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Design and Build Basic Electronics Trainer as a Practicum Teaching Aid at the Electronics Engineering Laboratory, Universitas Pembangunan Panca Budi, Medan

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ABSTRACT

This research aims to design and build a basic electronics trainer as a practicum teaching aid at the Electronics Engineering Laboratory, Panca Budi Development University, Medan. The problem faced in the learning process in the industrial automation course is the lack of supporting learning media, so that students have difficulty understanding the theory and its application, especially in the assembly and programming of basic electronic systems. Based on the results of observations, interviews, and questionnaire distribution, it is known that the lack of practicum teaching aids affects the effectiveness of learning.This research method includes the stages of hardware and software design, the manufacture of trainer kits, and the testing of tool functionality. The designed trainer is expected to facilitate students in understanding the basic principles of electronics through interactive and applicable practicums. The use of this trainer aims to provide convenience in understanding theory, as well as improve students' practical skills in assembling and operating basic electronic systems.The result of this study is a basic electronics trainer that can be used as an effective, efficient, and easy-to-operate learning medium. This trainer also makes a significant contribution to increasing student motivation and understanding of the material taught. With this tool, students are expected to be more involved in the learning process, both theoretically and practically, and ready to face challenges in the real industrial world.

Keywords: Basic Electronics Trainer, Teaching Aids, Learning Media, Practicum.

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1. INTRODUCTION

Learning in the field of vocational education, especially in the Department of Electrical Engineering, is highly dependent on students' ability to master theory as well as practice. The Industrial Automation course, for example, demands an in-depth understanding of the assembly and programming of industrial systems, one of which is the goods sorting system. Based on the researcher's experience, as well as the results of questionnaires, interviews, and observations to students who took the course, it was found that the current practicum support facilities are inadequate, especially in terms of learning media. One of the main problems identified is the unavailability of learning media in the form of trainer kits for the goods sorting system, so students have difficulty understanding how this system works and implements.

The use of the right learning media can have a positive impact on increasing student learning motivation and understanding. Learning media that are interactive, interesting, and in accordance with current technological developments, such as electronic-based trainer kits, can be a solution to simplify the learning process. This trainer kit allows students to directly practice the material they are learning, so that they not only understand theoretical concepts, but are also skilled in their implementation.

In line with technological developments, electronic-based learning media is increasingly used in various educational institutions because it has been proven to increase student participation and skills. According to Kuswanto and Radiansah (2018), technology-based learning media can help students stay motivated and not bored while learning, while Rasyid Karo-Karo (2018) emphasized that learning media can facilitate interaction between teachers and students, so that the learning process becomes more effective.

Observations made at the Electrical Engineering Vocational Education Laboratory also show the lack of availability of practicum tools, which has an impact on the less optimal teaching and learning process. Based on this, this study aims to design and build a basic electronics trainer that can be used as a practicum teaching aid for students at the Electronics Engineering Laboratory, Panca Budi Development University, Medan. This trainer is expected to facilitate students in learning basic electronic system assembly and programming techniques, as well as improving their competence in this field.

The use of trainer kits as a learning medium has several significant advantages in the vocational education process. One of its advantages is that it allows students to learn actively and independently. In the context of practicum, students are required to explore electronic circuits directly, both in terms of component assembly and function testing. The trainer kit acts as an interactive tool that can be used repeatedly for simulation and experimentation, thus providing a more immersive learning experience.

Trainer kits also help teachers in delivering material in a more systematic and structured manner. The use of the right tools such as trainer kits can clarify concepts that may be difficult to understand through conventional teaching methods. According to Hidayati et al. (2017), instructional media such as trainer kits are very effective in facilitating learning, because they can concretize abstract theories into more real and easy to understand by students. In this case, trainer kits designed specifically for basic electronics courses allow teachers to provide better illustrations related to the functions and applications of electronic components.

However, until now, the facilities at the electronics engineering laboratory of the Panca Budi Medan Development University are still limited, especially in terms of practicum aids that are relevant to the needs of industrial automation learning. The lack of practicum tools causes students to tend to find it difficult to apply the theories they have learned in the form of real applications. This has the potential to reduce the effectiveness of learning and hinder the development of students' technical skills.

