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Smart Locking System for Ron95 (R95-Atech) By Implementing Motor and Claw Application

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Abstract

The implementation of Radio Frequency Identification, RFID locking mechanism on nozzle pump represents an innovative approach to improve access control measures over subsidized fuel, RON95. The following report details the development, execution and assessment of sophisticated locking system that incorporates RFID technology through the utilization of motor and mechanical components. RON95 is a cost-effective means for Malaysian consumers to fuel their vehicles. Although Malaysians have benefited financially from the system, it has been taken advantage of by citizens from other countries, particularly Singaporeans. In order to resolve this problem, the study suggests implementing a locking mechanism that utilizes recognition technologies. The access is only available to Malaysian nationals and may only be obtained by registering their personal information for the access where in this case, the Unique Identification UID of their identification card, IC. The goal is to mitigate the unauthorized utilization of subsidized RON95 petrol, guaranteeing that only intended beneficiaries reap the advantages of this governmental endeavor. The system also integrates with alarm system which triggered for specific reason which could prevent from unwelcomed action from be taken that could damage the unit. The prototype appeared to give a quite successful result. The prototype manages to carry out the stated program which follow certain instructions and rules. To conclude, despite having an impactful result, the prototype still open for upgrades. For instance, the microprocessor. A Wi-Fi type microprocessor could be used to extend its functionality.

1. Introduction

The implementation of a locking mechanism is a crucial element in upholding security measures and regulating entry to tangible areas, items, or data. The lock system comprises several essential constituents, such as the lock proper, keys, lock cylinders, locking mechanisms, strike plates, and access control systems. Locking mechanisms can be classified into two main categories: mechanical and electronic. The means of access can vary from conventional metallic keys to sophisticated electronic gadgets such as key cards or key fobs.

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The classification of locking mechanisms encompasses various types, including mechanical locks, electronic locks, smart locks, high-security locks, and padlocks, each presenting distinct attributes and degrees of protection. Contemporary locking mechanisms have integrated sophisticated technologies including biometrics, wireless communication, cryptographic security, mobile applications, and cloud integration to augment convenience, regulation, and safeguarding against unauthorized entry. The progressions made in locking systems have substantially enhanced their functionality and flexibility, resulting in increased efficiency and adaptability to diverse security needs.

This project applies the concept of the locking system onto the petrol station pumps by embedding the system with a recognition equipment. Smart Locking System for RON95 (R95-ATech) is a tool that implements the function of Radio Frequency Identification (RFID) for the locking system benefits. With the presence of this particular recognition equipment, only a certain or targeted consumer could benefit from it. This project will focus on blocking uninvited consumers from getting the benefits they should not have by the first place.

Furthermore, the established locking system is enhanced with a state-of-the-art alarm system that relies on a highly intricate coding program. If there are any unauthorized attempts to access the system or if any anomalies are detected, the system will activate a strong alarm mechanism. This supplementary security measure guarantees prompt reaction to suspected breaches, offering an additional disincentive against unauthorized usage. By integrating this alarm system, the Smart Locking System for RON95 is fortified, resulting in a comprehensive solution that effectively protects fuel dispensing facilities.

2. Literature Review

This chapter attempts to give an overview of the process for developing smart locking system for RON95 which implement the mechanism of motor and claw.

2.1 Review on Related Smart Locking Systems

Prior research on smart locking systems has consistently emphasized the incorporation of both hardware and software elements, with the goal of improving home automation and security.

The initial study focuses on the increasing incidence of criminal activities, specifically theft-related crimes, and emphasizes the insufficiency of conventional security methods. The system implements a Smart RFID System for locker cabinets, employing an Android application for the purpose of monitoring and control. The essential components of the system include the WeMos D1 R2 microprocessor, RFID reader, and servo motor. The paper presents an innovative approach that enables an administrator to determine the unique identifier of an RFID card and make a decision on whether to authorize or refuse entry to the locker [4].

