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Design of an Arduino-based automatic sound timer system for mosques and prayer rooms

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ABSTRACT
The uncontrolled use of sound systems in mosques, especially after the call to prayer and iqomah, often leads to waste of energy and disturbances to the surrounding environment. This research aims to develop an Arduino-based automation system that can set the time of turning on and off the sound system in the mosque according to the adhan schedule, in order to improve operational efficiency and reduce electricity consumption. The system is designed using an Arduino UNO microcontroller, which regulates the sound device via a relay based on manually entered timing. Testing was carried out using Wokwi software simulations, and the results were then applied to a physical prototype. Testing is carried out with various time settings (5, 10, 15, and 20 minutes) to assess the accuracy and reliability of the system. The test results showed that the system was able to control the sound device with a 100% success rate in all the times tested. This system has proven to be effective in reducing the duration of unnecessary use of sound devices, potentially saving energy. The developed system provides a practical solution to reduce energy waste in mosques and improve the operational management of sound devices. Further implementation of this system in mosques can provide significant social and environmental benefits, especially in terms of congregational comfort and energy savings. Field testing as well as the development of IoT-based technologies in the future can expand the functionality of these systems.

Keywords:
Sound System Automation; Energy Management; Prayer Schedule; Operational Efficiency.

Introduction

Adzan is an extraordinary medium to pronounce monotheism against the omnipotence and the (prophetic) treatise of the Prophet Muhammad PBUH. Adhan is also a call to prayer to Muslims, which continues to resonate throughout the world five times every day. In Indonesia itself, the call to prayer almost always echoes in mosques and muhsolas in all corners of the country from both villages and cities whenever it is time to pray (Maksum, 2010). In Islamic Law, the entry of prayer time is marked by the following things, the Zuhr prayer begins when the sun slips until the shadow of an object is the same length as the object. The time of the Asr prayer begins at the end of the Zuhur time, namely, the shadow of an object slightly exceeds the object until the perfect sunset of the Sun's disk. The Maghrib prayer time begins at sunset until the red mega disappears. The time of the Isha prayer begins when the red mega has disappeared until the second dawn, namely the dawn of shadiq. The Fajr prayer time begins when the second dawn appears, until the top of the Sun's disk rises (Zainuddin, 2020). From dawn to isha, the number of adhans sounded by mosques and prayer rooms is five times a day.

There is an almost even phenomenon that most muadzin or marbot in prayer rooms or mosques in villages are on average an elderly (Abidin et al., 2021; Barbade et al., 2021) This happens because most young people are busy with work and teenagers are busy with school activities. So what happens is that most of the Marbot or muadzin officers are old people and are

no longer busy with worldly affairs. This phenomenon also occurs in the author's environment where most of the adhan officers are parents, although some are young but not as diligent as the old. The consequence or consequence of this phenomenon is the forgetfulness factor, where after the call to prayer and iqomah are sounded, it often happens that the system sound switch is forgotten to be turned off (Et. al., Ajeng Mayang, 2021; Hakim, 2023). Actually, this is not only the responsibility or mistake of muadzin or marbot but also the responsibility of the imam or jamaa'h of the mosque to always actively supervise and assist in the operation of jammah prayers in the mushala or mosque (Riyanto, 2024; Setiawan & Dahliana, 2022).

In various previous studies, it has been found that the use of electronic devices in places of worship, such as sound systems in mosques, is often not well controlled, resulting in wasted energy and disruption to the surrounding environment. Previous studies have highlighted the importance of automation in energy management, especially in mosque lighting, as discussed by Ahmad et al. (2018) and Nur et al. (2020). However, there has been no research that specifically addresses the problem of sustainable use of sound systems in mosques. The use of uncontrolled sound systems not only increases operational costs but also disrupts the tranquility of the mosque environment. Therefore, this research is important to fill the gap in literature by developing an automation system that can adjust the time of the sound system on and off according to the prayer time, so that it can improve operational efficiency, reduce electricity consumption, and ensure comfort for worshippers and the environment around the mosque (Azmi et al., 2021; Harsritanto et al., 2021).

