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Design of a DC Power Supply with Selectable Output Voltages Using Different Regulators for Electronic Lab Prototyping

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Abstract. A Direct Current (DC) power supply is an electronic circuit that convert Alternating Current (AC) to Direct Current (DC). The main function of this circuit is to supply Direct Current (DC) electrical power to an electronic device such as lamp, DC motor, phones, laptops etc. This paper discusses the design and simulation of a four output DC power supply circuit using fixed linear voltage regulators to provide 5V, 6V, 9V, and 12V outputs. The objective of this research is to design a four output DC Power Supply circuit which can use for multi-voltage electronic applications. The circuit use LM7805, LM7806, LM7809 and LM7812 voltage regulators to generate the respective output voltages. The design of DC Power Supply circuit was simulated using Proteus software to validate output performance with no load and with load conditions. Simulation results confirmed that each output maintained its designated voltage level with minimal deviation, demonstrating the effectiveness of the design. This project highlights the practical implementation of multiple regulated outputs from a single source, which is essential in prototyping and testing of various electronic devices.

Keywords: DC Power Supply, Variable Output Voltage, Linear Voltage Regulator

1. INTRODUCTION

A linear DC power supply circuit is a fundamental component in electronic systems, designed to convert an AC (alternating current) input or an unregulated DC voltage into a stable and constant DC output. In Malaysia, the standard AC voltage and frequency for household electricity are 230V at 50 Hz. The required DC voltage for electronic circuits, however, typically ranges from 5V to 24V depending on specific application needs.

A basic linear DC power supply comprises five main functional stages: transformer, rectifier, filter, regulator, and DC output. The transformer steps down the AC voltage from 230V to a lower AC voltage such as 24V AC. This lower AC voltage is then converted into a pulsating DC voltage by a rectifier. Since the output from the rectifier is not a pure DC signal, filter capacitors are employed to smooth the waveform by charging and discharging, thereby reducing ripple voltage. The final stage, the voltage regulator, further processes the filtered DC to maintain a steady, constant output voltage regardless of variations in load or input conditions.

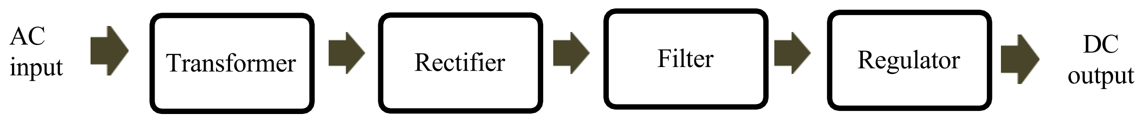

Figure 1. Block diagram of DC Power Supply

This research focuses on the design and simulation of a linear DC power supply circuit capable of providing four regulated voltage outputs: 5 V, 6 V, 9 V, and 12 V. The circuit utilizes linear voltage regulators from the 7800 series, specifically the 7805, 7806, 7809, and 7812 to ensure stable and reliable output voltages. Each regulator stage is equipped with 0.1 µF filtering capacitors at both the input and output to enhance voltage stability and suppress transient noise. Additionally, heat sinks are incorporated into the design to dissipate excess heat and prevent thermal overload during continuous operation. This research aims to support students' understanding of DC power supply circuits as covered in the courses Electronic Circuits (DEE30043), Project 1 (DEE40082) and Project 2 (DEE50102). To evaluate the circuit's performance, proteus simulation software was used. Virtual instruments such as voltmeters and resistive loads were connected to monitor voltage regulation and load response.

2. LITERATURE REVIEW

The development of DC power supply circuits has been widely studied and implemented due to their essential role in powering electronic devices and systems.[1] A DC power supply converts alternating current (AC) from the mains into a regulated direct current (DC) output with specified voltage levels. Among the various types of DC power supplies, linear power supplies are preferred in applications where simplicity, low noise, and cost-effectiveness are important, especially in educational and low-power environments. [2], [3].

Linear voltage regulators such as the 78XX series provide a fixed output voltage and are commonly used in laboratory equipment and low-current devices. Their simplicity and ease of use make them ideal for circuits requiring precise voltage regulation without the complexity of switching regulators. However, Kumar also notes that their main drawback lies in power dissipation, especially when the difference between input and output voltage is large [5].

Design of a switching-regulated power supply based on flyback topology achieves stable and adjustable DC voltage output with low ripple and deviation within a wide input voltage range. The design includes an emphasis on optimizing the control loop compensation to ensure both stability and responsiveness of the power supply. It also describes the hardware circuit design and its implementation, which are crucial for ensuring the intended operation of the power supply. The paper highlights experimental results that show the power supply functions properly across a wide input voltage range (85–265 V). It achieves an adjustable DC voltage output (1–36 V). Furthermore, the design demonstrates acceptable stability and output quality, with output voltage deviation within 1% and output ripple between 1% and 2%. In essence, the introduction sets the stage by detailing the design and implementation of a stable, responsive, and variable DC power supply, emphasizing its utility and performance for laboratory environments. (Huang et al., 2019).

