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Design and Build Operational Amplifier Practicum Trainer Based on IC Tl084 and 741

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Abstract

The op amp amplifier is a very important component in electronics education. because, there is nothing more fundamental in teaching electronics than the op-amp (operational amplifier). This research is used to analyze op amp circuits with a focus on their performance characteristics and versatility in various configurations such as inverting, non-inverting, summing inverting, summing non-inverting amplifiers. This practical tool requires several supporting tools such as a power supply as a voltage input and an Oscilloscope as a wave reader, input, and output from the circuit in practice, using a laptop with the livewire application which is used to carry out the simulation first before carrying out the practice and several other supporting tools. The aim of this research is to design and create a practical application for Op-amps (Operational Amplifiers) based on IC TL084 and IC 741. The use of practical modules based on Op-Amp ICs is expected to provide direct experience that is relevant to real applications in the industrial world, such as sensor signal processing, health monitoring devices (EKG and EEG), Audio Amplifiers, Motor controllers, and others.

Keywords Op-amp, IC TL084, IC 741, Inverting, Non-Inverting

INTRODUCTION

The rapid development of electronics technology has significantly increased the demand for practical learning media that can support students' understanding of electronic circuit concepts, particularly in the field of analog electronics. One of the most important components in analog electronic systems is the operational amplifier (Op-Amp), which is widely used in various applications such as signal amplification, filtering, instrumentation, sensor systems, audio processing, and control systems. Therefore, understanding the characteristics and applications of operational amplifiers is an essential competency for students in electrical and electronics engineering education programs.

In the learning process, operational amplifier material is generally delivered through theoretical explanations accompanied by limited laboratory practice. However, many educational institutions still experience limitations in terms of practicum facilities, learning media, and supporting laboratory equipment. Conventional practicum methods often rely heavily on breadboard assembly, which can cause unstable connections, measurement errors, and difficulties for students in understanding circuit configurations. In addition, the lack of integrated practicum trainers makes the learning process less effective and reduces students' opportunities to directly observe the behavior of operational amplifier circuits in real-time applications. These conditions indicate the need for an innovative and practical learning medium that can improve students' conceptual understanding and practical skills.

A practicum trainer is one of the learning media that can bridge theoretical concepts and practical implementation in laboratory activities. The use of trainers in engineering education has been proven to increase learning effectiveness because students can directly interact with the designed system and observe the performance of electronic circuits experimentally. Through a trainer-based learning approach, students are expected to better understand circuit analysis, signal characteristics, voltage gain, and the influence of electronic components in operational amplifier configurations. Furthermore, practicum trainers can improve learning efficiency, reduce assembly errors, and provide safer and more organized laboratory activities.

The operational amplifier trainer developed in this study is based on IC TL084 and IC 741. The IC 741 is one of the most commonly used operational amplifiers in educational laboratories because of its simple configuration and ease of implementation in basic analog circuit experiments. Meanwhile, IC TL084 offers advantages such as high input impedance, low power consumption, and the availability of four operational amplifiers in a single package, making it suitable for more complex circuit applications. The combination of these two ICs allows students to compare the characteristics and performance of different operational amplifier types in various circuit configurations. This research focuses on designing and building an operational amplifier practicum trainer that can be used to demonstrate several basic Op-Amp applications, including inverting amplifiers, non-inverting amplifiers, summing inverting amplifiers, and summing non-inverting amplifiers. The trainer is designed to support both AC and DC signal experiments and is equipped with measurement points that facilitate observation using oscilloscopes and multimeters. Prior to hardware implementation, the designed circuits are simulated using the Livewire application to ensure that the system operates according to theoretical principles.

The novelty of this research lies in the integration of multiple operational amplifier configurations into a single compact practicum trainer using both TL084 and 741 ICs, combined with simulation-based validation and experimental analysis. This integrated approach is expected to provide a more comprehensive learning experience for students in understanding operational amplifier applications. In addition, the trainer is designed to be simple, portable, cost-effective, and easy to operate in laboratory activities. Therefore, the purpose of this study is to design, implement, and evaluate an operational amplifier practicum trainer based on IC TL084 and IC 741 as an effective learning medium for analog electronics education. The results of this research are expected to contribute to the development of innovative laboratory learning media and improve the quality of practical learning in electronics engineering education.

