Earthquake detection in mountainous homes using the internet of things connected to photovoltaic energy supply

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ABSTRACT

The North Sumatra region is an area with the potential for earthquakes originating from volcanic and oceanic eruptions which have resulted in many fatalities. Therefore, through the application of automatic monitoring and control system technology connected to the internet of things (IoTs), it is the right solution to provide efforts to increase security for residents of the house to always be vigilant. The security enhancement method referred to in this study is a home security system protection system by anticipating earthquakes. The advantage of this tool is that it applies a notification security system method with a sensitivity sensor which is automatically sent via email and sonor buzzer which also acts as sound vibrations due to an earthquake. The test results show that when a vibration occurs, the system will send a short email message to the user's smartphone so that the user will receive an email in the form of a warning message that the state of the house has an earthquake and the light-emitting diode (LED) interrupts and the buzzer is also on so that the alarm sounds which has been integrated into IoT. Then an integrated security monitoring system using the web can be monitored in real time.

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1. INTRODUCTION

The territory of Indonesia, if viewed from a geographical location, is an area with earthquake activity that often occurs because the position of this country is located at the confluence of three world tectonic plates or usually called the ring of fire area. The triggers that most often occur are caused by mountain and sea activities resulting in frequent movements of the earth's slopes resulting in vibrations so that the risk is fatal which can result in fatalities and environmental damage [1]–[3]. Several cases that often occur due to fatalities, namely the unconsciousness of the occupants of the house due to an earthquake such as being at work, falling asleep and also not having an alarm at home so that the owner of the house is complacent so he cannot run out of the house [4]–[7]. North Sumatra is an area where earthquakes frequently occur due to Mount Sinabung [8], [9]. The occurrence of eruptions due to volcanic eruptions also affects the health of the local community which will endanger the people who live around Mount Sinabung [10]. Therefore, the occurrence of volcanic eruption activity will also have the potential for earthquakes and will result in the occurrence of volcanic ash around the mountain [11]–[14]. Because a technology will be designed that can be controlled automatically using internet of things (IoTs) devices in combination with renewable energy connected to Android so that it can be accessed anywhere [15], [16]. One of the most popular devices for controlling automatically and also a cheap device is an IoT device with a system that is more efficient to use [17]–[19]. The implementation that will be developed is for smart homes so that later people living around the mountain can be alert and move quickly when an earthquake occurs. Applications for the use of IoT that are commonly used are only limited to the use of sensors and do not look at the system reliability of the device, so that implementation for the wider community is still minimal. For this reason, the design of this device technology will continue to continuously monitor and provide access to homeowners with connected integration to the internet network [20]–[23]. With the high potential for earthquakes to occur, there is an orientation of a security system that is able to increase the level of security inside the house using various methods. The IoT-based home security protection system has a working system when the vibration sensor is active, the buzzer and light-emitting diode (LED) will light up, then the camera will capture images and transfer messages to the email application until it is received by application users using Android [24]–[26]. A home security system can be used to remotely monitor and control home security via an e-mail smartphone capable of accurately detecting objects. In addition, the use of the passive infrared receiver (PIR) sensors is added to the light dependent resistor (LDR) sensor using a laser beam which is able to detect objects that are farther away than the PIR sensor. So that the application of PIR sensors and LDR sensors can detect human movement which causes the house door to activate an emergency lock that can be controlled by the home owner. Additional technology to support the control power so that it is always stable using photovoltaic (PV) technology with the aim of fulfilling a home security system [27]–[29].

2. RESEARCH METHOD

The research method used is an experimental method that examines the relationship of independent variables from integrated sensors regarding the relationship between magnetic distance and reed switch status on smartphones for housing security notifications with the dependent variable namely LDR sensors and laser diodes with the NodeMCU control system connected to email. While the sequence of experimental research methods consists of methodology, mechanical and electrical architecture of input and output devices, as well as mechanical and electrical architecture of the NodeMCU ESP8266 control device which is integrated on several sensors. The security system for additional power supply using PV energy sources is connected to the battery. Where after going through the process of making the tool which consists of mechanical, electrical design and a combination of connections between integrated sensors NodeMCU ESP8266 then interfaced via web and android display. The following is the realization of the results of making the tool as shown in Figure 1.

