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Home door security system based on Internet of Things

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ABSTRACT

The development of technology in the digital era has a significant impact in various fields including home security. The existence of conventional door locks that are easily broken into and the risk of losing physical keys raises the need for a more sophisticated security system. This research aims to design an Internet of Things (IoT)-based home door security system that utilizes the Telegram application as a remote control medium. The system integrates a fingerprint sensor, keypad, and push button to open and close the door. Passive Infrared Receiver (PIR) sensor and ESP32-CAM to detect motion and take pictures that are sent to Telegram. In addition, the system is equipped with an Uninterruptible Power supply (UPS) to ensure the device remains operational during a power outage. The results show that the electronic door lock system works well. The motion detection system is also able to accurately detect activity around the door and send images to Telegram with a fast response time. In addition, the use of UPS to keep the system functioning despite the interruption of electricity supply proved to be effective. Based on the test results, it can be concluded that this IoT-based home door security system is effective, easy to use, responsive, and continues to function despite a power outage.

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1. INTRODUCTION

The development of technology in the digital era has a significant impact on various aspects of life, including the security sector [1]. With the high number of cases of theft and house break-ins, the need for a more sophisticated security system is increasingly urgent [2]. Based on data quoted from padek.jawapos.com, throughout 2024 there were 131 cases of theft and house break-ins in Padang City [3]. Conventional door locks, although still commonly used, have serious weaknesses because they are easy to break and are vulnerable to theft [4]. This causes unrest among the public, especially when the house is left empty or when the occupants are resting [5].

As a solution, Internet of Things (IoT) technology offers a new way to improve home security. IoT allows physical devices, such as door locks and surveillance cameras to connect to the internet and be controlled remotely [6]. Applications such as Telegram that have a bot API feature make this integration easier by allowing users to open and close the door of the house and receive notifications about suspicious activity [7]. Thus, users can monitor and control access to their homes wherever they are [8]. IoT-based security systems can also be integrated with smart cameras, such as the ESP32-CAM which will take pictures when motion is detected around the door [9]. These images are then sent to Telegram, providing homeowners with visual evidence that can help in quick decision making [10]. This integration not only improves security, but also provides peace of mind because the house can be monitored in real-time..

To keep this system running during a power outage, an Uninterruptible Power Supply (UPS) device is used [11]. UPS ensures that devices such as the ESP32 and solenoid door lock remain operational even if the main power source is cut off. This is important to prevent device damage and data loss, and to give users

time to take necessary actions [12]. This study aims to design an IoT-based home door security system that combines various technologies such as Telegram, fingerprint, keypad, push button, PIR sensor, and ESP32-CAM. By using UPS as a power backup, this system is expected to provide better protection for home occupants [13]. The results of this study are expected to provide a real contribution in reducing cases of theft and housebreaking, as well as increasing the sense of security in the community [14].

2. METHOD

In making a tool, the first thing that must be done is designing the tool. Designing the tool is a planning process before making the tool [15]. The purpose of this design is to make it easier to make the tool. Because in the design, the selection of the right circuit and calculations and selection of components will be carried out [16]. In principle, systematic tool design will provide convenience in making the tool. The system block diagram is a flow in a working system of a tool that has different functions and lines to show block relationships [17]. The overall working method that will be created can be seen in the block diagram so that the entire block diagram will produce a system that can be used or can work [18]. The block diagram of the system is illustrated by Figure 1.

