaching aids is in accordance with the existing literature. This Arduino-based parallel series circuit trainer can be said to have a relatively good level of measurement accuracy. that the props that have been made can work well in series circuits and parallel circuits. The parallel series circuit is arranged using an arduino uno R3 microcontroller and uses a 30 ampere acs 712 current sensor. The level of measurement accuracy produced is relatively good at around 88%. according to experts, the percentage of similarity of 80%-90% can be said to be good. Thus, this Arduino-based series parallel circuit trainer can be said to have a relatively good level of measurement accuracy.

INTRODUCTION

The delivery of different physics ideas in the learning process is more than just a transaction of information from teacher to student because physics is a discipline that describes various physical events in an abstract manner. A thorough understanding of the material is essential, and this can only be achieved by repeated exposure and application. If this can be incorporated into classroom teaching, the widespread belief that physics is complicated will gradually disappear. The best way to get students interested and invested in learning physics is to base their studies in the real world using real-world examples [1].

The concept of Ohm's law is one of the most common in physics. Ohm's law is ubiquitous in the world around us. One of the cornerstones of electronics is Ohm's law, which describes the relationship between voltage, current, and resistance in a circuit. German scientist and mathematician Georg Simon Ohm is recognised as the first person to study the correlation between electric current and potential difference in a conductor, leading to the formulation of the law now known as Ohm's

law. In terms of electricity, Ohm's law explains the relationship between current, voltage, and resistance. For electric current to flow across a circuit, a potential difference must exist. The potential difference at the source of a circuit is created when a power source or battery is paired with other components to create a circuit. Electricity flows through the circuit wires from one terminal of the battery to the next. [2]. Components in an electrical circuit are usually installed in various ways. the simplest and most frequently used type is a parallel series circuit. Series circuits are arranged in series or lines. All components are connected to the power source through the same cable in a series circuit. while a parallel circuit is an electrical circuit arranged in parallel or stacked. so that the resulting electric current source is branched. because the circuit is branched, then if one of the lights goes out it will not affect the other lights.

Students' lack of familiarity with abstract electrical ideas, along with their lack of engagement in the learning process, necessitates the development of effective learning media to stimulate students' interest and improve their academic achievement. The ideal learning process relies heavily on the lecturer and student relationship facilitated through learning media. Besides helping students to learn in a way that best suits their respective visual, auditory, and kinesthetic styles, educational media also helps to clarify content so that it is less vocal. [1]. According to [3] Learning tools are meant to inspire students to provide and acquire more diverse forms of knowledge. Concrete objects are great teaching tools. Students need real items such as teaching aids to understand theoretical ideas about electricity.

Teaching aids are tools designed to improve students' understanding of the subject matter [4]. Therefore, research and development is needed regarding arduino-based parallel series circuit teaching aids to facilitate students in understanding the concepts of Ohm's Law. The results of current calculations in parallel series circuits are displayed on the LCD. LCD (Liquid Crystal Displays) is a typical modern display technology. A single liquid crystal acts as a point of light on the LCD, allowing it to display images or text. [5]. Arduino Uno is a microcontroller system board that is *open* source. [6]. According to Prastia, *et al.* (2021) in their research stated that the Arduino board can be used as an innovation in making physics practicum tools, because the Arduino board can be connected to various modules such as sensors and transducers. [7]. According to Prathidina, *et al.* (2021) electric current can be measured using an ammeter or current sensor such as ACS712. [8]. Hall effect allegro ACS712 is a precision sensor as an AC or DC current sensor in current readings in industrial, automotive, commercial and communication systems. [5].

RESEARCH METHODS

The method used in this article is to use *research* and development procedures with Nieveen's description. From the quote of Nieveen and Plomp (2007) the process is as follows: a. *Preliminary research*; b. *Prototyping stage*; and c. *Assessment stage* (*summative evaluation*). [9]. The making of the Arduino Uno-based Parallel Series Physics Teaching Aid Design was carried out around mid-May, precisely on 20 May to 06 June 2023. The research was conducted at the Advanced Physics Laboratory of the Physics Education Study Program, FKIP, University of Jember, which was carried out in the even semester of 2023.