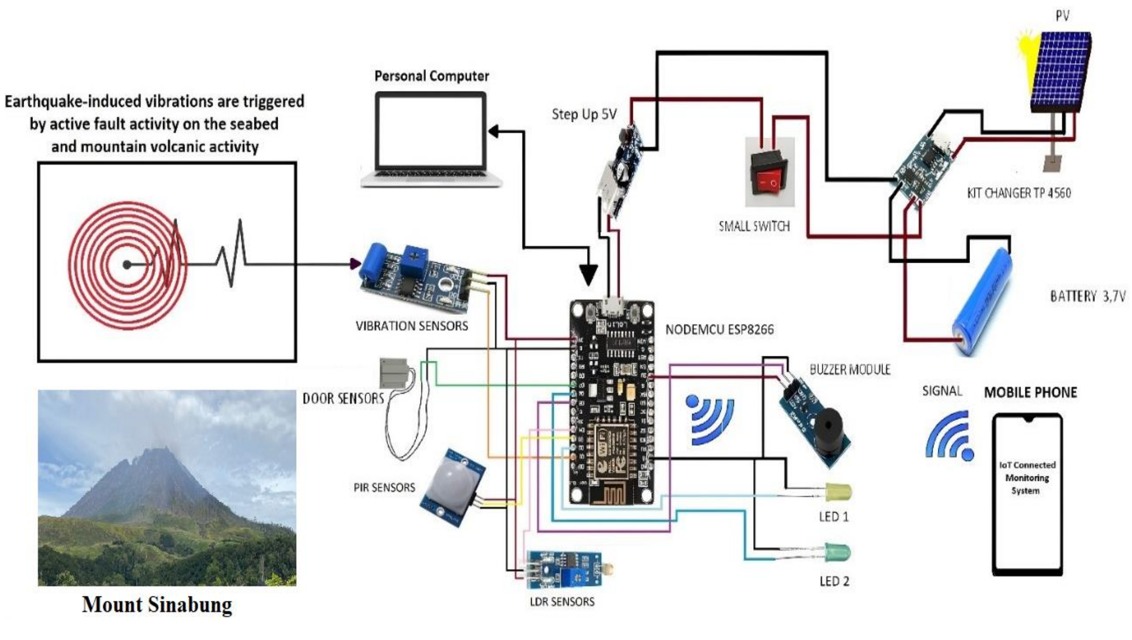

Figure 1. Smart home control design security technologies for IoT-based earthquake protection connected to PV source networks

3. RESULTS AND DISCUSSION

The implementation of the tool that has been designed is then installed in the house with the aim of monitoring the sensitivity sensor that has been connected to the house. The objects to be tested are door, shadow and vibration sensors at home using sensors that are integrated into the IoT. The purpose of implementing this tool is to see how much the sensor uses to minimize crime and vibration activity carried out on the earthquake sensor. The new paradigm is still being implemented on a shift in focus on object devices that are connected to the user. The benefits of this test are very important in offering efficiency for people who are in the mountains, especially residents around the mountains to be more alert to threats from nature. Identification of risks in the smart home security status in reducing can be a solution to the problems that exist at this time. For this reason, integrated sensor testing really needs to be used. The test results of the SW420 sensor can be seen in Table 1. From testing Table 1, the results of the SW420 sensor test above can be seen that the system can work when the sensor vibrates, the sensor status is low and cannot send messages, so there is no response to email. On the other hand, when the sensor is in high condition, the sensor will send a message and there will be a response to the email so that the user or home owner receives the email on the smartphone.

Table 1. Reliability testing on the SW420 sensor

No	The state of the vibration sensor	Vibration sensor state	Message states	Email responses
1	0	Low	Not sending	Not response
2	1	High	Send	Response

3.1. Test results for the NodeMCU ESP8266

The module reliability system must be properly tested so that the accuracy of the sensor integration can work as expected. The module testing application that is being tried is NodeMCU ESP8266, where this module is oriented towards the duration of sending email and data and receiving data that will be sent by integrating sensors on a smartphone or vice versa. As shown in Table 2, the results of several tests on the NodeMCU ESP8266 module on transmitted data and received data.