The second study examines the weaknesses of traditional door locks and suggests a strong smart door lock system. The system utilizes three-input sensors, namely fingerprint, RFID, and keypad, to establish a triple-level security system, which is a distinctive method. The prototype incorporates supplementary components such as a relay and buzzer, offering a versatile and durable security system. The system's adaptability is highlighted by its ability to provide multilayer protection, effectively addressing possible threats [5].

The third study investigates the integration of a comprehensive home automation system, which includes a mobile application and diverse technological components. It highlights the importance of simplifying human life through automation and introduces a centralized server for remote control. The use of the ESP8266 NodeMCU microcontroller, in conjunction with various sensors and displays, enhances the system's adaptability and enables wireless communication [6].

These studies demonstrate the development of intelligent locking systems, highlighting the importance of wireless connectivity, multifunctionality, and superior security characteristics. The incorporation of diverse sensors, microcontrollers, and user interfaces exemplifies a comprehensive strategy for tackling the complexities of home automation and security. Citing these relevant findings, the RON95-ATech locking system implements measures to control the flow of the system.

3. Methodology

The methodology of this project offers a comprehensive account of the techniques utilized, covering both the physical and digital components. The package comprises a flow chart illustrating the functioning of the system, a block diagram, a layout design, and a circuit/wiring diagram. In addition, the chapter presents a compilation of the hardware and software utilized, as well as the essential preparations required. Prior to commencing the project, it is essential to acquire the overall notion from scholarly articles, previous initiatives, and web resources. These procedures jointly ensure the most efficient approach for engineering the project.

Figure 1 depicts the system block diagram of the R95-ATech Smart Locking System for RON95. The system employs three inputs: an RC522 RFID Module, a SW420 Vibration Sensor, and an HC-SR04 Ultrasonic Sensor. The RFID module retrieves data from a validated UID card and transmits the information to the Arduino Mega

2560 microcontroller unit for subsequent processing. After receiving authorization, signals are transmitted to the servo motor and LCD for future actions. The computer analyses the input from the vibration sensor, which then activates the LCD display and triggers the alarm system's buzzer. The input from the ultrasonic sensor is utilized to trigger the commencement of the closing procedure of the servo motor.

Figure 2 displays the sequential flow of the system process, starting with the identification step that involves scanning the UID card data using the RFID module. The authorization output results in two specific actions: for UIDs that have been authorized, the servo motor causes the claw to rotate, granting access to the nozzle; for UIDs that have not been authorized, the system blocks access and activates the alarm system, which includes a built-in vibration sensor. Figure 3 depicts the configuration of the threshold that triggers the activation of the alarm system, resulting in the transmission of a signal to the buzzer. The alarm system is triggered for a duration of 5 seconds before reverting back to its original state. The ultrasonic sensor guarantees that the servo will revert back to its original position and close the claw when it detects an object within its range.

