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# Design and Implementation of a Touch-Free Door Lock System Based on Arduino

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**Abstract**

This study details the design of an Arduino-based touch-free door lock system utilizing ultrasonic and sound sensors, and a magnetic switch, following the Pahl and Beitz methodology. The goal was to develop a reliable system that enhances convenience and reduces physical contact, particularly relevant during the COVID-19 pandemic for providing an affordable and widely applicable automatic door opening module. Results indicate the ultrasonic sensor functions effectively and the magnetic switch operates within a 10 mm range, though the sound sensor requires accuracy improvements. Nevertheless, this study holds significant implications for promoting hygienic and accessible household technology, opening substantial opportunities to enhance health standards and convenience in various environments, and laying the groundwork for future touch-free technological innovations.

**Keywords**: *Touch-free; door lock; arduino; hygienic*

***Abstrak***

*Penelitian ini berfokus pada perancangan alat pengunci pintu tanpa sentuh berbasis Arduino dengan memanfaatkan sensor ultrasonik, sensor suara, magnetic switch, dan kunci slot, menggunakan metode perancangan Pahl dan Beitz. Tujuan dari penelitian ini adalah mengembangkan sistem yang andal untuk meningkatkan kenyamanan dan mengurangi kebutuhan kontak fisik dengan pengunci pintu. Hasil penelitian menunjukkan bahwa sensor ultrasonik bekerja dengan baik dalam mendeteksi jarak, magnetic switch memiliki batas pembacaan maksimum sejauh 10 mm, namun sensor suara menunjukkan tingkat presisi yang rendah sehingga membutuhkan lebih dari satu tepukan untuk terdeteksi. Produk yang dikembangkan dinyatakan berfungsi sesuai tujuan, meskipun keterbatasan pada sensor suara menunjukkan perlunya perbaikan lebih lanjut untuk mengoptimalkan presisi dan responsivitas.*

***Kata-kata kunci***: *Pengunci Pintu; tanpa sentuh; arduino*

## 1. Introduction

The advancement of technology has significantly contributed to the development of smart home systems, particularly in enhancing security through automated door locking mechanisms [1]. Contactless door lock systems are becoming increasingly relevant as they minimize the need for physical interaction with locks, offering both convenience and improved hygiene [2], [3]. The design and implementation of such systems typically involve the integration of microcontrollers, sensors, and actuators to create functional, efficient, and user-friendly solutions.

Previous studies have explored various approaches to automated door locking [4]. For instance, the system consists of hardware and software. Hardware consist of sensor which are buzzer, ATTiny85as microcontroller and solenoid lock as actuator has been utilized in combination with buzzers and hand-clap detection patterns to enable contactless operation [5]. Similarly, Radio Frequency Identification (RFID) modules and password keypads integrated with Arduino microcontrollers have gained popularity for their reliability and ease of use [6]. Other applications include systems employing sound sensors, temperature sensors, and motion detectors for light automation, showcasing the versatility of these components.

In recent years, smaller Arduino variants like the Nano and advanced modules such as NodeMCU have enabled compact and lightweight door lock systems with Wi-Fi connectivity. Smartphone applications have also been integrated into smart lock systems, allowing users to control locks via password inputs or programming algorithms like Jaro-Winkler for enhanced efficiency [7]. The Internet of Things (IoT) has further expanded the functionality of these systems, enabling user data logging and remote control features through platforms like BLYNK [8].

Sound-based locking mechanisms using the KY-037 sound sensor have been investigated to measure sound intensity for triggering operations in specific environments [9]. Additionally, solenoid door locks controlled by Arduino Mega2560 and Bluetooth HC-05 modules have been developed for secure room access [10]. Advanced mechanical systems such as 2-DOF (Degree of Freedom) mechanisms, Sarrus linkages, and crank-slider simulations have also been applied to understand the kinematics and improve locking efficiency [11].

While various lock types—manual padlocks, handle locks, and slot locks—remain effective for conventional applications, integrating these with modern automation systems can significantly enhance security and functionality. Despite the sophistication of smartphone-based [7] or RFID-based IoT systems [6], their reliance on specific devices or complex infrastructure can present barriers to widespread, low-cost adoption in existing conventional door setups. Our proposed design, by contrast, leverages the combination of ultrasonic sensors for touch-free presence detection and magnetic switches for precise lock status feedback. This approach offers a compelling advantage by providing a robust, highly cost-effective, and easy-to-integrate solution that does not require additional user specific devices (like smartphones or RFID tags). This makes it particularly suitable for rapid, widespread deployment in diverse communal and residential settings, enhancing hygiene and accessibility, especially relevant during public health concerns like the recent pandemic.

This study focuses on designing a contactless door lock system using ultrasonic sensors, sound sensors, magnetic switches, and slot locks based on Arduino microcontrollers, aiming to offer a practical and efficient solution for modern security challenges.

