Borneo Engineering & Advanced Multidisciplinary International Journal (BEAM)
Volume 3, Special Issue (ICo-ASCNITech 2024), September 2024,
Pages 64-72

Design and Implementation of a Programmable Locking Quotation Submission Box for Majlis Perbandaran Pasir Gudang

Zinvi Fu[1], Nurul Maizatul Ab Razak[1], Muhammad Mustapha[1]*

[1]Department of Mechanical Engineering, Politeknik Ibrahim Sultan, KM 10, Jalan Kong Kong, 81700 Pasir Gudang, Johor, Malaysia

*Corresponding author: muhammad@pis.edu.my
Please provide an **official organisation email** of the corresponding author

Full Paper

Article history
Received
6 August 2024
Received in revised form
6 August 2024
Accepted
16 August 2024
Published online
30 September 2024

Abstract

The quotation receiver box is designed to address issues with the conventional quotation submission box at Majlis Perbandaran Pasir Gudang (MBPG). Previously, prospective vendors and contractors for a project will submit their quotation in a sealed envelope to a quotation box in MBPG by a strict dateline. However, the process is exposed to flaw where the submission box is not automatically sealed after the cut-off time. Thus, documents can still be submitted after the dateline resulting in reduced integrity to the submission system. The proposed system aims to overcome the issue by introducing a programmable locking system in the quotation submission box to enforce the strict dateline. In this work, the mechanical and electrical design was carried out for the quotation box. The main locking mechanism and user interface was developed with the Raspberry Pi. The fastest average time it takes to lock and unlock the quotation box is 3.52 and 3.61 s respectively. The enhanced box is also able to display the quotation name and dateline. Through a limit switch, the system is also able to count and report the number of quotation submissions.

Keywords: - Quotation box, town council, Raspberry pi, smart letter box

1. Introduction

In Malaysia, the procurement procedure through tender and quotation is a regulated practice for government departments to acquire services or supplies from the private sector. According to Abul Hassan et al. (2021) the most important public procurement objective is to ensure a continuous supply of material and services to meet the government needs from the best and reliable sources. The procurement system is complex as it involves many parties. As the government procurement process involved public funds, transparency accountability is paramount as noncompliance (Ismail & Salleh, 2022) and issues related transparency, ethics and monitoring may occur (Abdullah et al., 2022).

For the quotation process, the prospective supplier or contractor will submit their quotation to the respective government department in response to the advertised quotation notice. In the case of Majlis Perbandaran Pasir Gudang, the request for quotation (RFP) process is manual. In the process, when a dateline for an RFP is made, prospective contractors or suppliers must submit by a strict dateline which typically ends on Thursdays 12.00 pm. After the dateline, late submission is strictly forbidden and disqualified automatically. However, the system needs human monitoring and action to seal or move away the box at the exact time. Therefore, it is difficult to strictly enforce the rules as the person in charge may be late to manage the quotation box. Hence, it is also impossible to tell if the last documents received were past the dateline or otherwise. Therefore, there is a need for a system that can automatically lock the quotation box on time.

Therefore, the objective of this work is to design and develop a quotation box which can be programmed to lock

and unlock on time to ensure strict enforcement of the dateline.

1.1 The Conventional Quotation Box

In the current practice, the quotation box is a movable furniture produced by cabinet and furniture makers. For the construction, it can be made with various material including wood, acrylic or metal. A slot is located on the top or front for inserting documents while a lockable door enables retrieval of the documents after the quotation notice period has ended. In the conventional method, the quotation box must be manually locked or removed after the dateline to prevent further submissions. However, it requires alert human intervention for enforcement. Fig. 1 shows the example of conventional quotation boxes. These systems are simple, however they require constant supervision.

(a) (b)

Fig. 1. Examples of conventional quotation box constructed with (a) acrylic (b) wood

1.2 Smart Parcel Box

A smart parcel box is an enhanced iteration of the conventional system with the addition of sensors, actuators and internet-of-things (IoT) whereby remote monitoring and administration can be performed. Tahyuddin et al. (2021) presented a smart parcel receiver to solve the problem of unattended parcel which is exposed to theft. In their design, the circuit was built with Arduino, which allows the recipient to access the mail box with a QR code. Their design was constructed primarily with acrylic. With the Arduino, many features can be added to the smart mail box, for example an automated signature acknowledgement was. (Nonthaputha et al., 2020). With sensors, mail and parcels can be detected and notify the owner (Mokhsin et al., 2021). Ooi & Tan (2021) introduced a modular contactless parcel system for receiving parcels. In such systems that allow identification and notification to users, the mail or parcel must be equipped with an identifier e.g. QR code, RFID or vision processing.