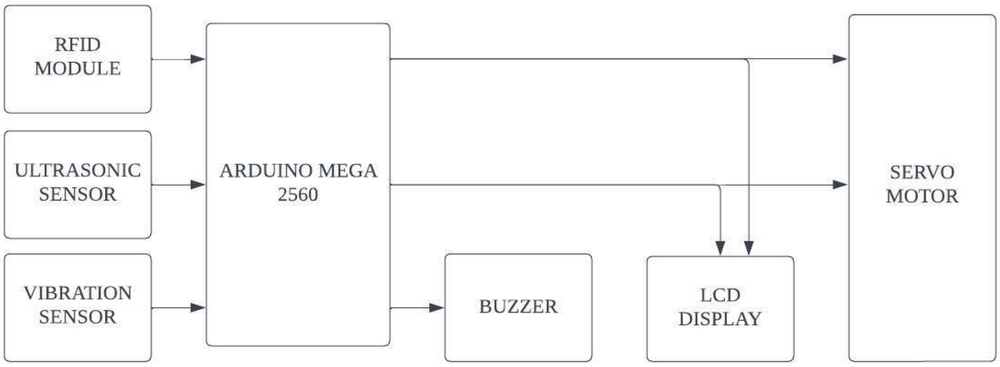

Fig. 1 *System block diagram*

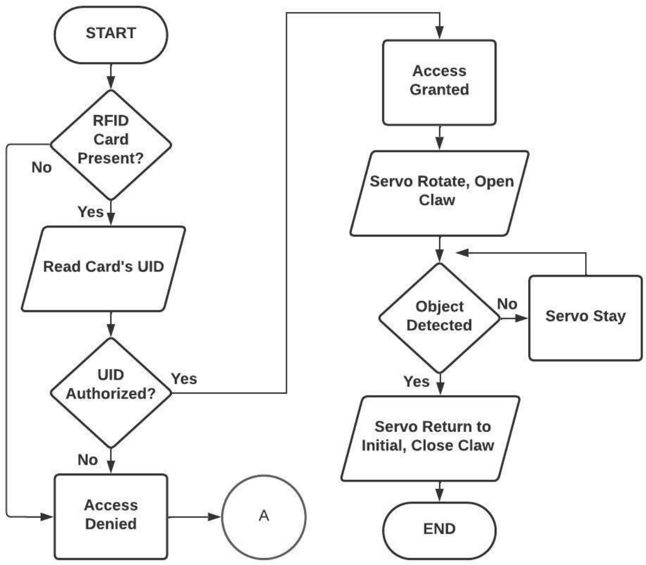

Fig. 2 *Main system flowchart*

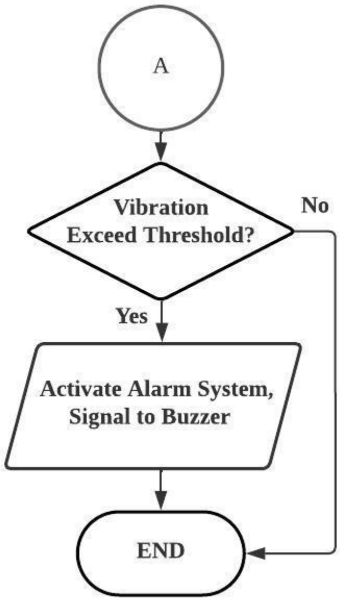

Fig. 3 *Conditional alarm system flow*

The modelling approach for the prototype is influenced by the configuration of a standard petrol station pump found in local areas. In order to improve the clarity and visibility, the prototype is made from transparent acrylic, which enables a clear view of the positioning of every component. The RFID module is strategically located in the uppermost part of the device to enhance the efficiency of the scanning process for users. This arrangement maximises user engagement and ease of usage.

To optimise performance, the ultrasonic sensor is positioned near the nozzle, reducing possible interruptions prior to the nozzle's reversion to its original position. The placement of the sensor is carefully calculated according to the sonar's sensitivity, guaranteeing accurate and dependable functioning. The placement of the vibration sensor near the handle, where the most intense vibration is produced, optimises its ability to detect any unauthorised access or tampering.

Citing sources Figures 4, 5, and 6 visually depict the carefully arranged placement of the components in the prototype. Figure 7 depicts the comprehensive model of the prototype, providing a holistic perspective of its design and configuration. Figure 8 presents an aerial perspective of the prototype, illustrating the modifications made to enhance functioning by taking into account geographical factors. These modifications are implemented with the objective of optimising the utilisation of the available space while ensuring that the prototype remains suitable for its intended function.