With the rapid development of control and automation technology, of course, this problem should be avoided by implementing an automation system (Agriawan et al., 2021; Annas et al., 2019; Prayoga et al., 2023; Putra et al., 2020). A lot of research and development has been carried out in previous research on the adhan automation system such as Muhammad Iqbal designing a tool that informs prayer times digitally based on the Arduino Uno which is able to display the time and alarm of the adhan automatically (IQBAL, 2020) In addition, there is Topan et al., which developed an automated system for audio sound players to be applied in mosques in the West Nusa Tenggara area (Topan et al., 2022) A digital clock system with a reminder feature for mosque activities automatically based on Wifi. However, from many previous studies, no one has made an automation system for the sound of the adhan system where it will automatically turn off after a certain time limit when it is forgotten to turn it off. So the purpose of this research is to design and make an automation system with a digital timer for the sound of the adhan system so that it can turn off/off by itself when it forgets to turn off manually.

Methods

The purpose of this project is to create and implement an automatic timer system using an Arduino microcontroller to efficiently control the use of the mosque's sound system by setting a time limit for its function, thereby reducing energy and other waste of resources (Elias et al., 2022; Kaur et al., 2016; KUMAR, n.d.; Satapathy et al., 2018). To achieve this, a timer system is installed into the control box to function as a power switch and safety safe, to turn on the mosque's soud system depending on the predetermined prayer time. o automatically set the time, programming must be embedded into the Arduino before it is used (Adelakun & Omolola, 2023; B. R. Babu et al., 2019; G. C. M. Babu et al., 2019; Daru & Darmawan, 2019; Palanisamy, 2020). Figure 1 illustrates the overall system block diagram. We divide this block diagram into two parts: the designed control part and the sound system part. There are several components in the control part consisting of AC cord power cable, 5 Volt DC power supply, up and down switch, push button switch, ESP8266 microcontroller, 2 x 16 LCD to display information, solid state relay to connect and disconnect the electric current, and AC output connector (Figure 1). In the sound system section, there are amplifiers and loudspeakers.