Research by W. Yang, H. Jun, and D. Zhijian (2020), DC regulated power supplies are widely used in teaching, scientific research, industrial production and other fields. The accuracy of the power supply in the automatic test system will affect the quality of the test results. In order to design a high-precision DC regulated power supplies, based on closed-loop negative feedback and self-calibration technology, we use four-wire Kelvin sense and fuzzy adaptive PID control algorithm to improve the accuracy of the output's power, while floating output method has also been used to simplify the design. A microcomputer has been used to control a DAC which outputs a analog voltage to drive a power amplifier, in this way, the power amplifier could output a adjustable voltage with continuously. At the same time, a ADC has been used to sample the amplifier's output and send the sample value to the microcomputer for negative feedback control. A power dissipation control circuit has been designed based on the junction temperature characteristics of the power amplifier to improve power conversion efficiency and accuracy. The experiment test results show that the designed power supply's output voltage range is 0~±30V, accuracy is ± (0.25%∗U±10mV), current range is 0~±6A, accuracy is ± (0.2%∗I±5mA), maximum power is 65W, which meets the expectations target.

Demonstrated a 3-output regulated power supply using 7805, 7809, and 7812 voltage regulators. Their findings showed that while linear regulators are less efficient than switching regulators, they maintain excellent voltage stability and low ripple, which is crucial for analogue and sensor-based applications. Singh also highlighted the importance of proper heat dissipation using heat sinks to ensure the long-term reliability of linear regulators (Chyan et al., 2022).

Research by A. Rahman et al. (2021) explored the implementation of a DC power supply using the LM317 adjustable regulator. The study focused on designing a flexible voltage output system using resistor networks to control the output level. The LM317's versatility in producing non-standard voltage levels complements fixed regulators, making it ideal for custom voltage configurations in multi-output systems.

In terms of simulation and pre-implementation testing, Proteus Design Suite has been widely used for modelling electronic circuits. A paper by N. Ismail (2020) demonstrated the effectiveness of Proteus in simulating power supplies and validating designs before physical prototyping. This approach reduces time and cost, while providing insight into circuit behaviour under various load conditions.

While most studies focused on single or dual-output power supplies, there remains a gap in low-cost, multi-output regulated power supplies designed specifically for educational and prototyping purposes. This research aims to address this gap by designing a 4-output linear DC power supply using LM7805, LM7806, LM7809, and LM7812, and validating its performance through Proteus simulation.

3. Research Methodology

This project followed a structured design and testing process to develop a multi-output linear DC power supply with four regulated outputs: 5V, 6V, 9V, and 12V. The methodology involves the following stages:

3.1 Circuit Design

The power supply was designed using standard linear voltage regulators: 7805, 7806, 7809 and 7812. A 230V AC input is stepped down using a 24V AC transformer. The output is then rectified using a bridge rectifier to produce a pulsating DC voltage. A large electrolytic capacitor (1000µF) is used to filter the ripple and smooth the DC voltage before it is passed to the regulators. Each voltage regulator is configured to provide its specific output, and 0.1µF ceramic capacitors are placed at both the input and output terminals of each regulator to improve stability and reduce high-frequency noise. Heat sinks are attached to each regulator to prevent overheating during continuous operation.

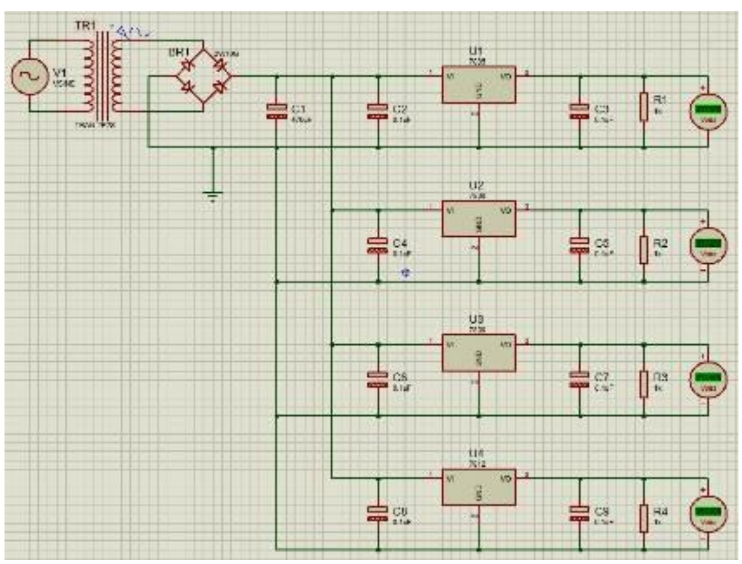

Figure 2. Schematic Circuit of DC Power Supply using Proteus V8. 13 SPO.