METHODS

This research focused on the design and development of an Operational Amplifier (Op-Amp) practicum trainer based on IC TL084 and IC 741 to support analog electronics learning activities. The study aimed to provide an effective educational medium that enables students to understand the working principles and applications of operational amplifiers through simulation, experimentation, and direct observation.

The research utilized several tools and materials to support the design, assembly, testing, and evaluation processes of the practicum trainer. The tools used in this research included a laptop for simulation and programming activities, a multimeter for measuring voltage and resistance values, a soldering iron for assembling electronic components, jumper cables and shock cables for electrical connections, cutting pliers for component preparation, a power supply to provide ±12 V operating voltage, an oscilloscope for observing signal waveforms, and a function generator to produce input signals during circuit testing. Meanwhile, the materials used in the construction of the trainer consisted of IC TL084 and IC 741 as the main operational amplifier components, resistors and capacitors as supporting electronic components, PCB boards for circuit implementation, and acrylic materials for the trainer casing and layout design.

The research method began with problem identification related to the limitations of practical learning media in operational amplifier courses. After defining the problem, simulations were conducted using the Livewire application to design and analyze the electronic circuits before physical implementation. The simulation stage was important to ensure that the designed circuits operated according to theoretical principles and to minimize design errors during hardware assembly. The research process was carried out through several stages. The first stage was literature study, where various references from scientific journals, books, and previous studies were reviewed to obtain theoretical foundations and technical references related to operational amplifier circuits and practicum trainer development. This stage aimed to support the design process and ensure that the trainer fulfilled educational and technical requirements.

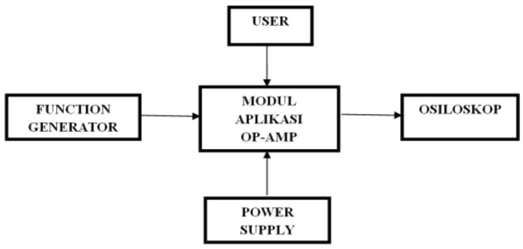

Figure 1. Drawing of Planning Block Diagram

The second stage was tool design and hardware development. At this stage, a block diagram of the trainer system was created as shown in Figure 6. The block diagram illustrates the relationship between the power supply, operational amplifier ICs, input signal sources, and output measurement systems. The trainer was designed using two operational amplifier ICs, namely IC TL084 and IC 741, which were configured into several circuit applications such as inverting amplifiers, non-inverting amplifiers, summing inverting amplifiers, and summing non-inverting amplifiers. The selection of these ICs was based on their widespread use in analog electronics learning and their suitability for practical experimentation.

After the hardware assembly process was completed, testing and data collection were conducted. Each circuit configuration was tested using AC and DC input signals generated by the function generator and power supply. Measurements were performed using a multimeter and oscilloscope to observe voltage gain, signal phase characteristics, waveform stability, and output accuracy. The experimental results were then compared with theoretical calculations and simulation results obtained from the Livewire application. This comparison was carried out to evaluate the accuracy and effectiveness of the developed practicum trainer.

Overall, the research method applied in this study combined simulation, hardware implementation, and experimental testing to produce an operational amplifier practicum trainer that is functional, accurate, and suitable for educational purposes in analog electronics laboratories.

FINDINGS AND DISCUSSION

FINDINGS

Trainer Operational Amplifier

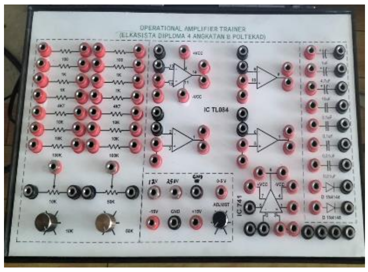

Figure 2 Practicum Trainer Op-Amp.

Reverse Network

The Inverting circuit has components such as IC 741, 1KΩ resistor, and 1KΩ resistor, and requires a supply voltage of +12 Volts and -12 Volts to be active. Here's a simulation of an inverting circuit using a livewire application:

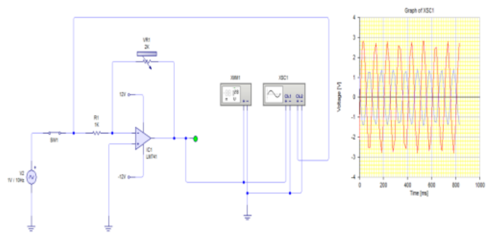

Figure 3 Ac inverting network using livewire

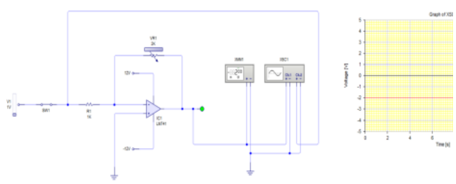

Figure 4 Dc reversing network using livewire

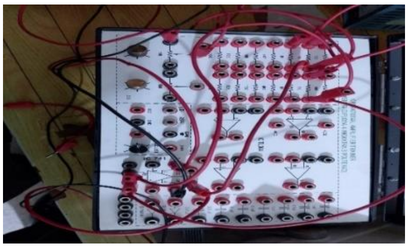

Figure 5 Network flipping using trainers

Network Doesn't Flip

Non inverting circuits have components such as IC 741, 2 resistors of 1 KΩ, and require a supply voltage of +12 Volts and -12 Volts to be active.

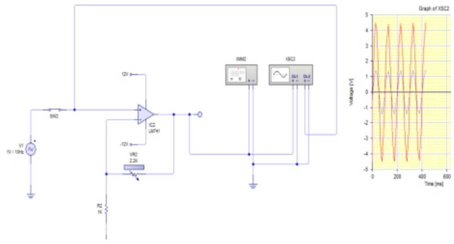

Figure 6 Network does not reverse Ac using livewire

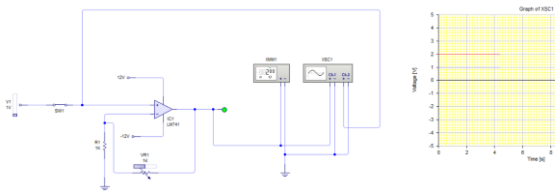

Figure 7 Network does not reverse Dc using livewire

Figure 8 Network does not flip using trainers

Inverted summing series

Summing inverting is one of the configurations on an op-amp (operational amplifier) that is used to sum multiple input signals. The output of this circuit is the result of summing the input signal with reverse polarity (inversion).

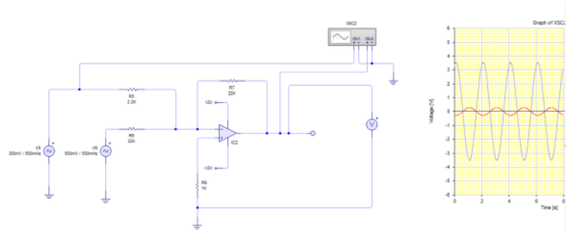

Figure 9 Results of AC inverted summation series

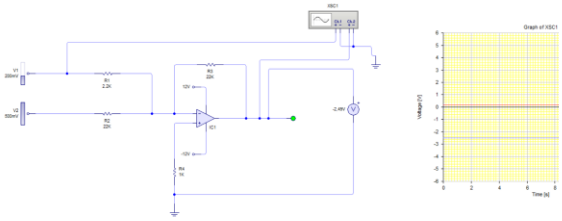

Figure 10 Results of DC inverted summing series

Figure 11 Inverted summing series using trainers

Summing Networks do not Flip

Summing Non-Inverting Summing Circuit is an op-amp circuit used to sum multiple input signals in a non-inverting configuration. In this configuration, the input signal is fed to the non-inverting (+) terminal, and the inverting terminal (-) is connected with feedback via a resistor.