Stages of Research Design

The following is a schematic of the research stages up to the *prototyping stage*

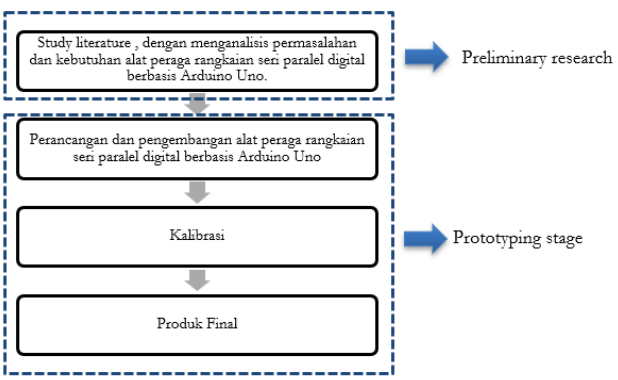


Figure 1: Schematic of the research stages

1. *Preliminary research*
   At this stage the researcher conducts a *literature study*, which is in the form of collecting theoretical studies from several library sources such as journals and books. The stage begins with a preliminary study which aims to collect various information from the results of previous research that is relevant to the research to be carried out.
2. *Prototyping stage*
   The design of the props was made with tools and materials including screwdriver, scissors, laptop, 220 ohm resistors (4 pieces), male-male jumper cables (7 pieces), breadboard (1 piece), Arduino Uno R3, USB serial cable, power supply, LCD (1 piece), alligator clips (2 pieces), and ACS 712 30 Ampere current sensor (1 piece).
   The design of the props consisting of several components is described in Figure 2.

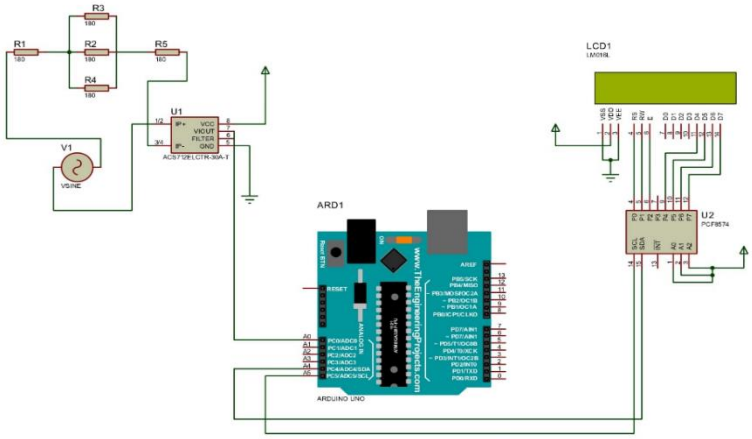
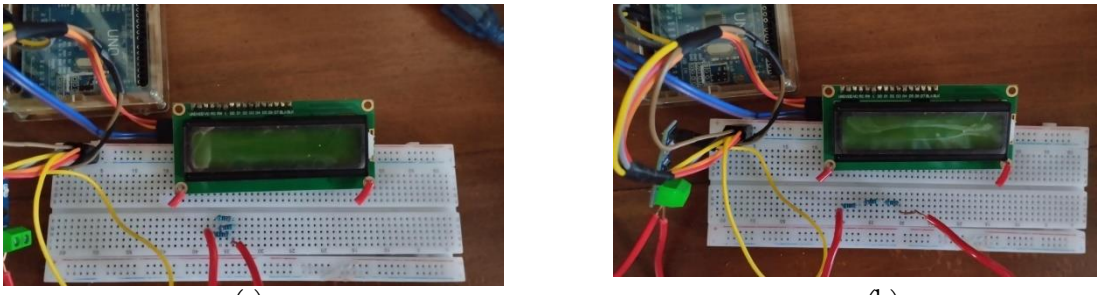


Figure 2. System design of the props

Figure 2. Is the design of the props design system using Proteus 8 software. The design of the research design made will determine the amount of current / voltage generated from resistors arranged in series and parallel. The voltage used comes from the power supply which is connected with an alligator cable clamp to the cable that has been arranged in series and parallel. The current sensor used to read the current is a 30 ampere acs 712 current sensor. This sensor is used because it has a fairly good reading accuracy because there is a low offset linear hall circuit with one track made of copper. The way this sensor works is by reading the current flowing through the copper cable inside. [5].

RESULTS AND DISCUSSION

Under the final design, the design stage of the digital Ohm's Law lab tool has been completed. Automatic measurements can be made using the trainer with an Arduino Uno R3, leading to more accurate results. Both series and parallel electrical resistance circuits are included in this trainer, with three slots each for resistors. The starting voltage applied to the specified circuit can be adjusted using the power supply voltage. Voltage levels of 6, 7, and 9.25 volts are applied quickly. The LCD module used in this trainer could display the current measurement results generated by each circuit as they occur. The following illustration displays the final prop design.



(a) (b)

Figure 3. (a) Series circuit props (b) Parallel circuit props

The first step in operating these props is connecting the USB arduino uno to DC current such as a laptop. Then arrange the resistors on the protoboard according to the type of circuit desired. If you want to test the series circuit, then the resistors are arranged in a row. Meanwhile, if you want to test a parallel circuit, then the resistors are arranged in parallel. When placing the resistor on the protoboard, make sure the resistor legs are in the same direction so that the current is not interrupted. After the resistor is arranged, connect the negative pole Sensor cable with the positive pole of the resistor. While the negative pole on the resistor and the positive pole of the sensor cable are connected to the power supply. Power supply which is intended to supply all the power to all components so that an electronic circuit can work. [10] . The last step turns on the power supply and set the voltage as desired.