3.2 *Simulation using Proteus*

The circuit was model and simulated using Proteus V8. 13 SPO Design Suite. Virtual instruments such as voltmeters and load resistors were connected to each output to monitor voltage levels and regulator performance under various load conditions. The simulation allowed for safe and efficient testing without physical hardware.

3.3 *Performance Testing*

Output voltages were measured in simulation under both no-load and loaded conditions to assess voltage regulation. Load resistors were adjusted to simulate different current draws. The stability, accuracy, and ripple of each voltage output were observed and recorded.

4. Results

The Table 1 compares expected voltage and measured voltages of voltage regulators. Each regulator provides a fixed output voltage. The measured voltages are very close to the expected values, showing good voltage regulation. Small differences are due to component tolerance and measurement error. The results confirm that the regulators operate correctly and provide stable output voltages

Table 1. The expected and real value output voltage & output current of DC Power Supply

Types of regulator	Expected Voltage	Voltage	Current
7805	5 V	5.01 V	5.00786 mA
7806	6 V	6.00 V	6.00397 mA
7809	9 V	9.01 V	9.0067 mA
7812	12 V	12.00 V	12.0082 mA

There was minimal ripple observed, confirming the effectiveness of the filtering capacitors. Heat dissipation was simulated, and all regulators remained within thermal limits when properly heat-sinked.

The Proteus simulation confirmed that the design was functional and stable for educational and prototyping use. The regulators responded well to sudden changes in load without significant voltage drop, indicating good transient response. The simplicity and reliability of the design make it ideal for low-power lab applications.

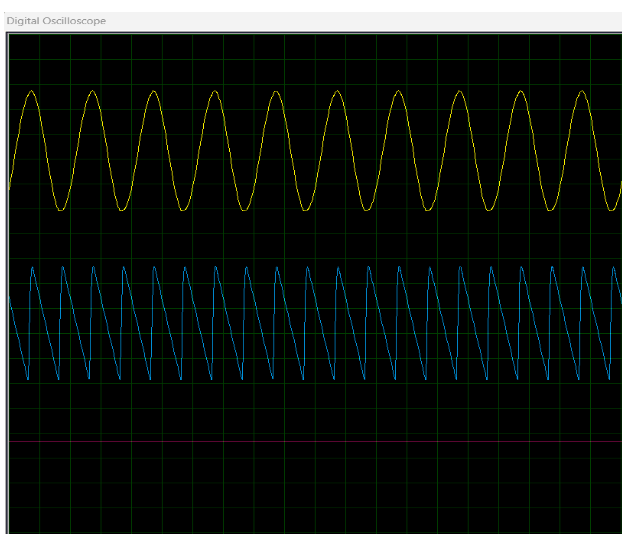

Figure 3. Output waveform of DC Power Supply

5. Discussion

The designed DC power supply successfully delivered selectable output voltages of 5V, 6V, 9V, and 12V using a combination of linear and fixed voltage regulators. The implementation and testing within the Proteus simulation environment verified the stability, accuracy, and functionality of each regulated output. The selection mechanism allowed users to easily switch between voltage levels suitable for various prototyping applications, reflecting a practical approach for electronic laboratories. Voltage outputs remained within acceptable tolerance ranges under simulated load conditions, confirming the effectiveness of the regulator choices.

For instance, the 5V and 12V outputs, regulated by 7805 and 7812, respectively, showed stable and ripple-free performance, ideal for powering microcontrollers and motors. The 6V and 9V outputs, which required slight modifications using voltage dividers or diode offset configurations, also maintained a stable output with minimal deviation, demonstrating design flexibility when fixed regulators are not directly available for those specific levels. Heat dissipation and efficiency, typically concerns in physical implementations, were not simulated in full detail; however, the results indicate the feasibility of further development into a physical prototype with added thermal management considerations. This simulation-based research confirms that a versatile, low-cost, and accessible DC power supply can be effectively developed for use in academic or prototyping settings, offering essential voltage options for a broad range of electronic components and circuit testing scenarios.

6. Conclusion

This research successfully demonstrates the design and simulation of a DC power supply with selectable output voltages using 7805, 7806, 7809, and 7812 voltage regulators. The circuit provides four stable voltage outputs suitable for a wide range of electronic applications. Simulation results confirmed that each output maintained accurate voltage levels with minimal ripple, validating the design's reliability and efficiency.

The use of Proteus simulation allowed for comprehensive testing without physical components, saving time and cost while ensuring design accuracy. This power supply design can serve as a cost-effective and practical solution for educational institutions, electronic prototyping labs, and beginner electronics enthusiasts.

Future improvements may include incorporating digital voltage selection, overcurrent protection circuits, or expanding the output range using adjustable regulators or switching power supply alternatives.

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