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Implementation of a 7-Segment LED Digital Clock with a Time-Based Alarm System

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Abstract

This study aims to implement a 7-segment LED digital clock with a time-based alarm system as a learning medium in interfacing techniques. The system is developed using a microcontroller as the main controller, a 7-segment LED display to show time information, and a buzzer as an alarm indicator. The research method consists of system design, hardware and software implementation, and functional testing. The testing process focuses on verifying alarm accuracy, buzzer activation duration, and system behavior when the alarm time has passed. The results indicate that the system is able to display time accurately, activate the alarm at the specified time, produce buzzer sound with appropriate duration, and remain inactive after the alarm time has elapsed. The alarm was activated at the set time with no deviation at 06:00, 12:00 amd 18:00. The Buzzer sounded for a consitent duration of five second in every test. Therefore, this system can be effectively utilized as a learning tool in microtronics and interfacing courses.

Keywords: *Digital Clock, 7-Segment LED, Alarm System, Interfacing, Microcontroller*

Abstrak

Penelitian ini bertujuan untuk mengimplementasikan jam digital LED 7-segment dengan sistem alarm berbasis waktu sebagai media pembelajaran teknik interfacing. Sistem dikembangkan menggunakan mikrokontroler sebagai pengendali utama, LED 7-segment sebagai penampil waktu, dan buzzer sebagai indikator alarm. Metode penelitian meliputi perancangan sistem, implementasi perangkat keras dan perangkat lunak, serta pengujian fungsional. Pengujian difokuskan pada verifikasi ketepatan waktu alarm, durasi bunyi buzzer, serta kondisi sistem ketika waktu alarm telah terlewat. Hasil pengujian menunjukkan bahwa sistem mampu menampilkan waktu secara akurat, mengaktifkan alarm pada waktu yang telah ditentukan, menghasilkan bunyi *buzzer* dengan durasi yang tepat, serta kembali tidak aktif setelah waktu alarm berlalu. Alarm aktif tepat pada waktu yang diatur—yaitu pukul 06.00, 12.00, dan 18.00—tanpa adanya penyimpangan. Buzzer berbunyi dengan durasi yang konsisten selama lima detik pada setiap pengujian. Oleh karena itu, sistem ini dapat dimanfaatkan secara efektif sebagai sarana pembelajaran dalam mata kuliah mikrokontroler dan antarmuka.

Kata kunci: Jam Digital, LED 7-Segment, Sistem Alarm, Interfacing, Mikrokontroler

Introduction

Advancements in embedded system technology have driven the use of microcontrollers in various electronic applications, one of which is a digital clock with an alarm system. A digital clock serves not only as a timekeeping device but also as an educational tool for understanding the fundamental concepts of hardware-software interfacing [1]. In this context, the implementation of a microcontroller-based digital clock with an alarm function provides students with a perceptible platform to learn real-time programming systems, peripheral interfacing (such as LCD displays, buttons, and buzzers), and interrupt-driven design [2].

In the Basic Microtronics course, interfacing techniques constitute a crucial topic covering the connections between input devices, the processing unit, and output devices [3][4]. Mastery of these competencies enables students to design and troubleshoot complete embedded applications, such as sensor-based data acquisition systems and real-time control modules [5], which are important in modern industries. A 7-segment LED digital clock with a time-based alarm system was selected for this purpose because it employs a simple operating concept while comprehensively illustrating fundamental interfacing processes. Previous studies predominantly used LCD or OLED for display clock projects, however, this research specifically leverages a 7-segment LED display to connect the pedagogical gap in teaching process.

This configuration will enable learners to observe and analyze, such as port addressing, segment encoding and time-based multiplexing through hands-on experiment [5]. Furthermore, the system involves time data processing, display control, and alarm activation based on programmed time logic. By integrating an internal time interrupt, the system could reliably manage time-critical task even during power interruptions [6]. Therefore, this research focuses on the implementation of a 7-segment LED digital clock system and the verification that the alarm feature functions at the designated time, produces a buzzer sound with the correct characteristics, and deactivates once the alarm time has passed.