## 2. Method

The methodology applied in this study follows the systematic design approach proposed by Pahl and Beitz, complemented by the House of Quality (HoQ) framework to evaluate the design's quality. Data processing from the experimental results employs quantitative methods to ensure objective analysis. The tools and materials utilized in this research include screwdrivers, nuts, bolts, screws, and electrical cables. The manufacturing process was conducted at the Manufacturing Laboratory of the Mechanical Engineering Department, while the installation and implementation of the contactless door lock system were carried out in the Grand Cilegon Residence.

The mechanical scheme of the contactless door lock system was developed based on a detailed product design, encompassing motion mechanisms and structural components. The schematic representation of the product design, including motion mechanisms and detailed components, is presented in **Figure 1.**

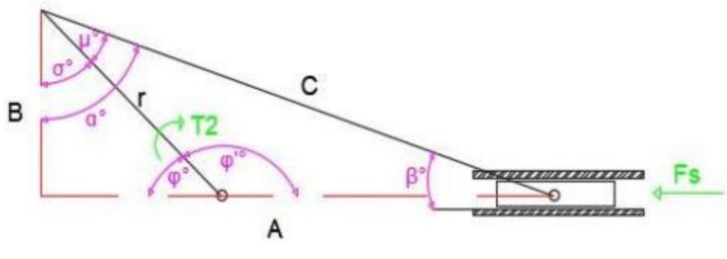


**Figure 1.** Schematic Representation of the Product Design

The systematic design process aligns with Pahl and Beitz's methodology, which emphasizes problem clarification, concept development, embodiment design, and detailed design stages **[12]**. The HoQ framework was incorporated to translate customer requirements into technical specifications, ensuring the product meets user expectations effectively. Following the design phase, the implementation of the automatic contactless door lock system was carried out on a door panel, as illustrated in **Figure 2**.

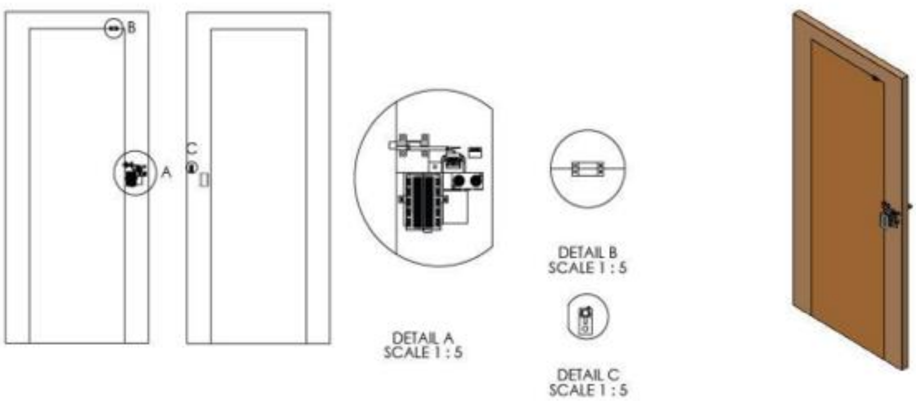


**Figure 2.** The Implementation of the Automatic Contactless Door Lock System

Detail A: This includes the Arduino microcontroller, ultrasonic sensor, DC servo motor, slot lock mechanism, and an electronic circuit board. These components are installed to form the core functionality of the system. Detail B: This detail comprises a pair of magnetic switches positioned at the top of the door, ensuring the system can detect door closure status. Detail C: This consists of the sound sensor placed outside the room, enabling the system to detect audio signals for operation.

The research employed experimental methods, involving trials to determine the system's response to various inputs and to evaluate the effects of the designed mechanisms. Data collection was documented in the form of photographs and videos to ensure thorough analysis and reproducibility of results.

## 3. Results and Discussion

The results of testing the distance detected by the ultrasonic sensor compared to the actual distance are presented in **Table 1**. The performance of the system's individual components was thoroughly evaluated. The ultrasonic sensor demonstrated reliable performance when combined with a gesture recognition system that requires two consecutive hand waves. However, the sensor's effectiveness is influenced by the minimum surface area or dimensions of the object (e.g., a user's hand) required to reflect the ultrasonic waves transmitted by the sensor. This factor is crucial for determining optimal sensor installation (vertical or horizontal) to ensure consistent detection. Additionally, variations in user hand size and shape affected the sensor’s accuracy and reliability.