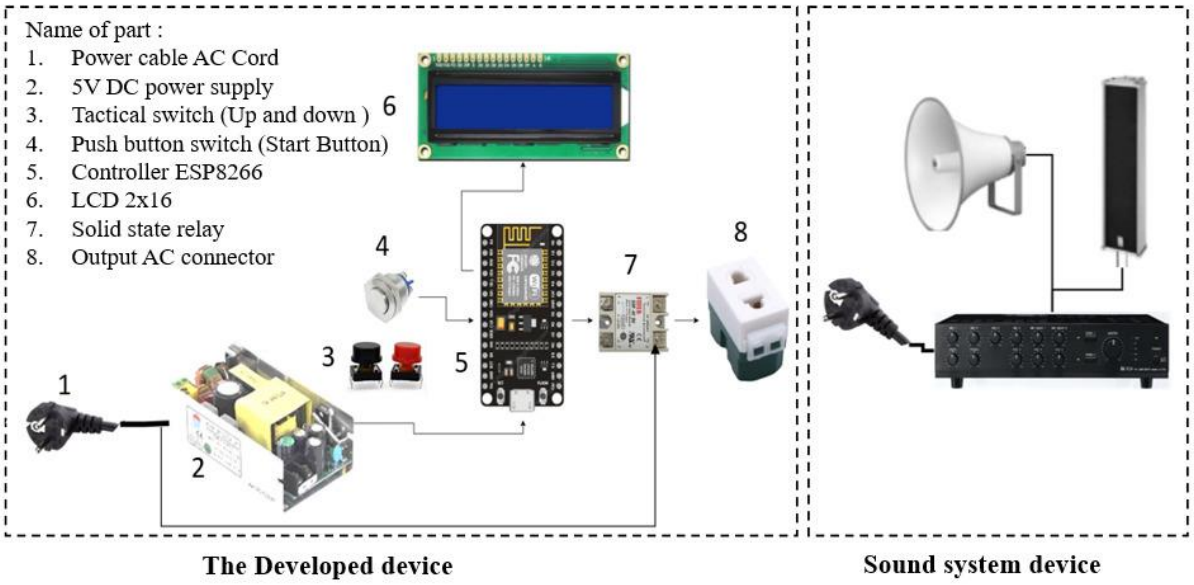

Figure 1. Automatic timer system diagram for mosque sound system

The timer system consists of a push button that allows the user to enter the desired time, and the necessary automation processing is carried out by a microcontroller (Arduino UNO) attached to all other actuators. The microcontroller serves as the brain of the system, directing when and how other connected components should work. The relay module turns the power tool on and off based on the signal received from the controller. The power supply unit powers the entire system, while the LCD screen generates the system status.