With this trainer kit, it is hoped that students can more easily understand the lecture material, be actively involved in the learning process, and have practical skills that are relevant to industry needs. This research will focus on the design and development of basic electronics trainers that are effective, efficient, and easy to use in practicum activities.

2. LETERATURE REVIEW

A. Control system

A control system is a collection of tools that function to control, regulate, and command the running of a system or program. This system plays an important role in ensuring that the tool or machine can work according to the goals and instructions that have been set by the manufacturer. Basically, a control system is designed to ensure that each component in a system runs efficiently, accurately, and in accordance with predetermined parameters. In today's technological developments, there are various kinds of control systems used, such as Arduino, PLC (Programmable Logic Controller), and microcontrollers, each of which has different characteristics and uses. Arduino, for example, is widely used for simple electronics projects and basic programming, while PLCs and microcontrollers are more commonly used in the industrial sector and large-scale automation.

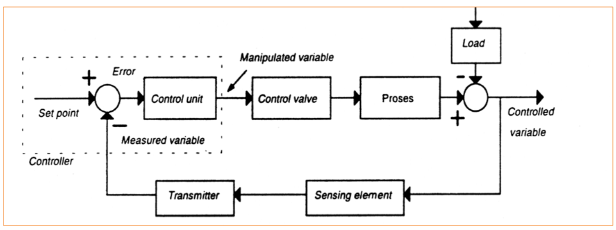


Figure 1: Control system

The importance of control systems in the industrial world cannot be ignored, especially in the production process. The control system plays a role in ensuring that each production process runs smoothly, coordinated, and with minimal errors. The tools equipped with modern control systems are capable of carrying out complex tasks automatically, thereby not only increasing production efficiency, but also reducing dependence on human labor. According to Tarigan and Setiono (2018), the use of the right control system in the industry is very helpful in accelerating the production process and improving the quality of production results. In addition, the control system also allows for easier monitoring and adjustment of various operational parameters, so that the company can achieve a higher level of reliability and quality in its production process.

B. **Power Supply Inverter**

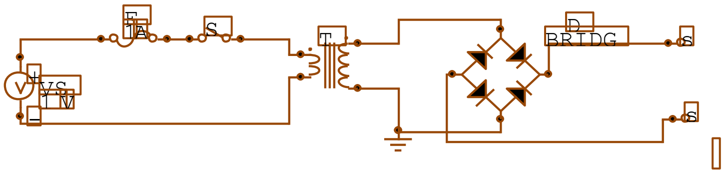


Figure 1. Power Supply Inverter

A Power Supply Inverter is a device that serves to convert direct current (DC) into alternating current (AC). Inverter power supplies are generally used for applications that require the conversion of power from a DC power source, such as a battery or solar panel, into AC power that can be used to run household appliances or electronic devices.

Working Principle of Power Supply Inverter

Basically, a power supply inverter works through several stages:

1. DC Current to AC Conversion: DC signals from a power source, e.g. a battery, are converted into AC signals through a series of electronic components such as transistors, MOSFETs, or IGBTs.
2. Frequency and Voltage Regulation: The inverter adjusts the output frequency and voltage to suit the needs of the device to be operated. For example, the standard output of 220V AC at a frequency of 50Hz in some countries.
3. Filtration and Signal Reinforcement: The inverter is also equipped with a filter and a series of amplifiers so that the AC signal produced is stable and clean from noise.

Main Components of Power Supply Inverter

- Power Source (Battery/Solar Panel): As a DC current source.
- Electronic Switches (MOSFETs/IGBTs): To convert DC current to AC by periodically cutting and switching DC signals.
- Transformer: Used to raise or lower the AC voltage as needed.
- Capacitors and Inductors: To filter the signal to produce a pure sinusoidal waveform (in sinusoidal inverters).
- PWM (Pulse Width Modulation) controller: To control the duty cycle and determine the AC output waveform.

Types of Inverters

1. Pure Sine Wave Inverter: Produces an AC signal that resembles a pure sine wave, perfect for sensitive electronic devices such as computers, televisions, and medical equipment.

2. Modified Sine Wave Inverter: Produces waves that are not completely sinusoidal, but are cheaper and sufficient for less sensitive devices such as lamps and heating devices.
3. Square Wave Inverter: Generates square waves, not ideal for most modern electronic equipment because the signal is rough and unstable.