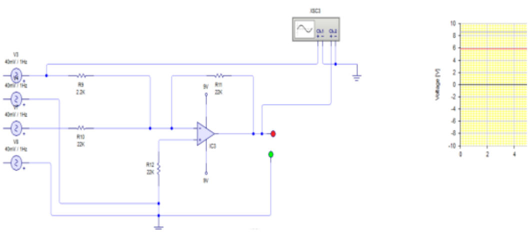

Figure 12 Summing Circuit does not invert DC

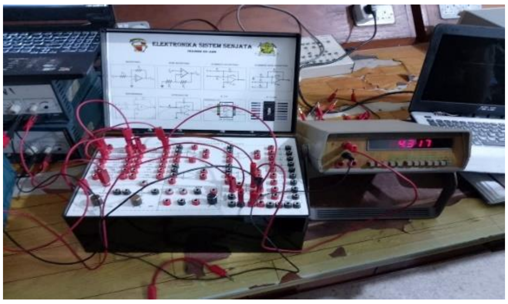

Figure 13 A non-inverting summing series Using a trainer

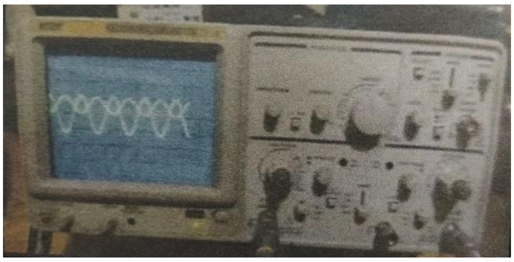

Figure 14 Results of the AC inverting oscilloscope

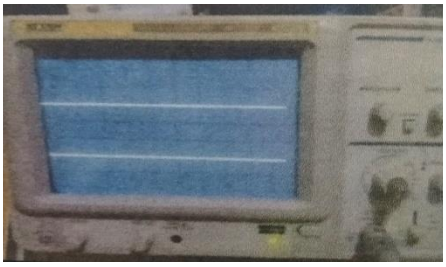

Figure 15 Results of oscilloscope DC reversing

Yes	Rf	V Out Count	V Out Measure	Error	Simulation
1.	2 K	-2,0	-2,05	2,5 %	-2,0
2.	2.2 K	-2,2	-2,30	4,5 %	-2,2
3.	4.7 K	-4,7	-4,76	1,27 %	-4,7
4.	5 K	-5	-5,07	1,4 %	-5
5.	7 K	-7	-7,08	1,14 %	-7

Table 1. Data Results of the inverting series experiment

Yes	Rf	V Out Count	V Out Measure	Error	Simulation
1.	2 K	2,0	2,21	5 %	2,0
2.	2.2 K	3,2	3,21	0,31 %	3,2
3.	3.3 K	4,3	4,43	3,02 %	4,3
4.	5.6 K	6,6	6,75	2,27%	6,6

5.	5.7 K	6,7	6,80	1,49 %	6,7

Table 2. Non Inverting series test results data

The development of the operational amplifier practicum trainer based on IC TL084 and 741 was carried out to support analog electronics learning through direct experimentation and simulation. Figure 7 shows the overall design of the Op-Amp practicum trainer, which was equipped with several operational amplifier configurations, including inverting, non-inverting, summing inverting, and summing non-inverting circuits. The trainer was designed to simplify the practicum process and help students understand the working principles of operational amplifiers through both hardware implementation and simulation testing.

The inverting amplifier circuit shown in Figures 8, 9, and 10 demonstrates the operation of an op-amp in reversing the phase of the input signal by 180 degrees. The circuit utilized IC 741 with resistor components of 1 KΩ and required a dual power supply of +12 V and -12 V. The Livewire simulations for both AC and DC signals confirmed that the output signal experienced polarity inversion relative to the input signal. The hardware implementation using the trainer also produced results consistent with the simulation. Based on the experimental data in Table 1, the measured output voltages were very close to the calculated and simulated values, with error percentages ranging from 1.14% to 4.5%. This indicates that the inverting circuit operated properly and provided stable voltage amplification according to theoretical expectations.

Figures 11, 12, and 13 illustrate the non-inverting amplifier configuration. Unlike the inverting circuit, this configuration maintained the same phase between input and output signals. The circuit also used IC 741, two 1 KΩ resistors, and ±12 V power supplies. The simulation results using Livewire for both AC and DC conditions showed that the output voltage increased proportionally without phase reversal. The practical implementation using the trainer successfully validated the theoretical concept. Table 2 shows that the measured output values closely matched the calculated and simulated results, with relatively small error percentages ranging from 0.31% to 5%. These results demonstrate that the non-inverting circuit can provide accurate and stable signal amplification.

Furthermore, Figures 14, 15, and 16 present the summing inverting circuit configuration. This circuit was designed to combine multiple input signals through the inverting terminal of the operational amplifier. The experimental results showed that the output voltage represented the inverted algebraic sum of the input voltages. Both AC and DC simulations using Livewire produced outputs consistent with the theoretical operation of the summing amplifier. The trainer implementation also showed good agreement with simulation results, proving that the designed circuit could effectively function as an analog signal summing device.

In addition, Figures 17 and 18 show the summing non-inverting circuit configuration. In this circuit, multiple input signals were applied to the non-inverting terminal through resistor networks, resulting in a summed output signal without polarity inversion. The experimental observations indicated that the output voltage was proportional to the total input signals while maintaining the same signal phase. This confirms that the summing non-inverting circuit worked effectively and can be applied in signal mixing and amplification systems.