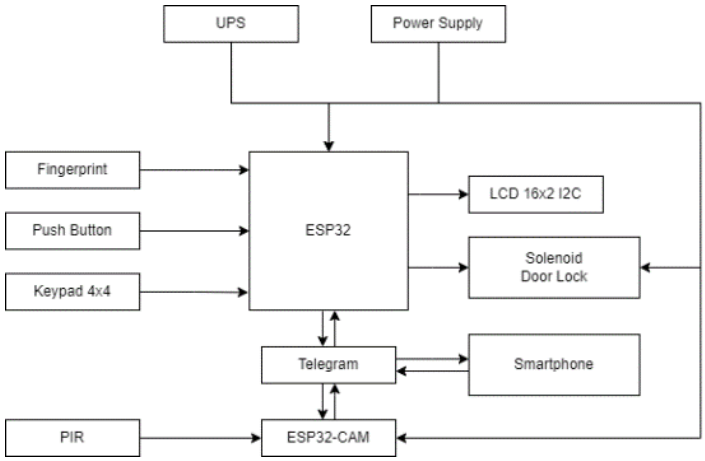


Figure 1. Block diagram of an internet of things-based home security system

Flowchart is a graphical depiction of the steps and sequence of procedures of a program [19]. The logical flow of the program will be shown by the Flowchart. Flowchart functions as a communication tool and programming guideline [20]. The flowchart of the designed system is shown in Figure 2.

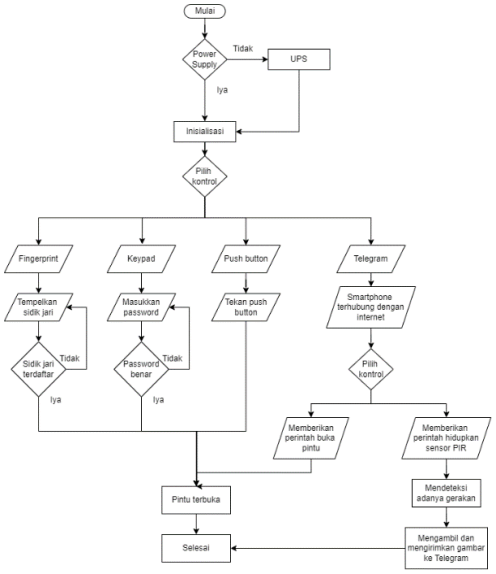
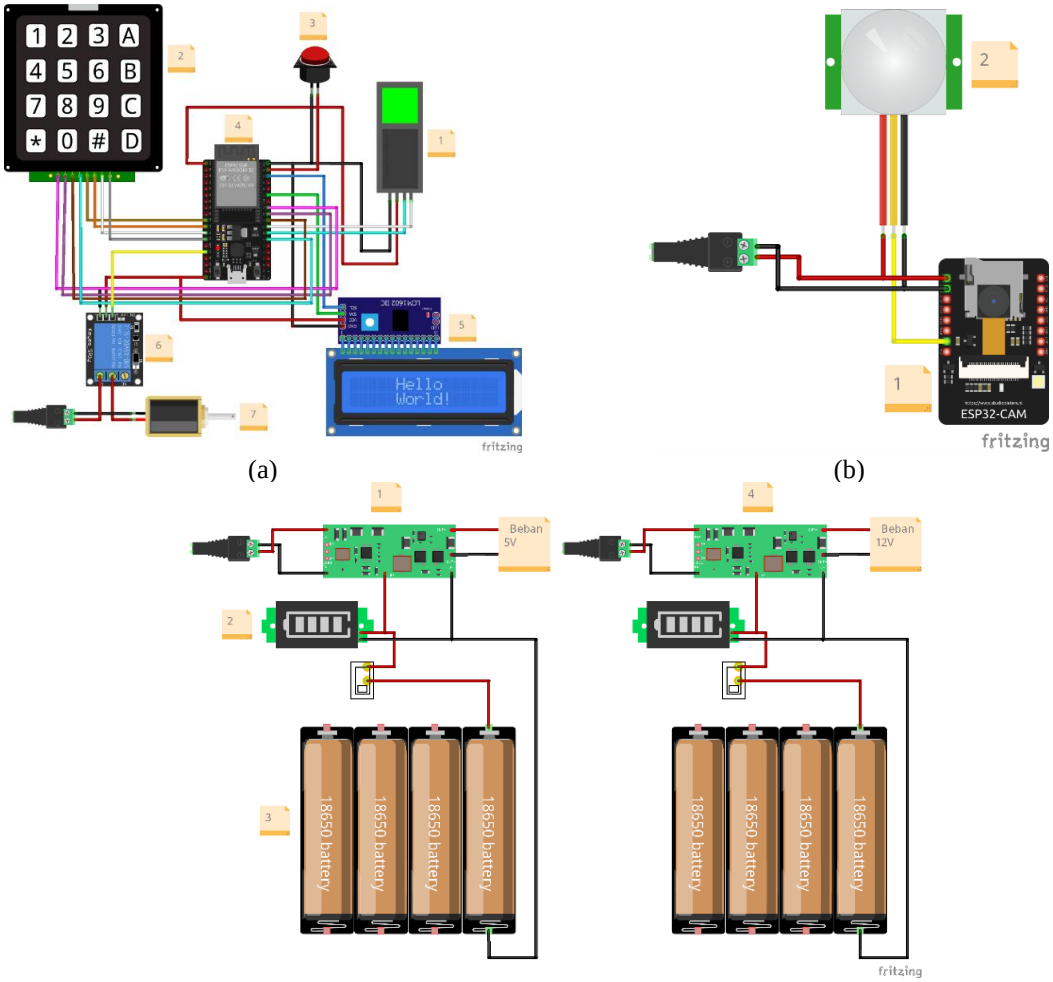