A different approach to the overall construction was presented by Zarin & Mon (2024) where the box was constructed with wood. Authorized personnel can open the door with a pin number and place the parcel manually. For the circuit, the ESP32 microcontroller serves as the main controller while the locking mechanism was driven with a stepper motor. In Rusli et al. (2022), a low-cost parcel receiving box was constructed with the Arduino Mega 2560. In their design, the courier will send the tracking number to the user, and a password will be generated for opening the door to place the parcel. The courier will then key in the password to the parcel box to open it and place the parcel.

2. Methodology

Before the design process was carried out, a brief survey was conducted to understand the specific user need of MPBG. As the product was produced by request from MBPG, the enquiry process can be simplified to the desirable features that were expected. The survey was conducted with ten respondents who are staff of MBPG in charge of the quotation box process. The questionnaire response was collected and statistically analyzed. A four-point Likert scale was used to determine the priority of the product based on the importance placed by the user. Table 1 shows the results of the customer survey analysis. From the results, it has been established that the user perceives the programmable start and end time of the quotation box, as well to lock and unlock the box on time. As the quotation box is meant to be located within the MBPG premise, the physical security was of a lower concern. The frame for the quotation box was subsequently provided by MBPG for the project.

The design process involves the conceptualization and fabrication of the mechanical and electrical parts of the product. As a foundation to the proposed design, three designs of similar submission boxes were shortlisted for comparison. The quotation box shares similarity in construction and functionality with smart letter and parcel receiver. For this study, three designs were considered for comparison as presented in Table 2. The design by Tahyuddin et al. (2021) was used as a foundation for the design, with adaptation to simplify user notification and authorization.

Fig. 2 shows the overview of the quotation box block diagram, as a result of the customer need survey. The documents are inserted through the front door and retrieved through the back door. The front door is installed with a solenoid lock and a limit switch for future application. These two devices are connected to the general-purpose I/O (GPIO) of the Raspberry Pi. An LCD screen displays information for the user and the administrator. For the administrator, the Raspberry Pi can be accessed with a mouse and keyboard from inside the box.

Table 1. Results of customer needs survey

Item	Not important	Less important	Important	Very important
Programmable start and end time	0	0	0	10
Lock and unlock on time	0	0	0	10
A programmable screen display for information	0	0	1	9
Notification of document received	0	1	7	3
Automatically identifying and registering the sender	3	4	2	0
Able to monitor and program online	0	2	6	2
High energy efficiency over performance	0	5	3	2
Highly secure cabinet construction	2	6	1	0

n=10

Table 2. Design consideration comparison between smart document and parcel box by authors

	Conventional	Nur Aqiela Shahira et al. (2021)	Nursyafieqa & Siti Zaharah (2024)	Luqmanulhakim et al. (2022)
Purpose and usage	Document	Parcel	Parcel	Parcel
Electronics involved	None	Arduino	ESP32	Arduino
IoT notification	None	Yes	Yes	Yes
Display status on box	None	Yes	Yes	Yes
Requires authorization to submit items	No	No	Yes	Yes
Requires authorization to retrieve items	No	Yes	Yes	Yes

