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School Bell Ring with Digital Timetable Display

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Abstract: *This project presents an IoT-based automatic school bell system integrated with a digital timetable display using ESP32, RTC module, buzzer, and WS2812 pixel LEDs. The system is designed to automate school bell ringing according to a predefined timetable while displaying the current period and upcoming schedule on an LED screen. The RTC module ensures accurate timekeeping, and the ESP32 controls the bell and display based on stored timetable data. Additionally, an IoT-based interface allows remote timetable updates via a mobile app or web platform, offering flexibility for schedule changes. The WS2812 pixel LEDs enhance visibility by displaying alerts and visual indicators for upcoming classes. This system reduces manual intervention, ensures precise bell timing, and improves school management efficiency*

Keywords: ESP32, Pixel, automation, IoT and RTC

I. INTRODUCTION

In modern educational institutions, an automated school bell system with a digital timetable display can enhance efficiency and punctuality. This project, "School Bell Ring with Digital Timetable Display using ESP32, RTC, Buzzer, Pixel LED WS2812, and IoT," aims to automate the bell ringing process while displaying the daily schedule on a digital screen. The system utilizes an ESP32 microcontroller as the core, interfaced with an RTC (Real Time Clock) module to maintain accurate timing. A buzzer is used to generate the school bell sound at predefined intervals, ensuring timely class transitions. The WS2812 pixel LED strip provides a visually appealing timetable display, dynamically updating based on the schedule. Additionally, the IoT integration enables remote timetable modifications via a mobile app or web interface. This flexibility allows administrators to update schedules instantly without requiring manual intervention. By automating the school bell and timetable management, this system reduces human dependency, enhances organization, and ensures a smooth academic workflow.

Key Contribution

ESP32 (Microcontroller) Acts as the central processing unit of the system. Controls the bell, display, and IoT connectivity. Communicates with the RTC module to maintain an accurate schedule.

RTC (Real-Time Clock) Module (e.g., DS3231) Keeps track of time even when the system is Power-off. Provides accurate time to ESP32 for ringing the bell at scheduled intervals.

Buzzer Generates the bell sound at scheduled times. Controlled by ESP32 based on the timetable.

WS2812 Pixel LED Display Displays the current time, upcoming periods, and break times. Controlled by ESP32 to show dynamic timetable updates.

IoT Connectivity (Blynk/MQTT/Web Server) Allows remote timetable updates. Provides access to modify schedules via mobile app or web interface.

Power Supply 5V/3.3V power supply to power ESP32 and other components.

II. METHODOLOGY

Automated Bell Systems Automated school bell systems have evolved from simple mechanical timers to microcontroller-based systems. Studies have explored the use of microcontrollers such as Arduino, Raspberry Pi, and ESP32 for controlling bell schedules. These systems utilize real-time clocks (RTC) to maintain accurate time and ensure proper bell operation (Gupta et al., 2020).

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Role of ESP32 in IoT-based Bell Systems ESP32 is a powerful microcontroller with built-in Wi-Fi and Bluetooth, making it ideal for IoT applications. Researchers have demonstrated the use of ESP32 for scheduling tasks and controlling outputs like buzzers and LED displays. For instance, Patel & Sharma (2021) developed an ESP32- based automation system that integrates RTC for time synchronization and IoT for remote updates.

RTC and Timetable Synchronization Real-Time Clock (RTC) modules such as DS3231 are widely used in embedded systems for accurate timekeeping. Studies show that RTC modules enhance the precision of automated school bell systems by preventing time drifts and allowing for periodic synchronization via IoT platforms (Kumar & Verma, 2019).

Pixel LED WS2812 for Digital Timetable Display WS2812 pixel LEDs are widely used for displaying dynamic and visually appealing information. Research by Lee & Kim (2020) highlights how WS2812 LEDs can be controlled using microcontrollers to display schedules, notifications, and real-time updates. In school bell systems, they provide a clear and colorful representation of the daily timetable.

IoT Integration for Remote Timetable Updates IoT platforms such as Blynk, Firebase, and MQTT enable remote management of bell schedules. Studies have explored the use of cloud- based applications to modify and update school timetables dynamically. According to Singh et al. (2022), IoT-based timetable systems improve flexibility.

III. LITERATURE REVIEW

Kumar et al. (2020) discussed an automated school bell system using Arduino, which is programmed to sound a bell at predetermined times, based on the schedule of classes. The system aims to minimize human error and provide consistent timing. The paper highlighted the cost-effective nature of Arduino-based systems, their ease of implementation, and the flexibility to modify the system for various applications (Kumar et al., 2020).