Figure 2. Flowchart of an Internet of Things-based home security system

Hardware design is a series that will be used in an IoT-based home door lock security system [21]. The hardware design that will be used can be seen in Figure 3 below.

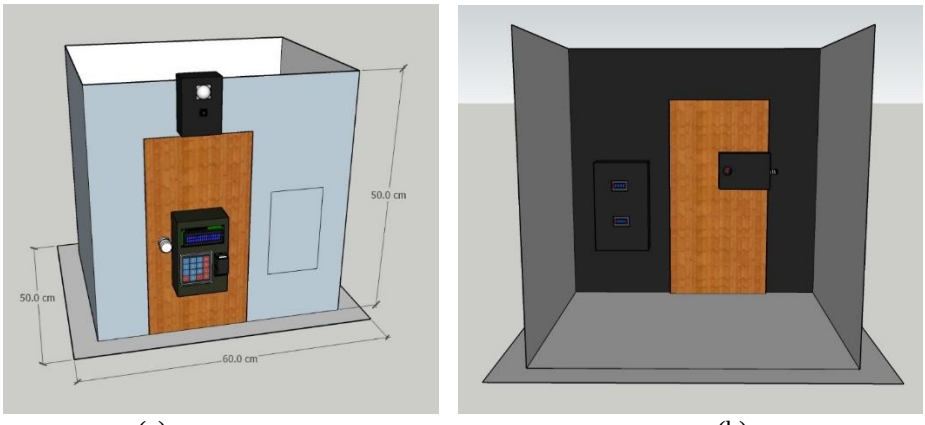


(a) (b)

(c)

Figure 3. Hardware schematic of proposed Internet of Things-based home security system, (a) Electronic door lock circuit, (b) Human motion detection system circuit, (c) UPS circuit

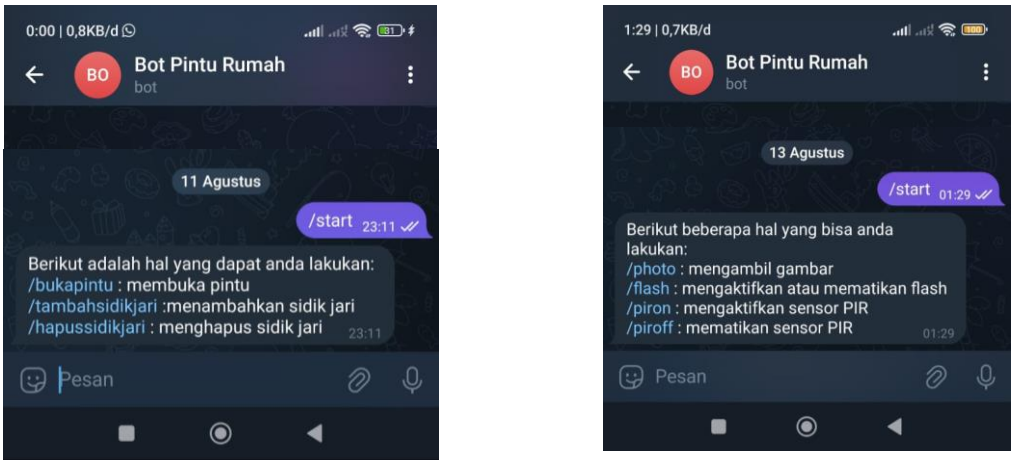
Mechanical design is a process in designing tools with the aim of facilitating and reducing the level of error in making tools [22]. Mechanical design discusses the physical form/design of the system [23]. Mechanical design from the outside and inside can be seen in Figure 4.