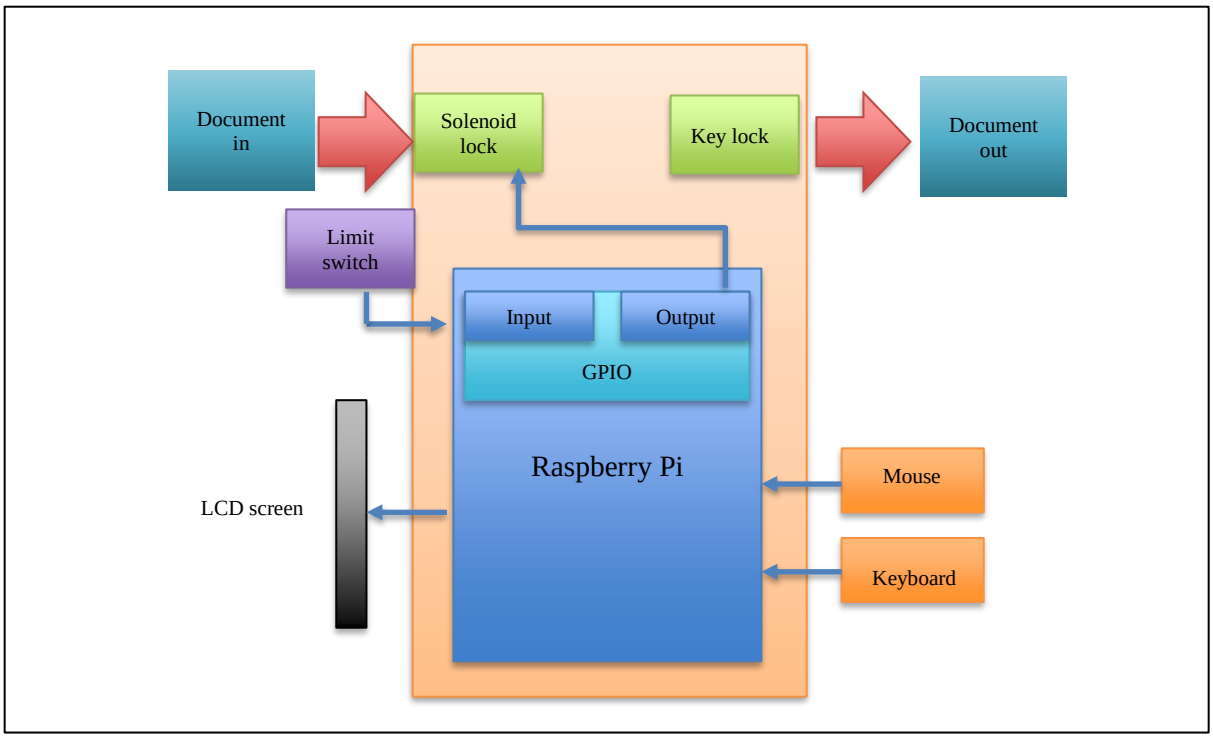


Fig. 2. Block diagram of the system

3. Result and Discussion

3.1 Mechanical Design

The proposed quotation box design consists of two main parts, which are the door and the body. The design of the door made with Autodesk Inventor 2024 is presented in Fig. 3, while the body is presented in Fig. 4. The purpose of the door is for document inspection and retrieval. A lock was installed in the door for security. The body was made in similar design to indoor mailbox. As the quotation box is placed in a secure location and not at risk to weather and vandalism, it was fabricated with MDF wood panel. A slot placed in the upper front of the box allows documents to be inserted. The overall dimension of the box is 446mm (W) × 857 mm (H) × 419 mm (D).

The quotation box fabrication was outsourced to a furniture maker according to specifications. The quotation box is shown in Fig. 5. In Fig. 5(a), the slot for document submission with the dimension of 308 mm by 57.5 mm is shown. Fig. 5(b) shows the rear view of the quotation box where locks are installed.

Fig. 6 shows the interior of the document door. The locking mechanism is provided by a solenoid door lock. When the quotation submission time is open, the latch of lock will retract and allow the door to swing open when pushed by the document. Once the submission dateline is reached, the latch will extend and blocks the door from opening. The frame surrounding the document door is reinforced with steel to prevent damage from forcibly pushing the door open.

3.2 Electrical Design of the Quotation Box

For the controller, the Raspberry Pi Pico was selected because it can provide general-purpose I/O and also IoT through its built-in WIFI connection. The main control circuit is shown in Fig. 7. The Raspberry Pi also comes with an operating system which facilitates the software development, and can be attached to an LCD screen for display. For the output, the solenoid latch is actuated by the instruction from the Raspberry Pi. Since the solenoid latch requires 12 V for actuation, two relays are connected to the Raspberry Pi to match the voltage level. The description of the relay action is described in Table 3. The ports GP7 and GP8 are connected to the relays. When GP7 and GP8 turns on, the normally-open (NO) connection will close, and complete the solenoid lock circuit which will extend the latch and mechanically lock the quotation box.