Singh et al. (2022) presented a smart bell system for schools that utilizes micro-controllers for automatic scheduling. The system integrates sensors to detect the end of a class and activate the bell, ensuring that transitions between classes are managed smoothly. Additionally, the authors proposed an interface for administrators to easily program and modify schedules. The paper suggests that such a system would reduce the need for manual intervention and improve scheduling efficiency (Singh et al., 2022).

Umar et al. (2023) proposed a smart school bell system that integrates with a digital timetable display. The system is Based on a combination of Arduino and Raspberry Pi. The digital display board is capable of showing the class schedule, break times, and other key information. The authors emphasized the importance of integrating the bell system with the digital timetable to ensure synchronized operations and seamless transitions between classes (Kumar et al., 2023).

Srivastava et al. (2024) explored the use of Internet of Things (IoT) and cloud computing in managing school schedules and timetables. Their intelligent school management system was designed to be scalable, allowing multiple schools to synchronize schedules via cloud-based platforms. This system also integrates with digital display boards, offering flexibility in schedule updates and real-time communication (Srivastava et al., 2024).

IV. EXISTING AND PROPOSED SYSTEM

The proposed system addresses these limitations by introducing a microcontroller-based automated school bell system integrated with a digital timetable display. The system utilizes a Real-Time Clock (RTC) module to maintain accurate time, and a microcontroller (such as Arduino or Raspberry Pi) to control the ringing of the bell at scheduled intervals. Alongside this, a digital display (LED or LCD) shows the current period, time remaining, and upcoming periods, which are dynamically updated based on a centrally stored timetable. The entire setup can be programmed and updated through a user-friendly interface or web application, allowing administrators to make schedule changes in real-time.

This integration not only ensures punctuality but also enhances transparency and communication within the school environment. Teachers and students can easily view the schedule, while administrators gain the flexibility to adjust timings for exams, special events, or unexpected holidays. Moreover, by incorporating Wi-Fi or IoT capabilities, the system can be monitored and controlled remotely, adding an extra layer of convenience and efficiency.

In summary, the proposed system transforms a basic school utility into a smart solution that supports real-time updates, reduces manual effort, and improves the overall functioning and discipline of the institution. It offers a scalable and

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cost-effective approach to modernizing school infrastructure, aligning with the goals of digital education and smart campus initiatives