(a) (b)

Figure 4. Mechanical design (a) exterior view (b) interior view

Software design is done to prepare the application interface design that will control the home door security system [24]. In the software design, the design of the Android application interface will be discussed using the Telegram application as the controller application on the smartphone. Figure 5(a) is when you are going to use the application, make sure the smartphone and ESP32 are connected to the internet. Next, we open the Telegram application and open the Telegram Bot with the name Bot Pintu Rumah. When the /start command is sent, the command menu will appear that can be used. Figure 5(b) is when you are going to use the application, make sure the smartphone and ESP32-CAM are connected to the internet. Next, we open the Telegram application and open the Telegram Bot with the name Bot CCTV Pintu Rumah. When the /start command is sent, the command menu will appear that can be used.



(a) (b)

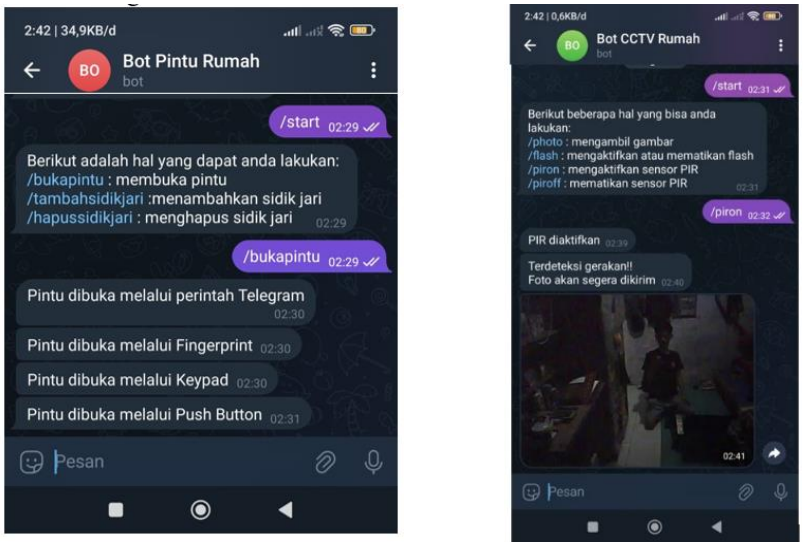
Figure 5. Telegram interface. (a) electronic door lock, (b) human motion detection system.

3. RESULTS AND DISCUSSION

The test was conducted to find out whether the system has been functioning properly [25]. This test was conducted to run the overall function of the tool. Starting from the electronic door lock, human motion detection system, and UPS. In the results of this mechanical design, the author used plywood, wooden blocks, and plastic boxes to make it. The results are shown in Figure 6.

Figure 6. Overall results of mechanical design

The results of this software design, the author uses a Telegram bot to make it easier for users to control and monitor the system remotely. The results of the software design are shown in Figure 7.



(a) (b)

Figure 7. Software design results (a) home door bot (b) home cctv bot

Testing push button done for test whether push button can give results proper reading with channel operation system. When the push button pressed so solenoid door lock will open and send notification to Telegram. Vice versa if push button No pressed so solenoid door lock still lock.