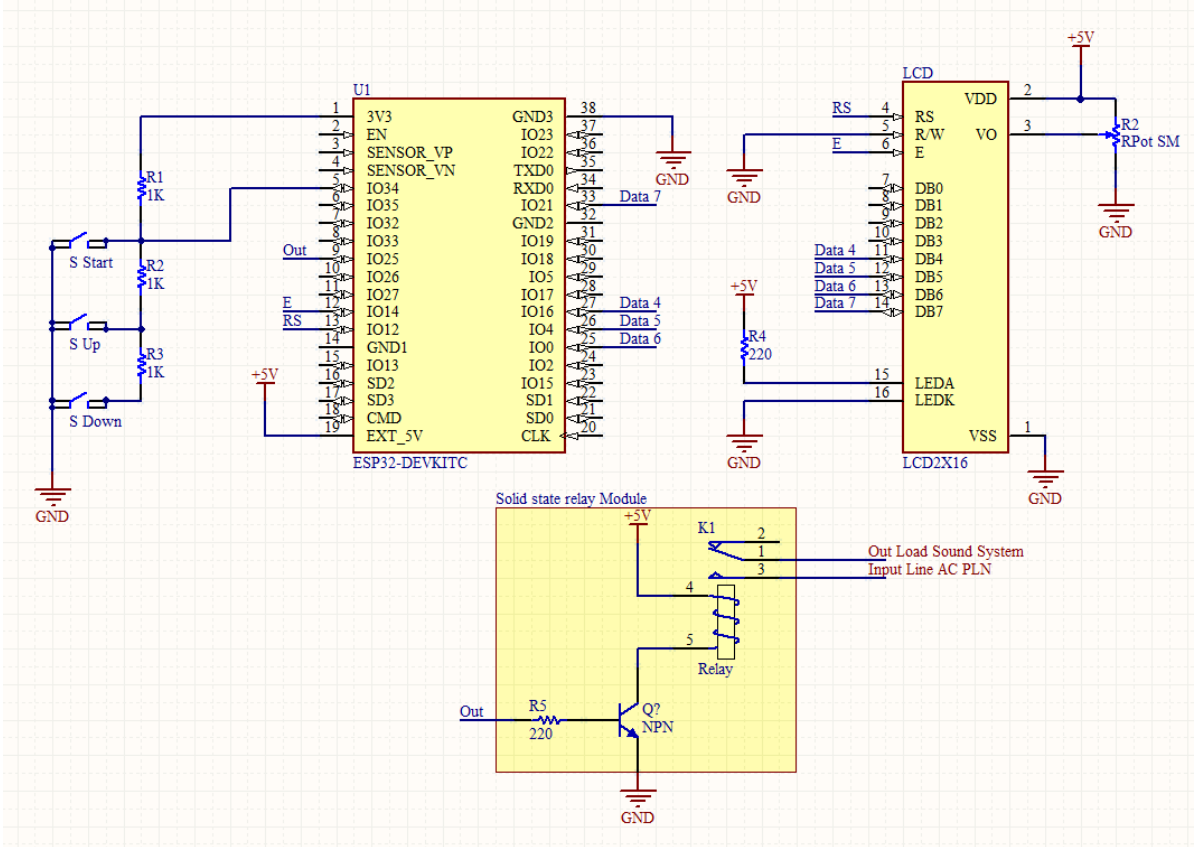

Figure 2. Schematic of device

Hardware Design

To complete the desired project, proper circuit design and simulation are required. Figure 2 depicts a circuit schematic that serves as a guide for designing the right circuit for the timer switch, where the ESP32 controls other components to perform the desired operation based on user preference. Wokwi simulation software is used to connect the necessary components virtually to identify how the circuit will connect to the pcb board, the simulation results can be seen in Figure 3 . The specifications of the ESP32 are listed in Table 1.

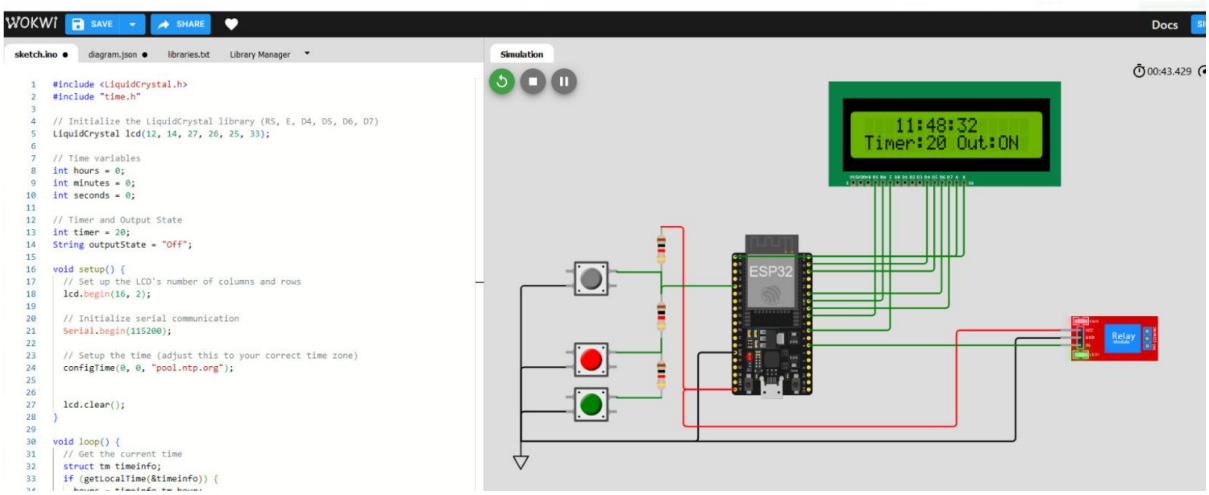

Figure 3. Simulation with Wokwi

Table 1. ESP32 specification

Parameter	Value
Prosesor	Xtensa dual-core (or single-core) 32-bit LX6 microprocessor, operating at 160 or 240 MHz
Operating voltage	2.2-3.6V
Pin GPIO	32
Pin ADC	18 (12 Bit)
Current consumption	80 mA
Flash memory	2MB
SRAM	520KB
EEPROM	1 KB
Clock Speed	16 MHZ

The system consists of an ESP32 microcontroller, which can collect the necessary information, process it, and in real-time give commands to other functional components. The push button is used to set the time displayed on the 16 x 2 LCD module in a countdown format. This allows users to see the remaining time. The single-channel relay module connects the sound system to the system and uses the microcontroller data to turn the power on or off. Figure 2 shows a circuit diagram of the ESP32 microcontroller timing system. To turn on, the circuit must be given 5V volts. This system uses only one power source to power the components and sound system; The voltage required by the device is about 220V-240V. A step down transformer is used to lower the voltage to the voltage required by the microcontroller, which will power the attached components to prevent damage. For example, each component has a specification datasheet; Microcontrollers have many brands and manufacturer specifications. The hardware consists of an LCD module, buttons, relay, microcontroller, and corresponding power supply. Each component is connected to a microcontroller with a voltage of 5V. Therefore, all installed components must run at a voltage lower or equal to 5V otherwise an external power source will be required.