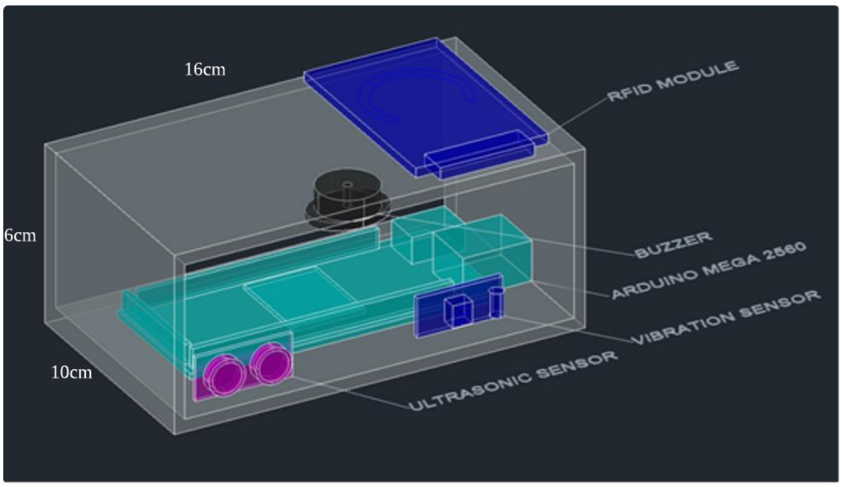

Fig. 4 *Components placement*

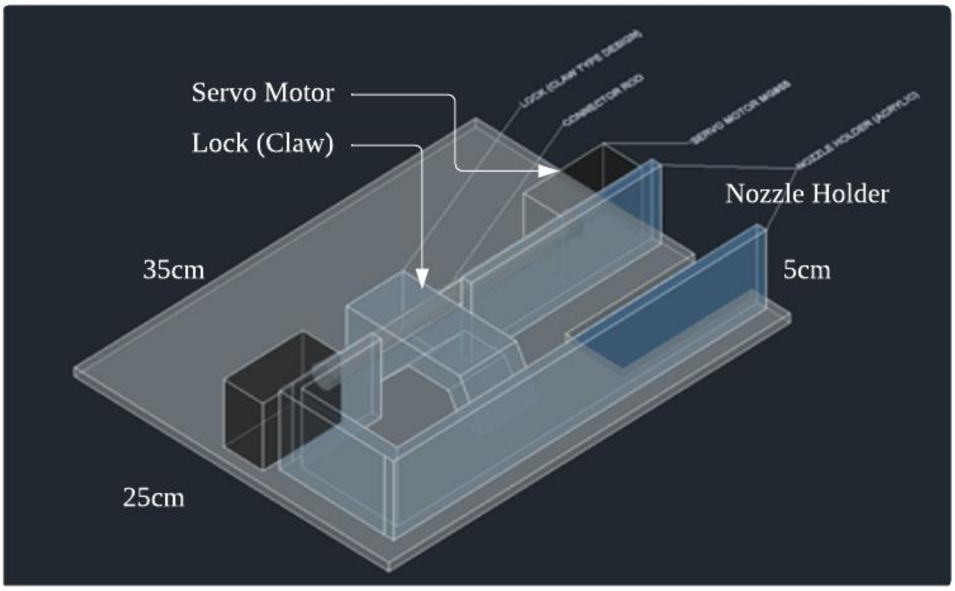

Fig. 5 *Servo motor placement*

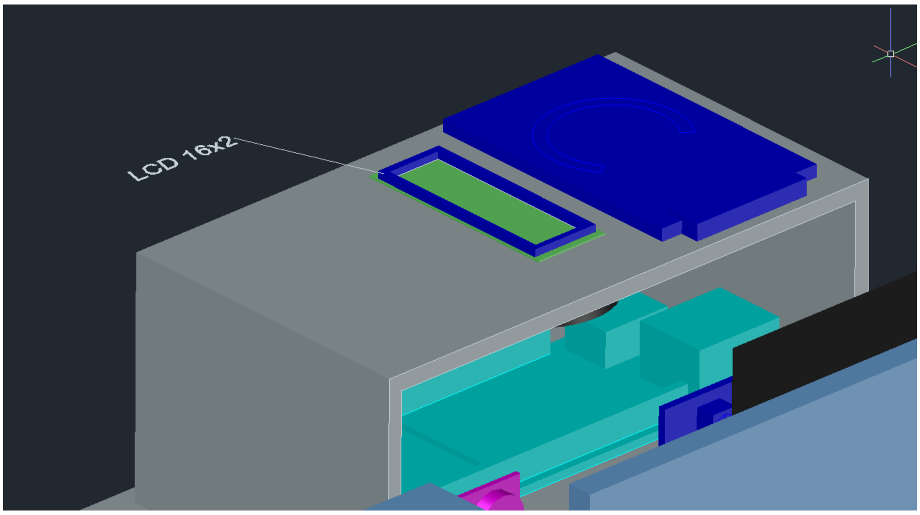

Fig. 6 *LCD placement*

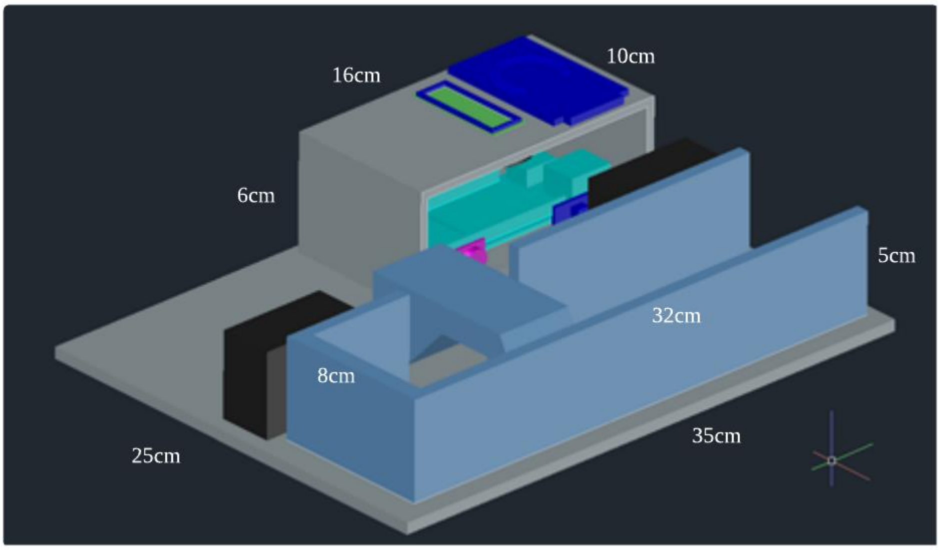

Fig. 7 *Prototype model in AutoCAD*

Fig. 8 *Aerial view of completed prototype*

The circuit diagram of the Smart Locking System for RON95, R95-ATech is seen in Figure 9. The prototype consists of six essential components: an RFID module, an LCD, a servo motor, an ultrasonic sensor, a vibration sensor, and a buzzer. The configuration and interconnection of these components inside the circuit are vital for the optimal operation of the system, and they are determined based on the signals they generate.

The Arduino Mega 2560 functions as the central processing unit to establish the connections. The pins located on the lower section of the Arduino Mega 2560 are specifically assigned for digital input/output signals. Each pin has a distinct function in the transmission or reception of information. The Pulse Width Modulation (PWM) signal is used on the right pin side. Pins 13 and 12 have a unique importance, as they are specifically intended to accept signals of both types, offering a flexible interface for the different components.

The circuit design facilitates seamless integration of the RFID module, LCD, servo motor, ultrasonic sensor, vibration sensor, and buzzer, enabling efficient communication and coordination among these essential components. The strategic assignment of pins and careful selection of signal types enhance the overall effectiveness and operation of the Smart Locking System, as seen in the circuit diagram provided.