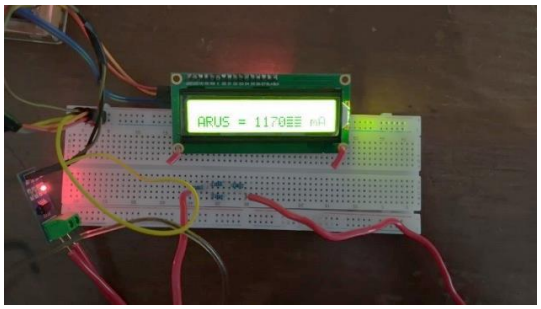


Figure 4. Operation of the trainer and resulting current on the LCD

Testing of this tool was carried out twice, namely testing in series and parallel circuits with each circuit being repeated 3 times. Both circuits use the same resistor value, namely 3 resistors with each resistor of 220 ohms. For the series circuit the total resistance value is 660 ohms. while for the parallel circuit the total resistance value is 0.013 ohms. The voltage used in each circuit uses the voltage from the power supply. Power supply is used to supply power to the arduino uno microcontroller. The amount of voltage used is 6 volts, 7.6 volts, and 9.25 volts respectively. Based on the results of testing the tool, the current in series and parallel circuits is obtained as follows:

Table 1. Tool Testing Results in Series

No.	Voltage (V)	Resistor (Ohm)	Current (A)
1.	6	220 + 220 + 220 = 660	1,82
2.	7,6	220 + 220 + 220 =660	2,08
3.	9,25	220 + 220 + 220 =660	2,34

Table 2. Test Results of Tools in Parallel Circuits

No.	Voltage (V)	Resistor (Ohm)	Current (A)
1.	6	0,013	1,04
2.	7,6	0,013	1,30
3.	9,25	0,013	1,56

Based on the results of the data obtained, it can be seen that the relationship between voltage and current produced is directly proportional. This is evidenced when the series circuit given a voltage of 6 volts produces a current of 1.82 A, when given a voltage of 7.6 volts produces a current of 2.08 A, and when given a voltage of 9.25 volts produces a current of 2.34 A. Likewise, in parallel circuits, the relationship between voltage and current is also directly proportional. When the voltage given is 6 volts, it produces a current of 1.04 A, when the voltage is 7.6 volts, it produces a current of 1.30 A, when the voltage is 9.25 volts, it produces a current of 1.56 A. Based on these data, it can be

interpreted that the greater the voltage given, the greater the current that will be generated. Thus the research and development of arduino-based parallel series circuit props is in accordance with existing literature. Where in the article discussed by (Prastia, et al. 2020) with the title "Design of Digital Ohm's Law Practicum Tool Based on Arduino Mega 2560" explains that the relationship between voltage (V) and current (A) in parallel series circuits is directly proportional and inversely proportional to resistance (R).

This arduino-based parallel series circuit trainer is more practical and the level of measurement is relatively better than the Ohm's law trainer that uses batteries. because this trainer uses a power supply whose voltage can be changed and the value is certain. In addition, this trainer is also equipped with an LCD that can show directly the amount of current produced. Evidence that this trainer has a relatively good level of measurement can be observed from the table below

Table 3. Equipment Analysis

v	v-$\bar{v}$	$(v$-$\bar{v}^2)$
6	-0,02	0,0004
7,6	0,12	0,0144
9,25	-0,08	0,0064
$\bar{v} = \frac{\sum v}{n}$ = 7,6		$\sum(v$-$\bar{v})^2$ = 5,2825

From the table above, we can find the value of similarity or the level of measurement accuracy of this props. The first step that must be done is to calculate the absolute error (Δv) by means of the root of the initial voltage result minus the average voltage of the quads divided by the amount of data multiplied by the amount of data minus one resulting in an absolute error value of 0.94. Then calculate the relative error (I) by means of the result of the absolute error divided by the average voltage given multiplied by 100% resulting in a value of 12%. The last step is to calculate the equality (k) by means of 100% minus the result of the relative error to get a value of 88%. according to experts, the percentage of equality of 80%-90% can be said to be good. Thus, this Arduino-based parallel series circuit trainer can be said to have a relatively good level of measurement accuracy.

CONCLUSIONS

Based on the discussion above, we can conclude that the props that have been made can work well in series and parallel circuits. The parallel series circuit is arranged using an arduino uno R3 microcontroller and uses a 30 ampere acs 712 current sensor. The level of measurement accuracy produced is relatively good at around 88%. According to experts, the percentage of 80%-90% accuracy can be said to be good. Thus, this Arduino-based parallel series circuit trainer can be said to have a relatively good level of measurement accuracy.

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