Software design

The microcontroller on the board is programmed using the Arduino C programming language and the platform uses software called Arduino Integrated Development Environment (IDE) which is a programming environment with debugging capabilities to debug programming errors. The process flow diagram is as seen in Figure 4. Once the time is set, the relay will turn on and the sound system will start working until a countdown runs when the sound system is turned off. Figure 5 show the 3D Design of the prototype.

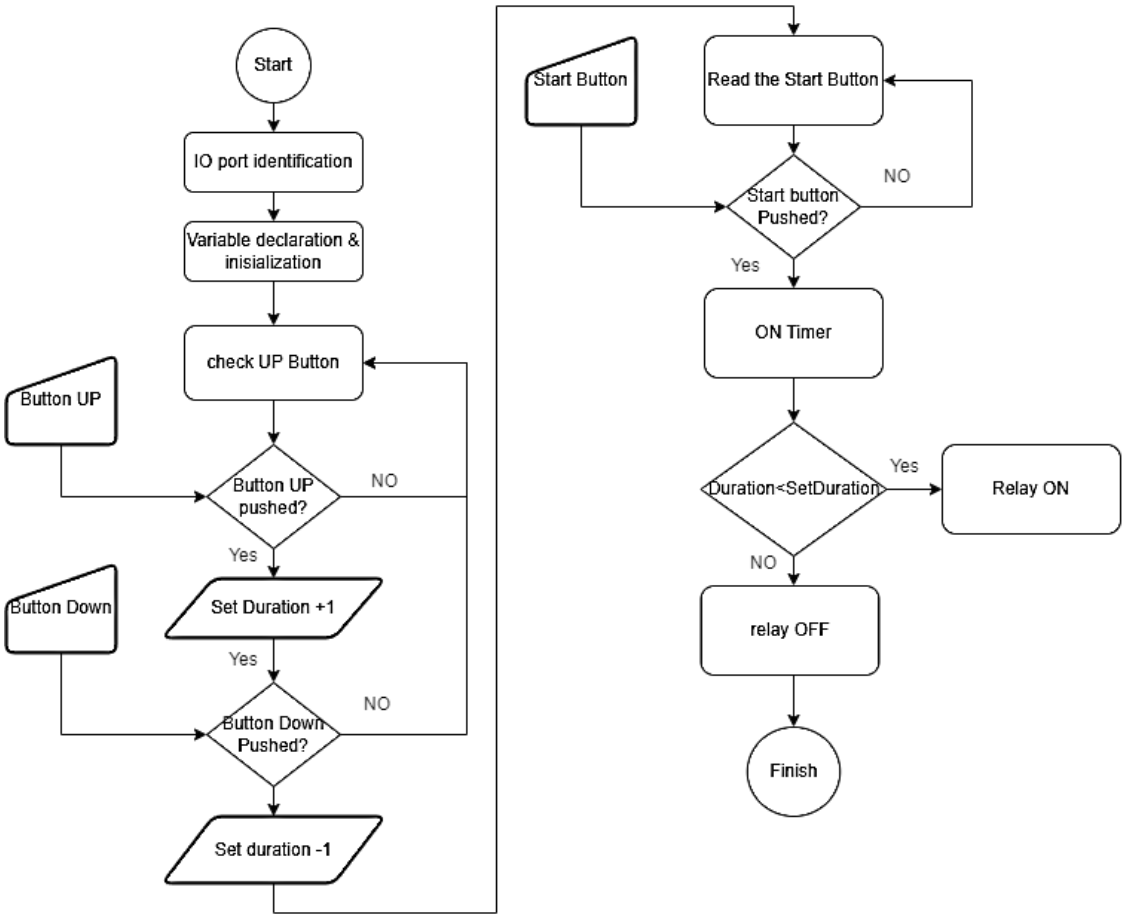

Figure 4. System flowchart

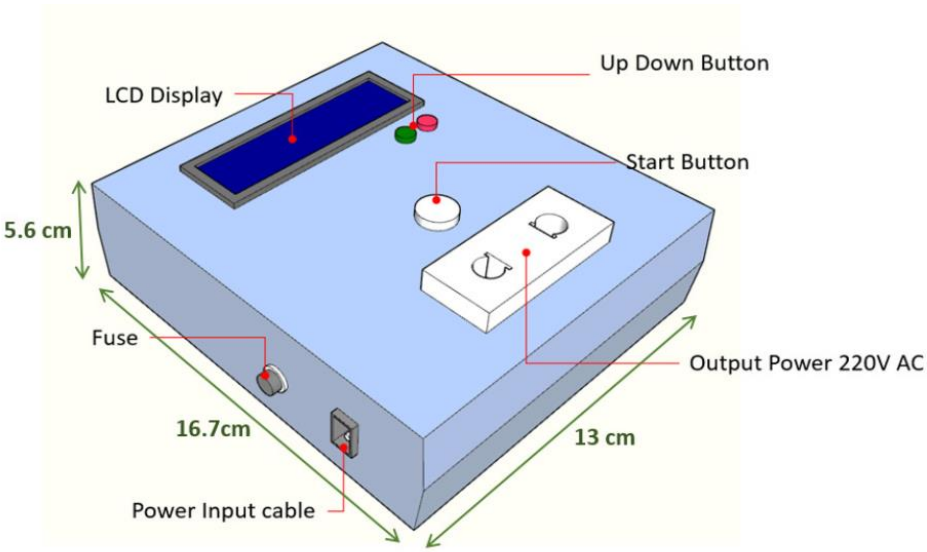

Figure 5. 3D Design

Results and Discussions

Before the system is run directly, this study uses simulations to test the success of the system. The simulation was carried out using wokwi, wok provides a practical and efficient solution for learning, teaching and designing electronics. In this simulation, it is possible to program and test electronic circuits virtually. When all programs and systems are ready, they are applied to the hardware