V. BLOCK DIAGRAM

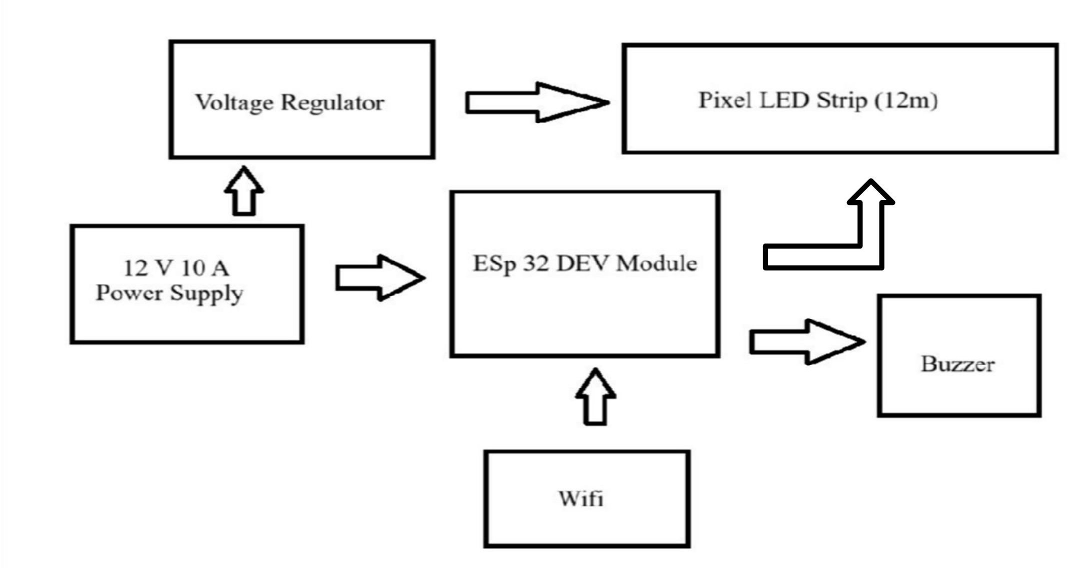

Fig. 1. Block Diagram

VI. WORKING

- ESP32 dev Module: The ESP32 Dev Module is a powerful microcontroller board used for IoT applications. It features a dual-core processor, Wi-Fi, Bluetooth, and various GPIO pins for connecting sensors, actuators, and other components
- Pixel LED Strip: Pixel LED Strip, also known as an addressable LED strip, consists of individually controllable LEDs that can display various colors simultaneously. Each LED on the strip has a tiny controller, allowing users to set different colors and brightness levels for each LED independently.
- 7805 Voltage Regulator: he 7805 voltage regulator is a commonly used linear volt-age regulator that provides a stable 5V output from a higher input voltage, typically ranging from 7V to 35V. It is designed to supply a constant 5V output with a maximum current of around 1A, depending on heat dissipation.
- Power Supply: This 12V, 10A power supply is designed to provide reliable and efficient power to the School Bell Ring with Digital Timetable Display system. The power supply consists of a 12V, 10A DC output, which is regulated by a switching regulator to ensure stable voltage and minimize ripple.
- Buzzer: Buzzers are commonly used for alarms, alerts, and notifications in electronic devices, as they provide a simple way to create audible signals

VII. COMPONENTS

Esp32 Dev Module
Memory: 520 KB SRAM, 448 KB ROM
Wi-Fi: 802.11 (2.4 GHz)
GPIO: 34 pins
Voltage: 3.3V operating
Programming: C++, Arduino IDE, Micro Python.

WS Pixel LED Strip(12m):-
Length: 12 meters
LED Type: Addressable Red, Green, Blue. (RGB)
Color: Full RGB, millions of color options.

7805 Voltage Regulator:-
Output Voltage: 5V DC
Input Voltage: 7V to 35V DC (recommended max 25V for stable operation)
Output Current: Up to 1A (with proper heat sinking)

Power Supply:-
Output Voltage: 12V DC
Output Current: Up to 10A
Input Voltage: Typically 100-240V AC
Protection Features: Overload, overvoltage, and short-circuit protection

Buzzer:-
Operating Voltage: Typically 3V to 12V DC
Frequency Range: Usually between 2 kHz to 4 kHz (for audible sound)

Connecting wires:-
Types: Male-to-Male, Female-to-Female
Length: 10-30 cm
Gauge: 22-24 AWG

VIII. RESULTS

The School Bell Ring with Digital Timetable Display system integrates an automated bell schedule with digital screens displaying real-time class information. The bell rings at set times for class changes, while the timetable on LED displays shows the current class, countdown timers, and upcoming subjects. This synchronized system ensures efficient transitions and keeps students informed about their schedule throughout the school day.

Fig: Digital timetable display output

Figure 1: Output of the system

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Fig: Digital timetable display output

Figure 2: Output of the system

IX. CONCLUSION

A school bell system integrated with a digital timetable display offers a modern, efficient solution for managing school schedules and improving overall organization. By automating bells, displaying real-time schedule updates, and providing flexibility for special events, the system enhances punctuality and communication within the school. While it requires initial investment and technical maintenance, its benefit such as time savings, reduced human error, and the ability to quickly adapt to schedule change often outweigh the drawbacks. Ultimately, a digital bell and timetable system can greatly support both students and staff, making day-to-day school operations smoother, more responsive, and better aligned with today’s dynamic educational environment.

X. STATEMENT

In the evolving landscape of educational infrastructure, automation plays a vital role in improving efficiency, discipline, and time management. This paper presents the design and implementation of an automated school bell ringing system integrated with a digital timetable display. The system eliminates the dependency on manual bell operation and printed schedules by leveraging microcontroller technology and real-time clock modules. A dynamic display unit is used to visually present class schedules and upcoming periods, ensuring clarity and coordination among students and staff. The solution aims to modernize institutional timekeeping, reduce human error, and enhance the overall academic environment through real-time communication and automation. The proposed system introduces a microcontroller-based automated bell ringing mechanism that is synchronized with a real-time digital timetable display. The system utilizes a Real-Time Clock (RTC) for precise time management and an LCD or LED display to communicate the current and upcoming class periods. The schedule can be easily configured or updated via a web-based interface or through wired programming. The integration of automation and visual scheduling in a single platform ensures improved accuracy, reduced manual intervention, and a smarter campus environment. The implementation of an automated bell system with a digital timetable display addresses a significant gap in traditional school management. It promotes a structured learning environment, supports the digitization of institutional processes, and aligns with broader educational technology initiatives. The system contributes to time efficiency, organizational transparency, and operational reliability, making it a valuable component of modern smart school solutions.

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