Finally, Figures 19 and 20 display oscilloscope measurements for AC and DC inverting outputs. The oscilloscope results clearly showed waveform inversion and stable signal amplification, further validating the performance of the developed trainer. Overall, the experimental, simulation, and oscilloscope results demonstrate that the operational amplifier practicum trainer successfully functions as an effective educational medium for understanding operational amplifier characteristics and analog circuit applications.

DISCUSSION

The discussion of this study focuses on the implementation and performance analysis of the operational amplifier practicum trainer based on the TL084 and 741 ICs. The trainer was designed to provide students with a practical understanding of several basic operational amplifier configurations, namely the inverting amplifier, non-inverting amplifier, summing inverting amplifier, and summing non-inverting amplifier circuits. Through the design and testing process, the trainer demonstrated its effectiveness as a learning medium for analog electronics practicum activities.

In the inverting amplifier configuration, the output signal produced by the circuit experienced a phase reversal of 180 degrees relative to the input signal. This result occurred because the input signal was applied to the inverting terminal of the operational amplifier. The output voltage magnitude was determined by the ratio of the feedback resistor to the input resistor, resulting in stable voltage amplification. The experimental results showed that the circuit worked according to the theoretical principles of operational amplifier circuits, where a positive input voltage generated a negative output voltage. This configuration is highly suitable for signal conditioning applications that require phase inversion and controlled amplification.

Meanwhile, the non-inverting amplifier circuit produced an output voltage with the same phase as the input signal. In this configuration, the input voltage was connected to the non-inverting terminal, causing the output to remain positive when the input signal was positive. The voltage gain obtained from this circuit was also stable and depended on the resistor configuration used in the feedback network. The results indicate that the non-inverting amplifier circuit is appropriate for applications requiring signal amplification without phase reversal, such as audio amplifiers, sensor signal boosters, and instrumentation systems.

The summing inverting circuit was designed to combine several input signals into a single output signal through the inverting input terminal of the operational amplifier. The experimental results showed that the output voltage represented the algebraic sum of all input voltages with an inverted polarity. This demonstrates the capability of the operational amplifier to function as an analog signal mixer. The circuit operation was influenced by the resistor values connected to each input, which determined the weighting factor of each signal contribution. Such a circuit is widely applied in analog computing and audio mixing systems.

Furthermore, the summing non-inverting circuit successfully combined multiple input signals while maintaining the same output phase as the input signals. In this configuration, the input signals were applied to the non-inverting terminal through resistor networks, resulting in a positive summed output voltage. The experimental observations confirmed that the circuit operated effectively and produced output values proportional to the combined input voltages. This configuration is advantageous in applications requiring signal addition without polarity inversion.

Overall, the operational amplifier practicum trainer based on IC TL084 and 741 functioned properly and provided clear experimental results. The trainer effectively supported the learning process by enabling students to directly observe the characteristics and behavior of different operational amplifier configurations. In addition, the use of proper measuring instruments and quality supporting components contributed significantly to obtaining accurate and stable measurement results. Therefore, the developed trainer can be considered an effective educational tool for enhancing students' understanding of analog electronic circuits and operational amplifier applications.

CONCLUSION

The operational amplifier (Op-Amp) IC is an important electronic component that can be used in various circuit configurations, such as inverting, non-inverting, summing inverting, and non-inverting summing circuits. These functions can be achieved simply by adding resistor components with appropriate values. The flexibility of the Op-Amp makes it widely used in electronic systems for signal processing and amplification purposes. In an inverting circuit, the Op-Amp produces an output signal that is reversed in phase compared to the input signal while maintaining stable gain. This type of circuit is highly suitable for applications requiring phase reversal and linear signal conditioning because of its simple design and reliable performance. Meanwhile, the non-inverting Op-Amp circuit generates an output voltage that remains in phase with the input voltage and provides positive voltage gain. Due to these characteristics, non-inverting circuits are commonly applied in linear amplification systems, including sensor signal boosters, audio amplifiers, and video amplifiers. Both inverting and non-inverting configurations demonstrate the versatility and effectiveness of Op-Amp ICs in electronic circuit design. In addition, the use of proper and high-quality supporting tools during the experiment or implementation process is essential to obtain accurate, stable, and clearly readable results. Good measuring instruments and supporting components can improve the precision of observations and ensure that the circuit operates optimally according to the intended design.

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