directly. The timing system is designed and implemented in the sound system of the mosque or prayer room with the aim of controlling the time of ON and OFF according to the adzan hour for prayer. Figure 6 and Figure 7 is the device applied to the sound system.

Figure 6. Display the device, (a) name of each part of the device, (b) Display of LCD, hour timer and status of output

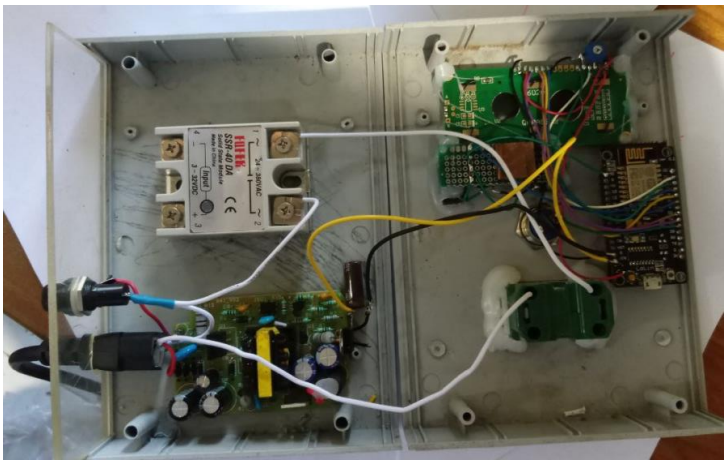

Figure 7. Display inner part of device

All modules are integrated into a single timing system to control and operate the mosque's sound system. The working system, lcd displays the realtime clock connected to the NTP server, the lcd also displays the current clock, the outlet will turn on when the adhan time is entered until the iqomat is for 15 minutes, this module is equipped with a manual setting where the setting button is pressed once to turn on for 10 minutes, the setting button is pressed twice will turn on for 20 minutes and the setting button pressed three times will turn on for 30 minutes. The test results are presented in Table 2-4.