Table 2. Testing the NodeMCU ESP8266

No	NodeMCU ESP8266	Transmitted data	Received data
1	Experiment 1	1.1 kb	22 bytes
2	Experiment 2	1.3 kb	26 bytes
3	Experiment 3	1.4 kb	32 bytes
4	Experiment 4	1.5 kb	34 bytes
5	Experiment 5	1.6 kb	36 bytes

3.2. Testing of sensor vibrate and sensor light dependent resistor

This test is oriented to find out whether the LDR sensor works properly or not when the door/window is opened. This test method is carried out by measuring the voltage on the LDR module when it is illuminated by light from a laser diode. The first testing stage is to find out how much the initial voltage of the LDR module is before it is irradiated and after it is irradiated by using a voltage measuring instrument in the form of a digital voltmeter. Then the vibration sensor is also tested so that when it is implemented, the measurement results can work with the accuracy of the smart home design that will be made. The results of measuring the vibration sensor and LDR sensor values can be seen in Table 3.

Table 3. Testing of vibration sensors and LDR sensors

No	Vibration sensor state	LED	Buzzer	LDR sensor	LED	Buzzer
1	1	On	On	1	On	On
2	0	Off	Off	0	Off	Off

From Table 3, it can be seen from the results of the system test that the results are quite good as seen from the average voltage value of 5 V, meaning that the voltage value is identical to the stepdown module voltage value and this condition makes the buzzer or alarm go off. Testing on an open door, the light from the laser diode will shine on the LDR module and the LDR module will receive light so that the alarm buzzer becomes active. Tests for vibration sensors obtained good sensitivity with good accuracy. Testing the two sensors is the most complex thing so that the success of the tool design becomes more perfect.

3.3. Recapitulation of pollycrystalline photovoltaic output results

After integrating the sensors, the circuit data that has been installed is retrieved using a multimeter. The data to be retrieved is the DC voltage value (V_{mp}), DC current (I_{mp}), and DC power on a DC wattmeter. Following are the results of data retrieval of PV output that is integrated with the smart home security system, shown in Table 4.

Table 4. Power result data integrated PV supply output of home security system

Time	Volt (V)	Ampere (I)	Power (DC)
10.00 am	12.52	0.40	6.20
11.00 am	12.35	0.12	1.42
12.00 pm	12.61	0.45	5.67
13.00 pm	12.63	0.41	5.17
14.00 pm	12.52	0.35	4.38

This smart home application is designed by a renewable technology as a resource to be used. The smart home system concept that is implemented requires additional power supply in the form of PV installation so that the technology used can survive even if the power goes out. To measure the reliability of PV testing connected to the battery, current, voltage and DC power are supplied during testing at peak loads. The test in Figure 2(a) monitors the output results of the DC voltage, then Figure 2(b) monitors the movement of the DC current output and Figure 2(c) monitors the movement of DC power. Monitoring results will later obtain valid data which is then processed to determine the energy conversion produced.

A power supply that uses a PV output source is useful for increasing the power supply to the battery so that when the power goes out the smart home system can still operate properly. In Figure 2, the power produced by the battery is sourced from PV to supply power. Then data is obtained as in Figure 2(a), the extraction is obtained from voltage fluctuations with a rating of 12 to 13 V from PV. Then Figure 2(b) is an extraction for the DC current obtained by fluctuating data due to unstable weather, namely from 0.4 A to down to around 0.1 and reaching a peak of 0.5 A and while Figure 2(c) is an extraction. For fluctuations in DC power output, weather also causes irregularities in charging the battery which will be used as an additional power supply. The results of the power supply obtained will later create a reliable system for earthquake detection in mountain houses using the IoT that is connected to the PV energy supply to have a system that will help the community to be vigilant in maintaining the safety of its citizens because it can be controlled from a long distance.

3.4. Overall system testing

After designing and testing several systems, the next process is to test the overall system performance. This process is oriented to see and evaluate whether the entire system is working properly according to its function. Testing of all integrated components on all sensors which can later send earthquake warning messages via email in real time connected to a smart phone. The results of the test have been very good because the test has been successfully carried out. To see the results of testing the condition of the vibration sensor and connected to IoT, it can be seen in Figure 3.