Literature Review

a. Digital Clock

A digital clock is an electronic device that displays time information in numerical form. Digital clocks generally utilize digital circuits and microcontrollers to process time data in real-time [7][8]. Digital clock system frequently implement low-cost microcontroller platforms (e.g., Arduino) which combined with real-time clock modules [9].

b. LED 7-Segment

A 7-segment LED is a display device widely used to show decimal digits [10]. This component is frequently employed in digital clock systems due to its ease of control and good readability [11]. The 7-segment LED an ideal choice for microcontroller-based which display-refresh mechanisms [12]. Consequently, the use of 7-segment displays in digital clock not only improve learners about the theory of binary-to-decimal encoding and I/O interfacing, but also provides a tangible context for learning interrupt [13].

c. Mikrokontroler

A microcontroller is a miniature computer system integrated onto a single chip and widely used in embedded systems [14][15]. It acts as a central controller that manages input, data processing, and output [16]. Microcontroller such as Arduino is increasingy adopted as accessible platforms for sensor interfacing, and real-time controlling [17].

d. Time-Based System

A time-based alarm system operates by comparing the actual time with a predetermined time [18]. When the two times match, the system activates an alarm indicator, such as a buzzer [1][19]. This system is typically implemented by compare actual time with set time limits. When the using of real-time clock (RTC) module are often implement in commercial application to maintain time accuracy [20]. The using of RTC module ensures time comparison and minimizing drift a risk or false alarm activation [21].

Method

a. Research Design

This study employs an experimental method consisting of several stages: literature review, system design, implementation, and testing. The literature review involved examining references related to microcontrollers, 7-segment LEDs, and time-based alarm systems. The system design stage focused on defining hardware and software which following a structured embedded-system development [22].

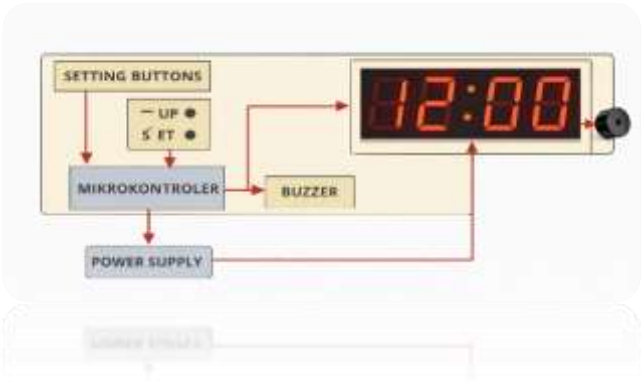


Figure 1. System Block Diagram

The system design encompasses both hardware and software components. The hardware consists of a microcontroller, 7-segment LEDs, push-buttons, and a buzzer. The software comprises a timing and alarm program uploaded to the microcontroller. Testing is conducted to ensure the system operates according to the design.

b. Data Analysis Techniques

Data analysis was conducted descriptively by analyzing the system test results, covering the accuracy of the time display, alarm activation time, buzzer sound duration, and the system's state after the alarm time had passed. This approach applies embedded syatem with fuctional performance, such as timing accuracy, alarm responsiveness and post alarm system environtment [23].

Result and Discussion

Test results indicate that the 7-segment LED digital clock system is capable of displaying the time stably and accurately. The alarm can be set to a desired time and activates precisely at that time. The alarm system test results are presented in Table 1. The buzzer sounds at a consistent duration and volume on each test. Additionally, the alarm is deactivated once the time has passed the specified time which indicates that the system is operating according to the programming logic.

Table 1. Test Results of the 7-Segment LED Digital Clock Alarm System

No	Alarm Time Set	System Actual Time	Alarm Status	Buzzer Sound Duration	Description
1	06:00	06:00	Active	5 second	Functioning normally
2	12:00	12:00	Active	5 second	Functioning normally
3	18:00	18:00	Active	5 second	Functioning normally
4	06:00	06:05	Not Active	-	Alarm time missed
5	12:00	12:10	Not Active	-	Alarm time missed

Based on the test results, the system performs its primary functions effectively. Timely alarm activation and consistent buzzer duration indicate that the programming logic operates as designed. Furthermore, the system does not re-trigger the alarm after the scheduled time has passed, demonstrating that the system's logic conditions are functioning effectively. These findings indicate that the implementation of time-comparison and alarm-control logic were reliable and good response [24]. In addition, the research was similar to other study, which claimed the implementation of time-comparison and alarm-control logic was reliable and exhibited a good students' response [25]. The study alligned the automatic bell systems using7-Segment LED was successfully implemented.

Conclussion

Based on the research results, it can be concluded that the 7-segment LED digital clock with a time-based alarm system was successfully implemented. The system is capable of displaying time accurately, activating the alarm according to the schedule, producing a buzzer sound of the appropriate duration, and ensuring the alarm does not remain active after the scheduled time has passed. This system is suitable for use as a learning tool for interfacing techniques. Particularly, the system will enable students to practice key embedded-system competencies, time multiplexing, RTC communication and interrupt alarm-controlling. Further development could involve adding more flexible alarm settings, incorporating a real-time clock (RTC) module, and implementing a more informative display, such as an LCD or OLED screen.

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