Table 2. Electrical parameter value testing

No.	Parameter	Value
1	Operating Voltage	220V AC 50Hz
2	Power Consumption	15 Watt
3	Output adaptor 5V	4.95V
4	Voltage Output Solid state Relay ON condition	219 V AC
5	Voltage Output Solid state Relay OFF Condition	0 V AC

Table 3. Prototype, Dimensions and Weight

No	Parameter	Value
1	Dimensions LxWxH	16.7x13x5.6cm
2	Weight	200g

Table 4. Function Testing

No.	Timer Setting Values	Measurement results
1	5 minutes	Valid
2	10 minutes	Valid
3	15 minutes	Valid
4	20 minutes	Valid

The test results on the prototype of the Arduino-based automatic timer system show excellent performance with a 100% success rate in each of the tested timings, i.e. 5, 10, 15, and 20 minutes (Table 4). This success reflects that the system is able to control the mosque's sound devices precisely according to the time that has been set. This achievement indicates that the prototype has high stability and accuracy in managing system on and off times, which is the main goal of this research.

Several previous studies have examined the use of automation to improve energy efficiency in mosques, but have focused more on lighting systems (Ahmad et al., 2018; Nur et al., 2020). The studies highlight the importance of automation to reduce excessive electricity consumption through automatic control of devices such as lights. Nonetheless, this research brings a new contribution in the realm of sound system automation in mosques, where irregular management often leads to energy waste and environmental disturbances.

Previous research by Iqbal (2020) and Typhoon et al. (2022) also examined the automatic setting of the adhan through an Arduino-based digital clock, but did not specifically address the problem of controlling the sound system's shutdown time after the adhan was completed. This research closes the gap by designing a system that automatically mutes the sound based on a predetermined time, thus eliminating the potential for human error such as forgetting to turn off the device after the call to prayer. The use of automation systems that have been tested in this study can significantly reduce electricity consumption in mosques. For example, sound devices are often left on after the call to prayer and iqomah due to human error or negligence, which leads to wasted energy. With the implementation of this system, the sound device will automatically turn off within a predetermined period of time, thus preventing the device from remaining on for an unnecessary time. Based on electrical parameter testing (Table 2), the system consumes only 15 watts of power when it is on,

and there is no power consumption after the system automatically shuts down. This can significantly improve energy efficiency, especially in large and frequently used mosques. From an operational perspective, this system also reduces the burden for mosque administrators, especially marbots and muadzin, who are often elderly people and may forget to turn off the sound device after use (Abidin et al., 2021). With this automation system, these errors can be minimized, which ultimately increases comfort for worshippers and the environment around the mosque.

Conclusion

This research successfully developed and implemented an Arduino-based automation system to control the turn on and off time of sound devices in mosques automatically based on the adhan time. The test results show that this system has a 100% success rate with validity on 5, 10, 15, and 20 minute time settings, which shows that this system can function accurately and reliably. The implementation of this system in mosques in Indonesia is expected to improve operational efficiency and energy management, as well as significantly reduce electricity consumption. In addition, this system also helps reduce the workload of mosque administrators, especially marbots and muadzin, by minimizing the risk of sound devices that are forgotten to be turned off after the adhan. This system complements previous research that focuses more on lighting automation by introducing a specific solution for the management of sound devices, thereby expanding the application of automation technology in places of worship. For further development, field trials with more varied conditions are needed, as well as the integration of IoT technology to enable more flexible and efficient management.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

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