Table 1. Test ResultsPush Button

No	Push Button Status	Solenoid door lock status		Response Time (ms)	Telegram Notifications
		Open	Locked		
1	Pressed	✓		5046	Succeed
2	Pressed	✓		5046	Succeed
3	Pressed	✓		5046	Succeed
4	Pressed	✓		5046	Succeed
5	Pressed	✓		5046	Succeed
		Average		5046	

Table 1 shows that when the Push Button is pressed, the solenoid door lock will open and send a notification to Telegram. This is in accordance with the expected flow of the security system work process. The average response time generated from this Push Button test is 5046 ms.

Table 2. Keypad test with password correct

No	Password	Solenoid door lock status		Response Time (ms)	Telegram Notifications
		Open	Locked		
1	160123	✓		6869	Succeed
2	160123	✓		6832	Succeed
3	160123	✓		6791	Succeed
4	160123	✓		6827	Succeed
5	160123	✓		6742	Succeed
		Average		6817	

Table 3. Test results keypad with wrong password

No	Password	Solenoid door lock status		Response Time (ms)	Telegram Notifications
		Open	Locked		
1	178523		✓	-	No Succeed
2	198665		✓	-	No Succeed
3	194569		✓	-	No Succeed
4	202324		✓	-	No Succeed
5	789765		✓	-	No Succeed
		Average		-	

Keypad testing is done to ensure whether the correct password can unlock the door or not. This stage begins by entering the correct password using the keypad to ensure that the person doing the process is the occupant of the house. When the password entered is correct, the solenoid door lock will open and send a notification to Telegram. Conversely, if the password entered is incorrect, the solenoid door lock will remain locked. Tables 2 and 3 show the results of the keypad test. In the table above, it can be seen that when the password entered is correct, the solenoid door lock will open and send a notification to Telegram. This is in accordance with the expected flow of the work process of this security system. The average response time generated from this keypad test is 6817 ms. This is because when we enter the password it takes time to press it. When we enter the wrong password, the door remains locked.

Fingerprint testing is done to ensure whether the registered fingerprint when entered can unlock the door or not. This stage begins by inputting the registered fingerprint into the fingerprint to ensure that the person carrying out the process is the occupant of the house. When the entered fingerprint is registered, the solenoid door lock will open and send a notification to Telegram. Conversely, if the entered fingerprint is not registered, the solenoid door lock will remain locked. Tables 4 and 5 describe the results of the fingerprint test.

Table 4. Fingerprint Test Results with Fingerprint Finger Registered

No	Fingerprint Finger	Solenoid door lock status		Response Time (ms)	Telegram Notifications
		Open	Locked		
1	ID 1	✓		5047	Succeed
2	ID 2	✓		5046	Succeed
3	ID 3	✓		5046	Succeed
4	ID 4	✓		5047	Succeed
5	ID 5	✓		5047	Succeed
		Average		5047	

Table 5. Fingerprint test results with fingerprint finger no registered

No	Fingerprint Finger	Solenoid door lock status		Response Time (ms)	Telegram Notifications
		Open	Locked		
1	No Recognized		✓	-	No Succeed
2	No Recognized		✓	-	No Succeed
3	No Recognized		✓	-	No Succeed
4	No Recognized		✓	-	No Succeed
5	No Recognized		✓	-	No Succeed
		Average		-	

From the tests carried out, it can be seen that when the fingerprint entered is registered, the solenoid door lock will open and send a notification to Telegram. This is in accordance with the expected flow of the work process of this security system. The average response time generated from this push button test is 5047 ms. When we enter an unregistered fingerprint, the door remains locked. Testing the door opening command in the Telegram Bot is done to test whether the door opening command can open the door automatically via the Telegram Bot. When the door opening command is pressed, the solenoid door lock will open and send a notification to Telegram. Conversely, if the door opening command is not pressed, the solenoid door lock will remain locked.