Power Supply Inverter Applications

- Solar Power System: Converts DC power from solar panels into air conditioning for home use or power grid.
- UPS (Uninterruptible Power Supply): Provides backup power during a power outage by converting power from the battery to the AC.
- Cars and RVs: Provides AC power from vehicle batteries to run electronic equipment.
- Industrial and Telecommunication Equipment: Used in places that require stable AC power from a DC source.

Power supply inverters are essential in the world of renewable energy technology and portable power solutions.

3. RESEARCH METHOD

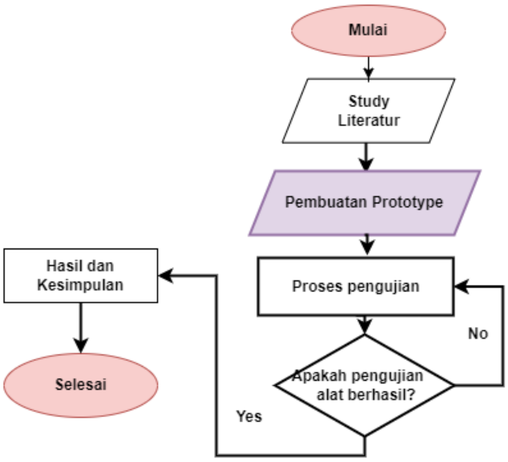


Figure 7. Flowchart

Here is a description of the flowchart:

1) Start: The starting point of the process.
2) Literature Studies: Conduct research and review relevant literature to understand the theoretical background or gather information.
3) Prototyping: Designing and developing prototypes based on literature studies and problems at hand.
4) Process: Testing or analyzing a prototype through experiments or practical applications.
5) Does Tool Testing Work?: Decision points:
6) If "Yes", proceed to Results and Conclusions.
7) If "No", go back to "Prototyping" to improve the design or approach.
8) Results and Conclusions: Based on successful testing, analyze the data and summarize the results.
9) Done: The process ends here.

This flow shows the process of developing and testing the tool, starting from research to final conclusion.

4. Results And Discussion

Design and Design of Component Parts

The design and design of the placement of component parts in the Power Electronics Trainer is an important step that affects the performance and efficiency of the tool in the practicum learning process. First, a needs analysis is carried out to determine the components to be used, such as diodes, SCRs, resistors, and measuring instruments, so that all practicum materials can be accommodated properly. The layout of the components should pay attention to accessibility, by ensuring that each component is placed in a position that is easily accessible and does not obstruct the user. In addition, safety considerations are a priority, where every electrically related component must have adequate insulation to prevent short circuits. Ergonomics are also important, so components are placed at a height that is comfortable for the user, both in standing and sitting positions. By designing prototypes or design sketches before production, it is hoped that an efficient, safe, and ergonomic tool will be created, supporting students' understanding of the basic concepts of electronics effectively.

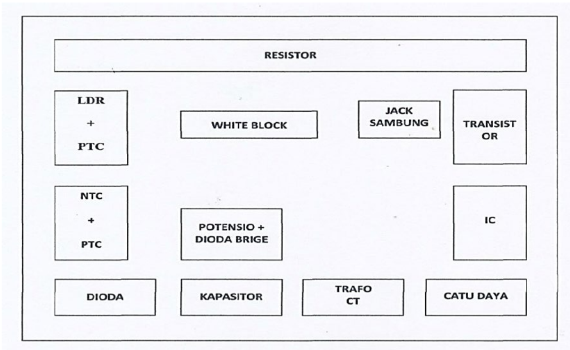


Figure 2. Basic electronics trainer scheme

Figure 37. Basic Electronics Trainer

The trial involves measuring the parameters of the electricity supply, both for three-phase and single-phase sources. In addition, the maximum load current and minimum load current measurements are also carried out. This measurement procedure is important to ensure that the electrical parameters on the trainer are at a good level and in accordance with the standards that have been determined.