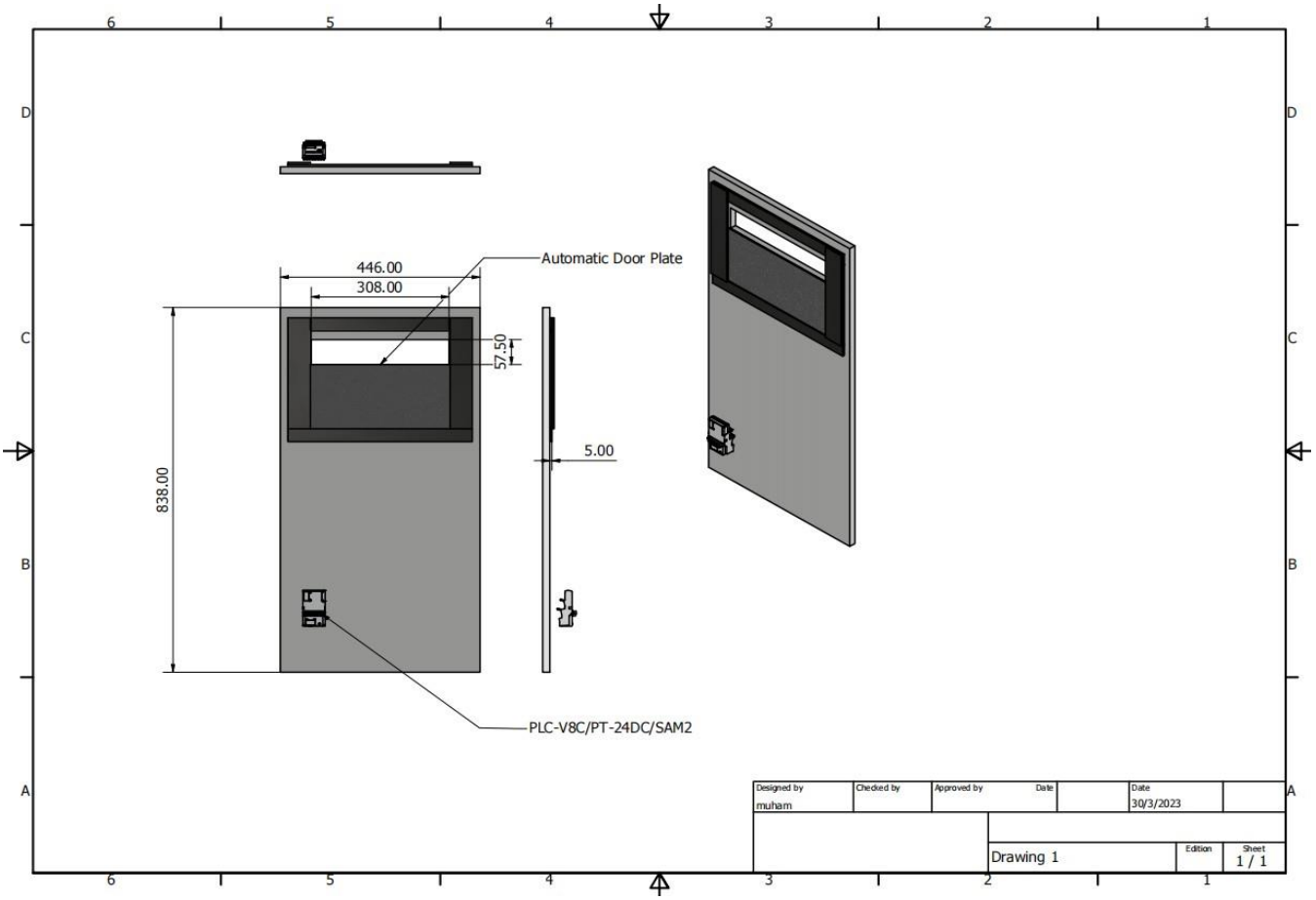


Fig. 3. Design of the door of the quotation box

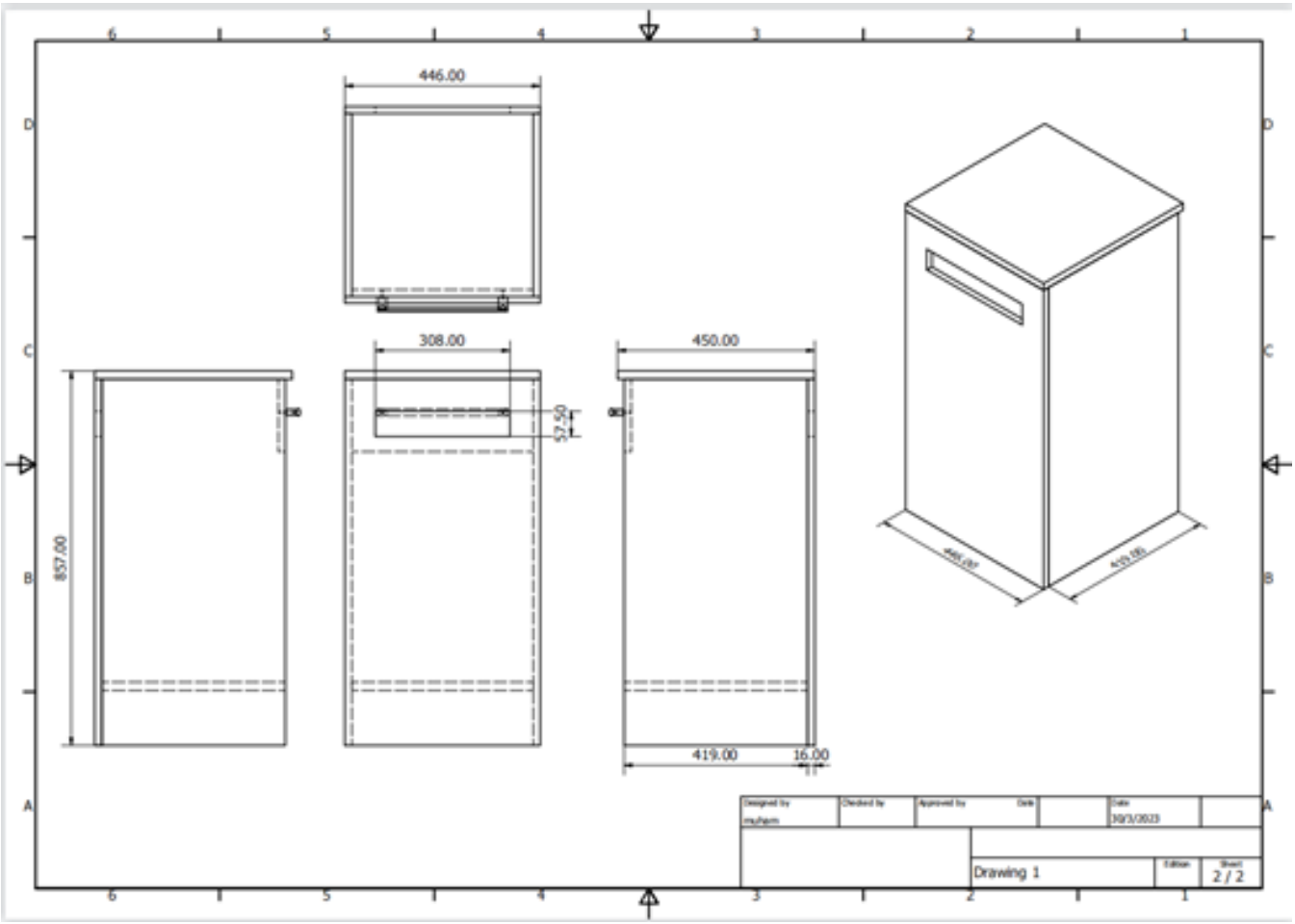
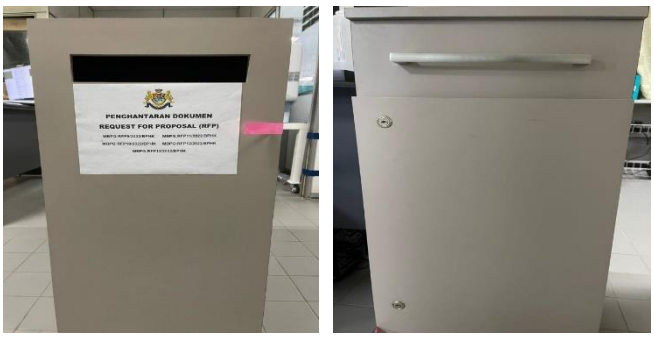


Fig. 4. Design of the body of the quotation box



(a) (b)

Fig. 5. Result of fabrication of the quotation box, (a) front view (b) rear view

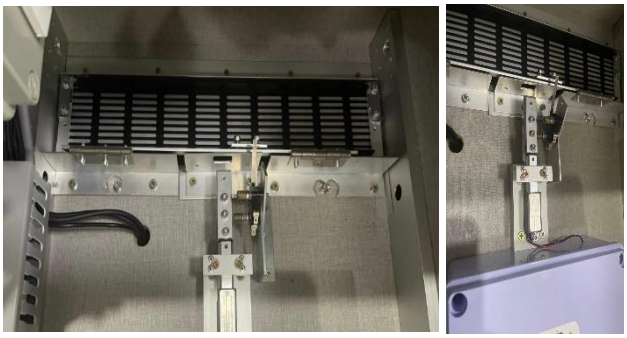


