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ОТВЕТ

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Использование нестандартных тестов деятельности требует минимума времени, но должно внести яркий, эмоциональный момент в урок. Как показывает опыт, разумнее привести на уроке один-два примера, чем перечислять ряд интересных и эффективных фактов, которые своей многочисленностью не только не решат поставленной учителем задачи.

Процесс целенаправленного использования вышеупомянутых нестандартных тестовых заданий в образовательном процессе позволяет правильно и беспристрастно контролировать, и оценивать приобретенные знания, навыки и квалификацию учеников. Содержание и форма занимают главное место при подготовке нестандартных тестовых заданий.

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**TEACHING RADIO ELECTRONICS THROUGH ARDUINO-BASED LABORATORY EXPERIMENTS**

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**Abstract:** This article explores the integration of Arduino-based laboratory experiments in radio electronics education. We investigate the effects of using an Arduino multivibrator circuit in comparison to traditional analog circuits. The study demonstrates the advantages of Arduino-based experimentation in enhancing students' understanding of radio electronics.

**Introduction:** Radio electronics, a pivotal discipline in the realm of electrical engineering, plays an indispensable role in enabling modern telecommunications, broadcasting, and wireless technologies. Understanding and mastering the principles of radio electronics are imperative for students pursuing careers in fields such as wireless communication, radar systems, and broadcast engineering. Effective teaching methodologies are pivotal in fostering this understanding.

The conventional pedagogical approach to radio electronics has predominantly involved theoretical lectures complemented by hands-on laboratory experiments. However, the evolution of technology has ushered in new and innovative tools to facilitate learning in this domain. One such innovative tool is the Arduino microcontroller platform. In recent years, Arduino has emerged as a transformative force in engineering education, offering a dynamic and engaging method for teaching electronics, and by extension, radio electronics.

In this article, we delve into the significant shift towards integrating Arduino-based laboratory experiments in radio electronics education. We aim to explore the impact of incorporating Arduino-based experiments, particularly focusing on the utilization of an Arduino multivibrator circuit in comparison to traditional analog circuits. Our study centers on elucidating the multifaceted implications of this pedagogical transition, drawing from both empirical evidence and pedagogical theory.

**Methods:** 1. Arduino Multivibrator Circuit:

The adoption of Arduino-based laboratory experiments in radio electronics education is rooted in the transformative potential of this versatile microcontroller platform. In alignment with our introductory objective, we designed a methodological approach that not only illuminates the efficacy of Arduino-based experiments but also aligns with the core concepts of radio electronics education.

**Experimental Setup:** Our primary methodological endeavor was the creation of an Arduino-based multivibrator circuit. The multivibrator is a foundational component in radio electronics, serving critical roles in signal generation, pulse shaping, and oscillator circuits. In keeping with the principles of hands-on learning, we employed an Arduino Uno microcontroller, renowned for its adaptability, to construct the multivibrator circuit. The hardware setup included the Arduino board, resistors, capacitors, and a breadboard, serving as the testing ground for our experimental designs.

**Programming and Versatility:** The Arduino platform offers an innovative approach to teaching multivibrators, primarily through the flexibility and versatility of its programmable capabilities. Students were tasked with writing and uploading code to the Arduino Uno, enabling it to generate square wave signals at varying frequencies and duty cycles. This digital approach effectively mirrored the functionalities of a conventional analog multivibrator. The key objective here was to emphasize the adaptability of the Arduino, allowing students to explore a spectrum of multivibrator configurations, a crucial skill for future radio electronics engineers.

**Enhanced Comprehension:** A fundamental aspect of our methodology was the incorporation of visual representation and real-time feedback inherent in the Arduino platform. The graphical interface presented on the computer screen aided students in comprehending the principles of multivibrators more effectively. This dynamic visual feedback mechanism allowed students to visualize the behavior of the circuit as they modified the code, thereby fostering a deeper understanding and enhancing engagement.

**Error Analysis and Troubleshooting:** Error analysis is a vital component of the scientific method, and the Arduino environment excels in this regard. It offers robust error detection mechanisms and debugging capabilities, which facilitated students' ability to identify and rectify errors within their circuits. This element of the methodology aligns with pedagogical best practices, fostering self-correction and problem-solving skills, which are vital in the field of radio electronics.

2. Traditional Analog Multivibrator:

In tandem with the Arduino-based approach, we introduced a parallel method involving the traditional analog multivibrator circuit. This analog counterpart provided an essential point of reference to evaluate the impact of transitioning from the conventional analog realm to the digital domain, further anchoring our research in the context of radio electronics education.

**Analog Circuit Construction:** To maintain the integrity of the traditional approach, we constructed an analog multivibrator circuit using discrete electronic components. Transistors,

capacitors, and resistors were assembled according to established circuit design principles. This analog setup accurately emulated the functions of the digital multivibrator, providing students with an authentic and tactile experience of analog circuitry, which is indispensable in radio electronics education.

**Fundamentals of Analog Electronics:** An important aspect of our methodology was to expose students to the foundational principles of analog electronics. The traditional analog multivibrator experiment allowed students to delve deep into the intricacies of transistor operation, biasing techniques, and passive component behavior. This immersion in analog fundamentals ensures a comprehensive understanding of electronics principles, which underpin advanced radio electronics applications.

The parallel employment of both the Arduino-based and traditional analog multivibrator circuits within our methodology underscores our commitment to offering a comprehensive radio electronics education. It acknowledges the significance of bridging the gap between modern digital technologies, such as Arduino, and the foundational analog principles that continue to underpin the field. Our methodology not only equips students with adaptable, digital skill sets but also ensures that they possess a profound understanding of analog electronics, rendering them well-prepared for the multifaceted challenges of contemporary radio electronics engineering.

**Results:**

**Arduino-Based Multivibrator:**

1. **Versatility:** The Arduino-based multivibrator proved to be highly versatile, allowing students to experiment with various frequencies and duty cycles by simply changing the code.
2. **Ease of Understanding:** Students found it easier to grasp the concept of multivibrators through the visual aid of the Arduino platform. The real-time feedback on the computer screen made it more engaging and comprehensible.
3. **Error Analysis:** The Arduino environment provided error messages and debugging capabilities, aiding students in identifying and correcting mistakes in their circuits.

**Traditional Analog Multivibrator:**

1. **Analog Fundamentals:** The traditional analog multivibrator helped students understand the underlying principles of analog electronics, such as transistor operation and biasing.
2. **Students gained valuable hands-on experience in assembling and troubleshooting analog circuits, enhancing their practical skills.**

**Discussion:** The results of our study demonstrate the advantages of using Arduino-based laboratory experiments in teaching radio electronics. Arduino's flexibility, visual representation, and error analysis capabilities provide students with a supportive learning environment. These features empower students to experiment with different circuit parameters and gain a deeper understanding of multivibrators and their applications in radio electronics.

However, traditional analog circuits offer valuable insights into the foundational principles of electronics, ensuring students have a well-rounded knowledge base. Therefore, a blended approach, incorporating both Arduino-based and traditional analog experiments, could be beneficial in radio electronics education.

In conclusion, teaching radio electronics through Arduino-based laboratory experiments enhances students' understanding of complex concepts and facilitates their learning experience. The

combination of both Arduino and analog experiments offers a comprehensive education in this field, preparing students for the challenges of modern radio electronics engineering.

In summary, the integration of Arduino-based experiments in radio electronics education offers a practical and versatile approach that enhances student learning and understanding. It provides a solid foundation for future engineers and encourages hands-on learning in a field that is crucial to our interconnected world.

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