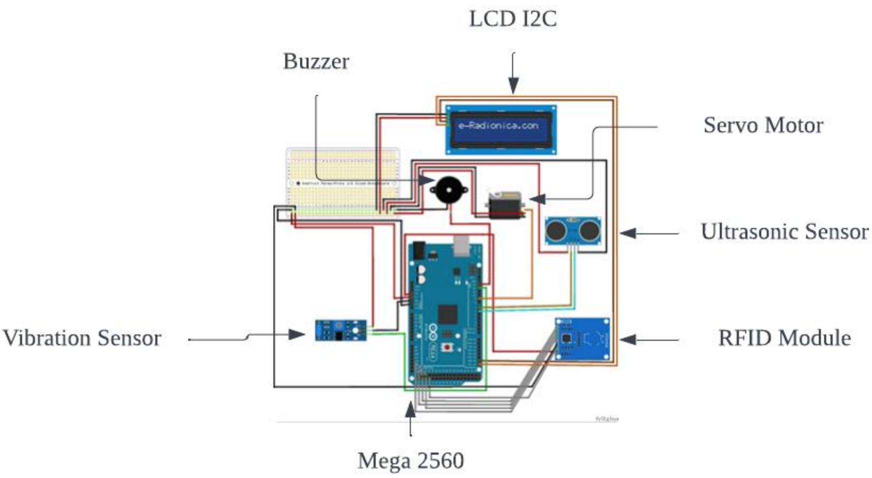

Fig. 9 *Circuit wiring diagram*

4. Result and Discussion

This chapter discuss about the design of the system, specifically the simulation and the end product. Basing on the simulation, the result of the end product is compared to the simulation for the working process to determine the smoothness of the program. The simulation of the prototype is divided into three section, main recognition system, alarm system and lastly the closing procedure. The data obtained was recorded in the Table 1, 2 and 3

4.1 System Performance

In the first case study, the main objective was to analyze the performance of the recognition system by utilizing 10 different cards which were carefully chosen as there were some cards that does not have a UID serial number printed in it.

Outputs were recorded as in the Table 1 and 2. During the experimentation, there were several times where the system malfunction and let out a different data as it should have to. These problems occurred mostly because there were confusions during the process which led the sensor could not perform as it supposed to. During the malfunction, the buzzer continuously produce sound until the reset button was pressed. The malfunction appeared to happen only when the registered UID was scanned. The data were also taken from a different distance between the card and the sensor. Based on the differentiation, it was concluded that the UID could be read well when the distance between was the nearest.

Table 1 *Distance between card and scanner 5mm*

UID	Trials, n	Distance, d	Result	Condition
Card 1	1	5mm	Authorized	Claw open
	2	5mm	Authorized	Claw open
	3	5mm	Authorized	Claw open
Card 2	1	5mm	Authorized	Claw open
	2	5mm	-	Malfunction
	3	5mm	Authorized	Claw open
Card 3	1	5mm	Authorized	Claw open
	2	5mm	Authorized	Claw open
	3	5mm	Authorized	Claw open
Card 4	1	5mm	Authorized	Claw open
	2	5mm	Authorized	Claw open
	3	5mm	-	Malfunction
Card 5	1	5mm	Authorized	Claw open
	2	5mm	Authorized	Claw open
	3	5mm	Authorized	Claw open
Card 6	1	5mm	Unauthorized	Claw not open
	2	5mm	Unauthorized	Claw not open
	3	5mm	Unauthorized	Claw not open
Card 7	1	5mm	Unauthorized	Claw not open
	2	5mm	Unauthorized	Claw not open
	3	5mm	Unauthorized	Claw not open
Card 8	1	5mm	Unauthorized	Claw not open
	2	5mm	Unauthorized	Claw not open
	3	5mm	Unauthorized	Claw not open
Card 9	1	5mm	Unauthorized	Claw not open
	2	5mm	Unauthorized	Claw not open
	3	5mm	Unauthorized	Claw not open
Card 10	1	5mm	Unauthorized	Claw not open
	2	5mm	Unauthorized	Claw not open
	3	5mm	Unauthorized	Claw not open

Table 2 *Distance between card and scanner 10mm*

UID	Trials, n	Distance, d	Result	Condition
Card 1	1	10mm	-	Initial position
	2	10mm	-	Initial position
	3	10mm	-	Initial position
Card 2	1	10mm	-	Initial position
	2	10mm	-	Initial position
	3	10mm	-	Initial position
Card 3	1	10mm	-	Initial position
	2	10mm	-	Initial position
	3	10mm	-	Initial position
Card 4	1	10mm	-	Initial position
	2	10mm	-	Initial position
	3	10mm	-	Initial position
Card 5	1	10mm	-	Initial position
	2	10mm	-	Initial position
	3	10mm	-	Initial position
Card 6	1	10mm	-	Initial position
	2	10mm	-	Initial position
	3	10mm	-	Initial position
Card 7	1	10mm	-	Initial position
	2	10mm	-	Initial position
	3	10mm	-	Initial position
Card 8	1	10mm	-	Initial position
	2	10mm	-	Initial position
	3	10mm	-	Initial position
Card 9	1	10mm	-	Initial position
	2	10mm	-	Initial position
	3	10mm	-	Initial position
Card 10	1	10mm	-	Initial position
	2	10mm	-	Initial position
	3	10mm	-	Initial position

4.2 Alarm System Performance

The findings of the experimentation regarding the performance of the vibration sensor are outlined in Table 3. Throughout the experiment, a constant force of 19.6 Newtons was exerted on the system. The force was calculated using the formula F=ma, considering a load of 2kg and a constant acceleration due to gravity of 9.81 m/s^2. The selected force magnitude nearly corresponds to the force necessary to open the door, as shown in prior literature [16], where it is defined as 5 pounds (22N).