Fig. 6. The door and it's locking mechanism

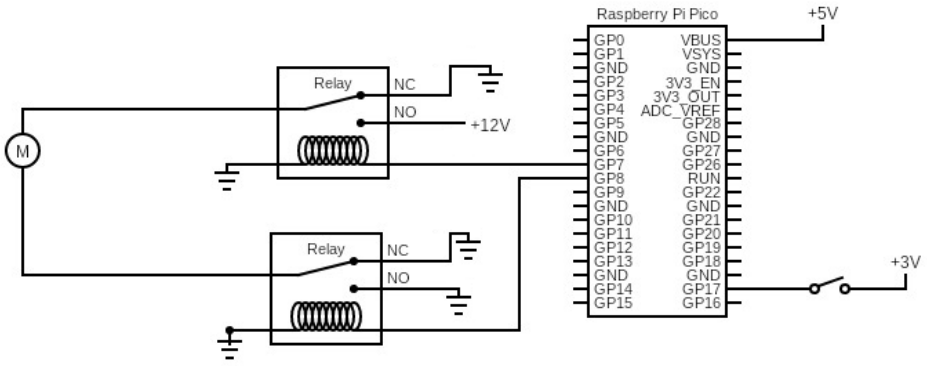


Fig. 7. Main control circuit of the quotation box

A limit switch is installed at the door to sense the door opening. It can be used as an input signal for document reception and door open/closed status. An LCD screen is connected via the HDMI output of the Raspberry Pi to display the dateline.