**Table 1.** Ultrasonic Sensor Test Results

| Devices | Distances (cm) | Range (cm) |
|---|---|---|
| Ultrasonic Sensor | 5 | 5 |
| | 10 | 10 |
| | 15 | 15 |
| | 20 | 20 |
| | 25 | 25 |

The results of sound sensor testing with respect to distance and the number of claps over ten trials are presented in **Table 2**. The sound sensor demonstrated reliable functionality under controlled laboratory conditions. Nevertheless, its sensitivity required manual tuning via a resistor knob. The sensor proved highly susceptible to environmental noise and airflow, which significantly impacted the consistency of clap detection data. These environmental variations led to inconsistent input readings, consequently increasing the response time required for sensor activation.

**Table 2.** Sensor Test Results Sound sensor

| Distances (cm) | Hand Claps |
|---|---|
| 5 | 1 |
| | 3 |
| | 4 |
| | 2 |
| | 1 |
| | 2 |
| | 4 |
| | 2 |
| | 3 |
| | 2 |
| 20 | 8 |
| | 8 |
| | 8 |
| | 7 |
| | 8 |
| | 9 |
| | 8 |
| | 9 |
| | 7 |
| | 8 |

**Table 3.** Magnetic Switch Test Results

| Distances (mm) | Functions |
|---|---|
| 1 | Yes |
| 5 | Yes |
| 10 | Yes |
| 12 | No |
| 15 | No |

Table 3 illustrates the effective distance testing for the magnetic switch. In this design, the magnetic switch functions as an input device to detect whether the door is open or closed. It is directly connected to and controlled by a microcontroller with an integrated program. Unlike its typical use as a standalone switch without programming or microcontroller integration, the implementation in this study leverages the switch's functionality within a more complex system. The microcontroller interprets the input from the magnetic switch, enabling automated responses based on the door's state. This integration enhances the versatility of the switch in daily use scenarios while maintaining its simplicity and reliability for fundamental operations.

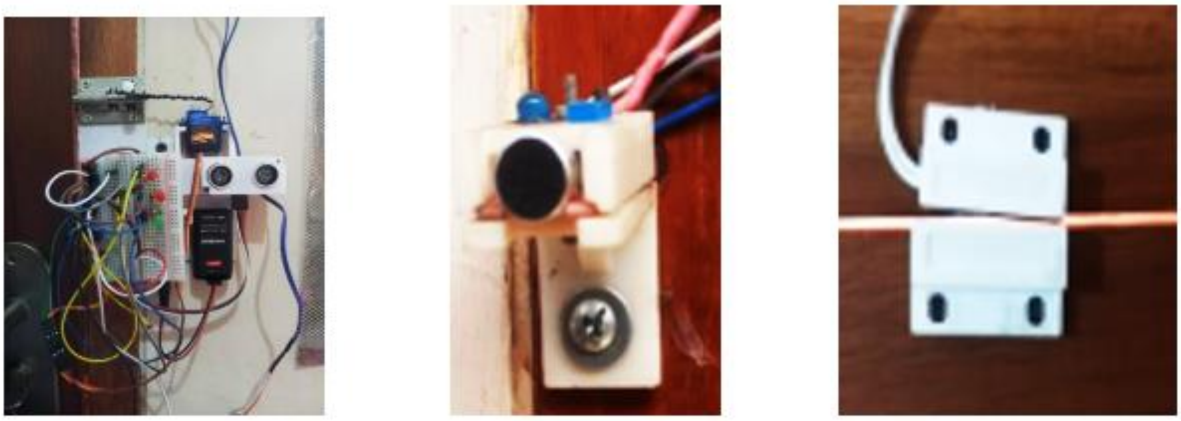

**Figure 3.** Product

The DC servo motor was directly connected to the slot lock using a wire linkage. The servo motor operated effectively, performing rotational movements at a 90° angle to push and pull the slot lock. This was possible because the load of the slot lock did not exceed the maximum torque capacity of the DC servo motor. The movement mechanism between the servo motor and the slot lock employed a crank slider system.

The findings from this study confirm the viability of developing an affordable, Arduino-based touch-free door lock system, particularly relevant for promoting hygiene in public and private spaces, as highlighted during the recent COVID-19 pandemic. The ultrasonic sensor's robust performance in distance detection, as evidenced in Table 1, establishes its core role in the contactless interface. While challenges related to the object's surface area and hand variations were noted, these are common for reflective sensing technologies and can be mitigated through careful calibration and strategic sensor placement, indicating its strong potential for practical implementation.

## 4. Conclusion

This Arduino-based touch-free door lock system successfully demonstrated the functionality of its core components: the ultrasonic sensor reliably detected hand gestures, the magnetic switch effectively identified door status, and the DC servo motor successfully actuated the slot lock. While the sound sensor proved highly sensitive to environmental disturbances and requires accuracy improvements, this research significantly validates the feasibility of developing a cost-effective and easily applicable touch-free access control system. This holds major implications for enhancing hygiene and convenience standards, particularly relevant during pandemics, by providing a practical solution readily integrable into existing door infrastructure, thereby paving the way for further innovations in universally applicable touch-free technologies.

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