The experiment entailed rotating the potentiometer from its starting point, and it was noted that as the potentiometer moved further, the vibration sensor had escalating challenges in reaching the recommended threshold of 30000. Figure 10 clearly depicts the results recorded by the vibration sensor at various angles of rotation when applying force. It is important to note that the measured values may vary depending on the positioning of the prototype during testing and the elevation at which the force was exerted.

This experiment yields valuable information about the correlation between the rotation of the potentiometer and the response of the vibration sensor. It helps to understand the sensor's sensitivity in different conditions. These findings highlight the significance of taking into account these aspects while adjusting and using the vibration sensor in the Smart Locking System.

Table 3 *Threshold determination with varied sensitivity*

Potentiometer Rotation (X^0)	Trials	Value
0	1	75541
	2	65118
90	1	54491
	2	60188
180	1	35764
	2	30980
270	1	25543
	2	26756

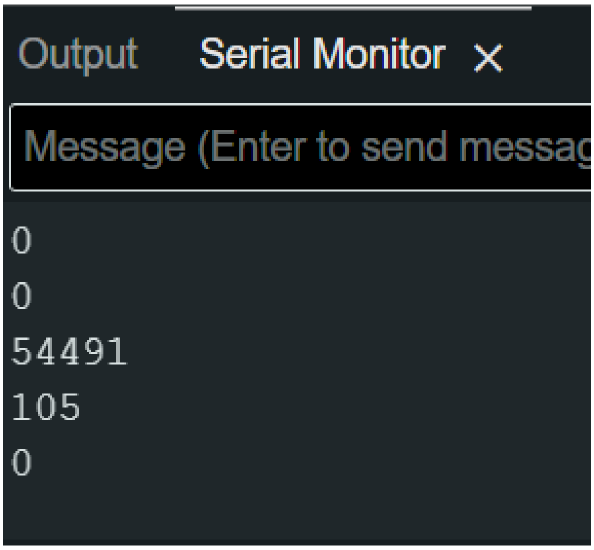

Fig. 10 *Captured value upon force applied*

5. Conclusion

After carefully examining the project's development, it becomes evident that there is a strong need for improvement in order to secure its successful completion. This need is based on both theoretical considerations and a thorough understanding of the project's inherent difficulties. The project development trajectory shows praiseworthy characteristics, however there are hidden potential to improve overall performance.

The proposed improvements go beyond simple repairs; they strive to establish a harmonious and effective integration of each component, surpassing expected results. This final chapter thoroughly examines potential enhancements, delving into modifications that go beyond the boundaries of traditional improvements. This is not merely a compilation of modifications, but rather an intellectual exploration into the realms of innovation and enhancement, with the goal of setting a new benchmark of excellence that influences every aspect of the project's framework.

While considering these proposed enhancements, it is crucial to acknowledge that this is a significant endeavour. The project, thoroughly strategized and implemented, demonstrates intricacy and innovation. The aim of this comprehensive inquiry is not only to correct any shortcomings, but also to establish a culture of ongoing improvement, ensuring that the project's progress becomes a constant pursuit of excellence.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Imad Yusuf Bin Saadon[1], Rasida Binti Norjali[2]*;* ***data collection:*** *Imad Yusuf Bin Saadon[1];* ***analysis and interpretation of results:*** *Imad Yusuf Bin Saadon[1], Rasida Binti Norjali[2]*;* ***draft manuscript preparation:*** *Imad Yusuf Bin Saadon[1], Rasida Binti Norjali[2]. All authors reviewed the results and approved the final version of the manuscript.*

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