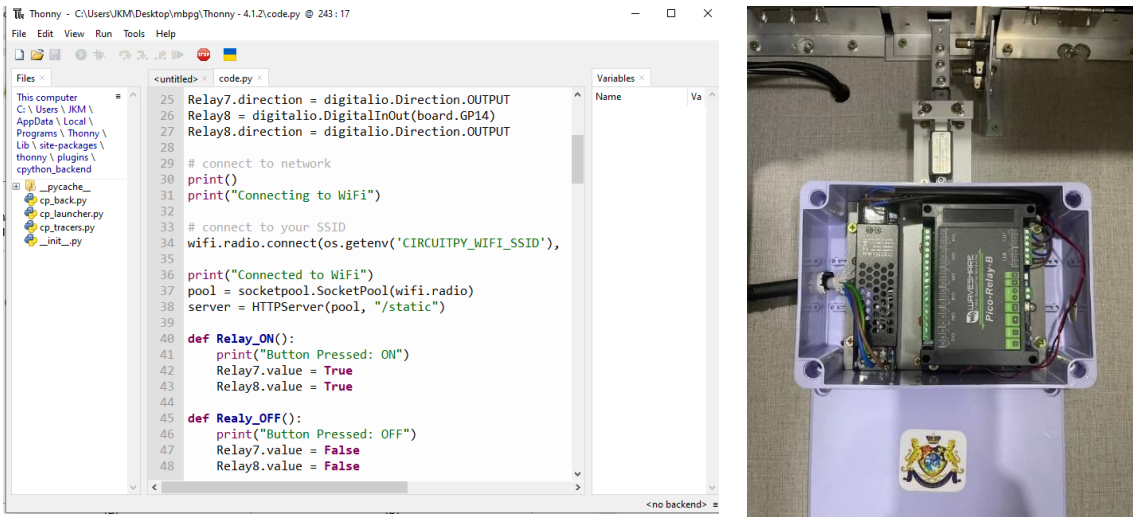
Table 3. Raspberry Pi output status and latch actuation

IO address		Latch Actuation
GP7	GP8	
Off	Off	Retract
On	On	Extend

3.3 Software Design

The software was developed in Python with Thonny 4.1.2 with the codes partially shown in Fig. 8(a). In Fig. 8(b), the Raspberry Pi Pico is used as the main controller. To actuate the relays, the Pico Relay-B shield was used. From the user perspective, it is necessary to set the opening and dateline time. Therefore, in the main user interface, the administrator of the quotation box will set the time according to the request for quotation (RFP) time. In the main display, the user has the option to set the start and end time of the request for the RFP time.

In Fig. 9, the algorithm of the main operation is shown here. On startup, the administrator sets the start and end time of the RFP. Through a simple -if-else iteration, the current real-time is compared with the set time. Once the two variables are equal, that means the time has ended and the program moves to the next instruction which is to lock the document door. The algorithm is web-based and requires a browser to function. Upon startup, the program can be run directly from the Raspberry Pi via the LCD screen or through a computer with the Thonny application. Once connected to Wi-Fi, the webpage can be accessed by any device available on the same network.



(a) (b)

Fig. 8. Software and controller design (a) code snippet of the quotation box developed in Python with Thonny 4.1.2 (b) Raspberry Pi Pico with the Pico Relay B shield