Table 6. Test Results When opendoor command is pressed Pressed

No	Command Status / opendoor	Solenoid door lock status		Response Time (ms)	Telegram Notifications
		Open	Locked		
1	Pressed	✓		5046	Succeed
2	Pressed	✓		5046	Succeed
3	Pressed	✓		5047	Succeed
4	Pressed	✓		5046	Succeed
5	Pressed	✓		5046	Succeed
		Average		5046	

From the tests carried out can known that when command / open door pressed so solenoid door lock will open and send notification to Telegram. That is in accordance with expected flow from the work process system security this. For the average time the response generated from testing push button this is 5046 ms. PIR sensor testing is performed with measure range the distance that can be detected by the PIR sensor and how long it takes for the ESP32-CAM to send picture to Telegram. PIR sensor testing only done until distance 5 meters because of this PIR sensor only can detect movement until a distance of 5 meters. At each

test done as many as 5 attempts with different distances for every the distance. The result of testing can known level PIR sensor reliability in detect movement and delivery photo to telegram. Table 7 sgows the PIR sensor test.

Table 7. Average PIR sensor testing and image transmission

No	Testing Distance (Meters)	Response Time (ms)	Response Time Image Delivery (ms)	Total Operation Time (ms)	Telegram Notifications
1	1	1885	11670	13555	Succeed
2	2	1900	11744	13645	Succeed
3	3	1823	11712	13535	Succeed
4	4	1959	11688	13647	Succeed
5	5	1959	11718	13677	Succeed

Testing without burden done for ensure that UPS can give stable output voltage without existence connected load. Testing This aiming for know whether UPS system is working with good moment No There is connected devices. From the tests carried out can known that measured voltage and current A little more tall from nominal value. This is reasonable and indicative that the voltage regulator on the UPS is working with goods. Testing This important for ensure that the UPS is capable provide proper tension without load, which is base for testing more carry on with burden. Testing with burden done for know can UPS give stable and appropriate power with need connected load. From the tests carried out can known that Output voltage is low decrease moment burden connected. Drop voltage This reasonable and indicative that the UPS is working in accordance with specification design. Testing This ensure that UPS can support appropriate load without lost stability or efficiency.

Testing this done for ensure that UPS can switch with fluent from source Power main to battery without disturbance on the load. The purpose is for ensure that burden still get stable power although happen blackout electricity. From the tests carried out can known that Output voltage when with *power supply* on UPS 12V is a little decrease moment burden connected. Drop voltage This happen because on this UPS designed for fill in battery moment *power supply* connected, then There is possibility battery currently in the process of filling moment Testing. Filling battery can cause change in output voltage because the UPS switches part Power For fill in battery. At the time without *power supply*, load still operate normally. This is show that UPS can reliable For guard device still operate moment happen blackout electricity.

Measurement time stand battery aiming for know how long UPS last provide Power for connected load before battery finished. This is important for evaluate UPS capabilities in guard device still operate during blackout prolonged electricity. The batteries used in the 12V and 5V UPS each use 4 batteries. 1 Battery own capacity battery of 2600mAh. The total of fourth battery the is 10,400mAh. So can changed be Ah with share with 1000. Based on results calculation the show that the UPS is 12V 1A at the time powering up the ESP32 is capable of turn on tool for 21.37 hours. When turning on the ESP32 and *the door lock solenoid* capable turn on tool for 4.21 hours. On a 5V 1A UPS at the time powered the ESP32-CAM for 29.09 hours

4. CONCLUSION

The test results show that all the equipment is working well and as expected. The push button works well, opening the solenoid door lock with an average response time of 5046 ms. The keypad locks and opens the door based on the correct password with an average response time of 6817 ms. The fingerprint works accurately with an average response time of 5047 ms to open the door. The /opendoor command test via Telegram was also successful with an average response time of 5046 ms. Testing the PIR sensor with various distances showed that the system detected movement and sent images to Telegram in a total response time between 13385 to 14287 ms. UPS testing without load and with load showed that the resulting voltage was stable and ensured power reliability for the system.

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