Table 1: Results of measuring the electrical parameters of the trainer:

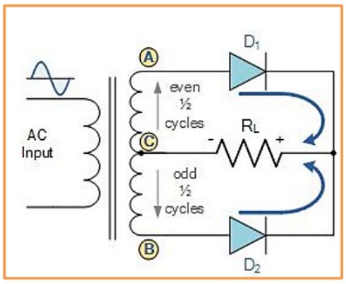
It	Phase Sequence	Standard Voltage (Volts)	Measurement (Volts)	Maximum Current (Ampere)	Information
1	R-N Phase	220	221	3	Usual
2	S-N Phase	220	219	3	Usual
3	T-N Phase	220	221	3	Usual
4	R-S Phase	380	382	3	Usual
5	S-T Phase	380	382	3	Usual
6	T-S Phase	380	380	3	Usual

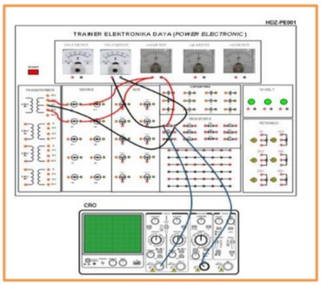
This table presents information in a structured manner, making it easier for readers to understand the results of electrical parameter measurements on trainers.

Analysis of Measurement Results

Based on the data presented in Table 1, it can be seen that the voltage and supply current values are at a normal level. Although there is a slight difference between the measurement results and the established standard, the difference is still within the tolerance limit of 5%. This shows that the electrical system on the trainer is functioning properly and stably.

For example, on the R-N phase voltage measurement, the measurement value is 221 Volts, which is slightly higher than the standard value of 220 Volts. The same thing happened in the S-N phase with a measurement of 219 Volts. This indicates that despite small fluctuations in measurements, everything is still within the allowable tolerance limits.





Circuit Testing on Power Electronics Trainers

The circuit made on this trainer is supplied with a voltage of 12 Volts AC generated through the transformer output. After the circuit is installed, measurements are taken to obtain accurate data on electrical parameters. The results of this measurement are then compared with the results of calculations carried out based on predetermined formulas.

Calculation Formula

In this test, the formula used for the calculation includes various parameters such as DC current, DC voltage, peak voltage (Vm), and RMS voltage (Vrms). With these formulas, we can analyze the performance of components in the circuit more precisely.

Test Results

The results of testing the Power Electronics trainer component in this laboratory test are presented in the following Table 2:

Load R (Ω)	Idc Input (mA)	Vdc (Volts)	Vm (cm)	Vrms (Volts)	Count	Measure

100	10	7,07	63,66	62,90	6,366	6
150	10	7,07	42,44	43,00	6,366	6,1
200	10	7,07	31,83	32	6,366	6,1
220	10	7,07	28,93	29	6,366	6
300	10	7,07	21,22	22,01	6,366	6
400	10	7,07	15,91	16,02	6,366	6,1
440	10,05	7,12	14,53	15	6,397	6,2
470	10	7,07	13,54	14,003	6,366	6,3
1k	10	7,07	6,37	7,302	6,366	6,3

Analysis of Test Results

Based on the table above, it can be seen that there is a difference between the measurement results and the calculation results at several measurement points. For example, at a load of 100 Ω, the RMS voltage measurement result is 62.90 Volts, while the calculation results show 63.66 Volts. This difference is also seen in other loads, where the measured and calculated values are not always aligned.

However, after further analysis, the difference between the calculation and measurement results is within the tolerance level of 5%. This shows that despite the differences, these values are still within acceptable limits for the use of practicum.

Based on the results of this test, it can be stated that the HDZ-PE001 Power Electronics Trainer has met laboratory standards, especially for the implementation of the Power Electronics practicum. Thus, this trainer is ready to be used in the learning process, providing valuable practical experience for students in understanding the basic concepts of electronics. These tests also show that the tool is reliable for use in laboratory environments, effectively supporting electrical engineering education.

CONCLUSION

Circuit tests on the Power Electronics Trainer show that the tool works well and meets laboratory standards for the Power Electronics practicum. Although there was a difference between the measurement and calculation results, the difference was within the tolerance limit of 5%, indicating that the trainer was reliable for use in an educational setting. This trainer is specifically designed to support courses and practicum at the Electronics Engineering Laboratory of Panca Budi Development University Medan, as well as considering time and budget constraints in the design process. By using components and technology that are in accordance with applicable safety standards and regulations, the Basic Electronics Trainer not only functions as a practicum tool, but also as an effective means of equipping students with the necessary skills in the field of electronics engineering. Overall, the HDZ-PE001 Power Electronics Trainer is ready to be used in the learning process, providing valuable practical experience for students in understanding the basic concepts of electronics.

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