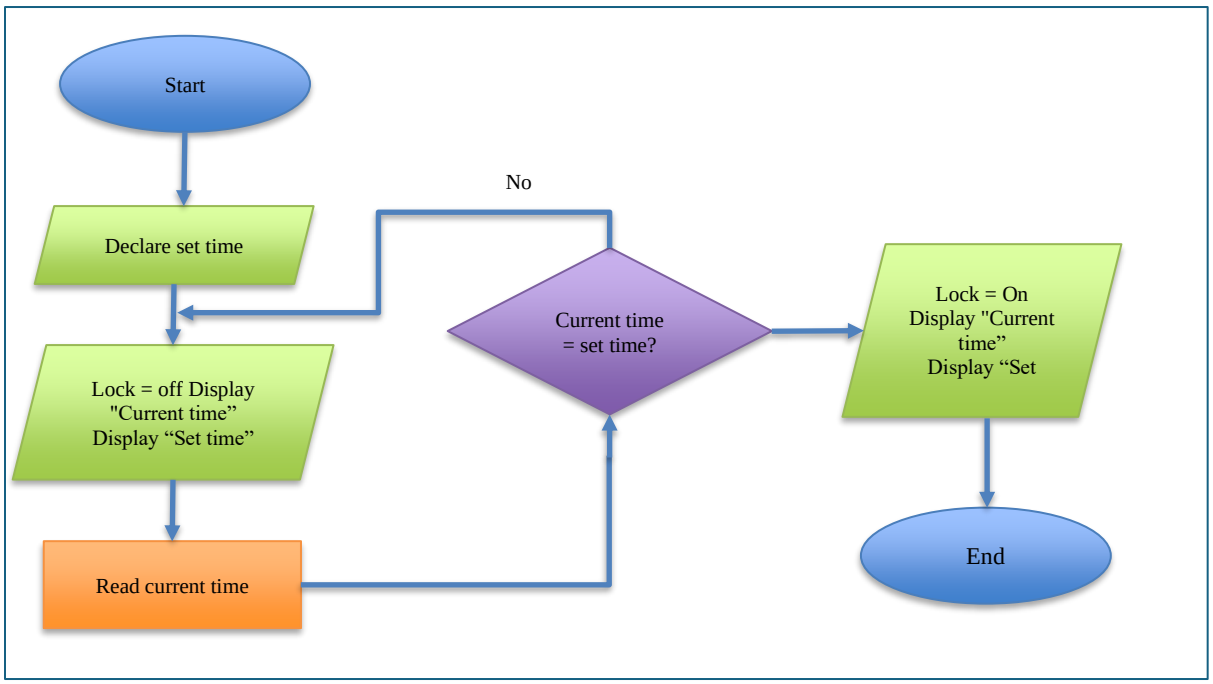
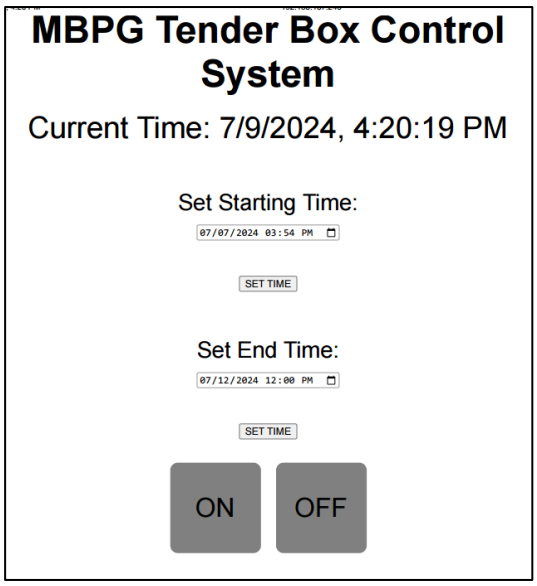


Fig. 9. Algorithm for user interface time setting and locking mechanism



(a)

(b)

Fig. 10. The display of the quotation box (a) administrator interface and (b) front panel display

The main display for the administrator is displayed in Fig. 10(a). For the administrator, their role allows setting the start time and end time with the form. Once the time is set, the lock will retract and allows the door to open. When the time has ended as set, the latch will extend and lock the door. The ON and OFF button allows the administrator to set and reset the latch manually when the RFP has ended.

Fig. 10(b) shows the LCD screen of the front panel. The front panel is connected to an LCD screen which displays the real-time clock showing the current time and also the dateline. The Raspberry Pi operating system can be accessed and configured through this screen.

3.4 Short-Term Test Results

For this project, the reliability of the system lies in the locking mechanism. To test the reliability, the ON and OFF button was pressed, and the time taken for the locking and unlocking actuation to complete was recorded with a chronograph for a given network connection. The process was repeated over local (direct Raspberry Pi) and remote

connection via LAN cable, Wi-fi and mobile hotspot. Fifty actuations were recorded for each procedure. In Table 4, the average time to open and close from the button press is displayed. On average, the time taken ranged from 3-5 seconds. From the results, there is no significant difference between the actuating the lock locally or remote via network. On average the locking time is slightly longer than the unlocking time. This may be an effect of the lock installed upwards and there was more mechanical resistance towards locking. For the mechanical aspect, the actuations were 100% successful with no jams, provided the door was fully shut during the actuation.

Table 4. Electro-mechanical latency test

Type of network connection	Average time to open (s)	Average time to lock (s)
Local	3.52	3.61
LAN cable 100 MBPS	3.57	3.67
Wi-fi 54 MBPS	3.52	3.67
Mobile hotspot (4G)	3.57	3.61
Average	3.55	3.64
Standard deviation (SD)	0.66	0.7

Number of actuations = 50

3.5 User Feedback

The effectiveness of the system lies in the feedback of the clients, which are the staff of MBPG. To determine their perception of the innovation, the quotation box was demonstrated, and the respondents had the opportunity to operate it. A simple questionnaire was distributed to the ten staff of various positions whose duty is related to the quotation box. The survey instrument is shown in Table 5. The instrument was divided into two sections. Section A is focused on the technical aspect of the quotation box. From the results, it can be summarized that all respondents agreed that innovation can satisfy the technical needs. In the case of screen display, there were two respondents who did not strongly agree that the screen display is useful. This is because the title of the RFP is keyed-in directly in the Python source code via Thonny. Further improvements will be made so it can be entered at the user interface.

On Section B, all users agree that the innovation simplifies their work. For the user interface three respondents agreed, rather that strongly agree that the user interface is simple. This is due to the current state of software development where the codes are directly run from Thonny, and this step requires some technical knowledge from the user.

Table 5. Customer feedback survey of the quotation box

Section A: Technical aspect				
Item	**Strongly disagree**	**Disagree**	**Agree**	**Strongly agree**
I can program the start and end time	0	0	0	10
The timer is accurate	0	0	0	10
The screen displays useful information	0	0	2	8
The locking mechanism is reliable	0	0	0	10
The locking system is secure	0	0	0	10
The overall construction is secure	0	0	0	10

Section B: User perception				
Item	**Strongly disagree**	**Disagree**	**Agree**	**Strongly agree**
The user interface is simple to use	0	0	3	7
The design is ergonomic and comfortable to use	0	0	0	10
The innovation simplifies the current process of my work	0	0	0	10
The innovation effectively ensures the compliance to the RFP dateline	0	0	0	10
With improvements, I will prefer to use this innovation over the current process	0	0	1	9

n=10

4. Conclusion and Further Recommendation

In this work, an innovation for the quotation box was introduced and applied at Majlis Perbandaran Pasir Gudang. Overall, the system was electrically and mechanically reliable and was generally accepted as an improvement over the current practice of using a conventional mail box. However, for long term application, the authors recommend the following improvements: first, to develop an executable shell application for the source codes so it can be launched directly from desktop of the Raspberry Pi. Next, to include more features on the front screen such as graphics and text which can be edited directly from the app instead of Thonny. Finally, an automated acknowledgement system can also be developed for the individuals who submit the documents.

Acknowledgement

The authors would like to extend gratitude to Majlis Perbandaran Pasir Gudang for their support.

References

Abdullah, W. N. H. W., Muhammad, K., Ghani, E. K., & Hassan, R. (2022). Factors Influencing Public Procurement Process Effectiveness: A Study in a Uniform Government Agency. https://doi.org/10.6007/ijarafms/v12-i3/14380.

Abul Hassan, S. H., Ismail, S., & Ahmad@ Abdul Mutalib, H. (2021). Public procurement in Malaysia: objectives and procurement principles. *Journal of Economic and Administrative Sciences*, *37*(4), 694-710. https://doi.org/10.1108/jeas-03-2020-0033.

Ismail, M. R., & Salleh, M. F. M. (2022). Ketidakpatuhan standard kualiti kawalan dalaman dalam pengurusan perolehan kerajaan: faktor penyebab berlakunya fraud. *Asian Journal of Accounting and Governance*, *17*, 27-46. https://doi.org/10.17576/ajag-2022-17-03.

Mokhsin, M., Ludin, M. Z. M., Suhaimi, A. I. H., Zainol, A. S., Som, M. H. M., & Halim, H. A. (2021, November). ParcelRestBox: IoT-Based Parcel Receiving Box System Design for Smart City in Malaysia. In *2021 IEEE International Conference on Computing (ICOCO)* (pp. 180-185). IEEE. https://doi.org/10.1109/ICOCO53166.2021.9673588.

Nonthaputha, T., Kumngern, M., Phookwantong, J., & Keawwang, S. (2020, November). Arduino based smart box for receiving parcel posts. In *2020 18th International Conference on ICT and Knowledge Engineering (ICT&KE)* (pp. 1-5). IEEE. https://doi.org/10.1109/ICTKE50349.2020.9289909.

Ooi, J. Z., & Tan, C. C. (2021, November). Smart modular parcel locker system using internet of things (iot). In *2021 IEEE 11th International Conference on System Engineering and Technology (ICSET)* (pp. 66-71). IEEE. https://doi.org/10.1109/ICSET53708.2021.9612542.

Rusli, A. L. M., Muhamad, W. N. W., Sarnin, S. S., & Hamzah, M. M. A. M. (2022). A Low-Cost Smart Parcel Box System with Enhanced Security. In *The 2022 International Conference on Artificial Life and Robotics (ICAROB2022), January* (Vol. 20).

Tahyuddin, N. A. S. M., Ab Rahman, A., Subramaniam, T. S., & Yusof, A. M. (2021). The Development of Smart Parcel Receiver Box. *Research and Innovation in Technical and Vocational Education and Training*, *1*(2), 009-017. https://doi.org/10.30880/ritvet.2021.01.02.002.

Zarin, N. A., & Mon, S. Z. K. (2024). Smart Parcel Receiver Box. *Progress in Engineering Application and Technology*, *5*(1), 489-499. https://doi.org/10.30880/peat.2024.05.01.052.