From Figure 3, it can be seen that in the first scenario when an earthquake occurs, the security system in the form of a short email notification is sent to the smartphone of the user or home owner and is accompanied by the sound of buzzer or alarm 1 (as a security alarm in the house) and buzzer or alarm 2 (as an alarm) security at the security post. Furthermore, the security system will spam email to Android users by sending a message that there was an earthquake around the house. The second scenario is when there is no earthquake, the sensor will send a notification in the form of a state that the house is safe. Based on the results of the performance and experiments carried out this system can function properly with a very good success rate. Then to see the results of message notifications sent via email can be seen in Figure 4.

The test results in Figure 4 are the notification display in the email, namely data from the vibration sensor where the sensor process will work in an earthquake caused by nature. Earthquake warnings on notifications are important so that homeowners can get out as soon as possible. For the second condition, the alarm will turn on loudly so that the focus on this smart home can be related. Then to monitor and analyze IoT capabilities that are integrated on the NodeMCU connected to the feeding sensor, you can see in the web Figure 5 display. The results of testing and analysis of all components of the tool that have been implemented can work as expected. The tool that has been designed will also be installed in the Mount Sinabung residential area. Adjust the web view on the web view to see the position of use in the terrain area at satellite. For data transmission, the last usage is 1.1 kB, received is 22 bytes and also live transmission, there is a fluctuating graph.

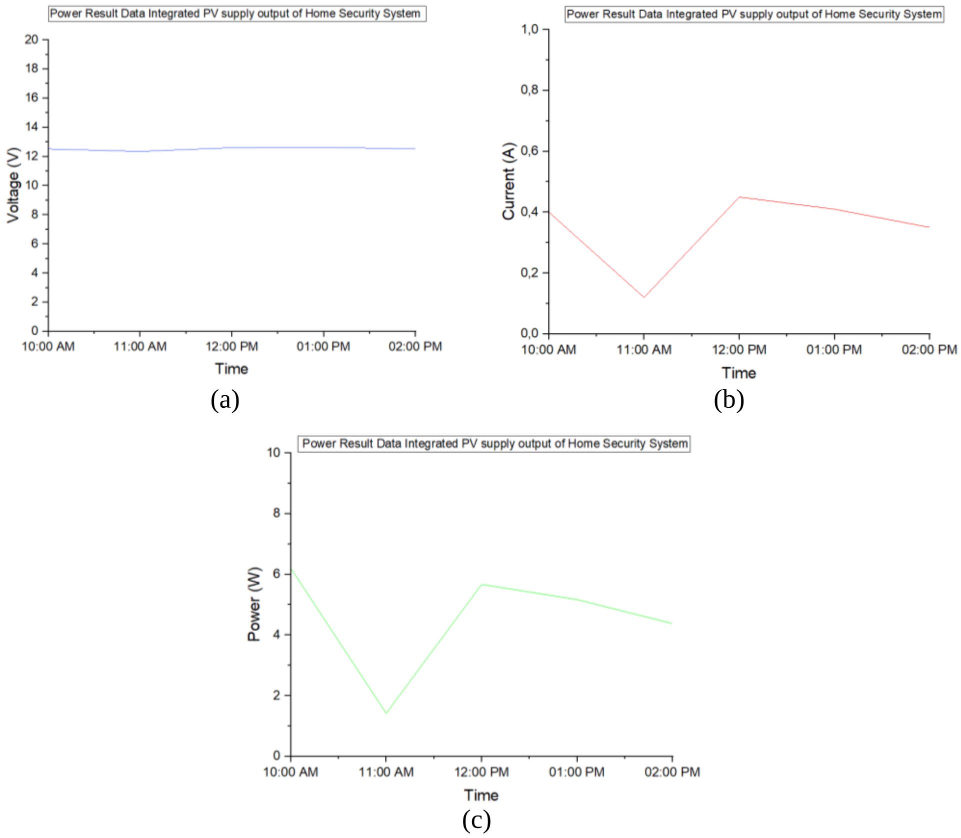

Figure 2. Additional power supply from PV sources (a) DC voltage measurement with graphic display DC, (b) DC current measurement with graphic display, and (c) power measurement with graphic display

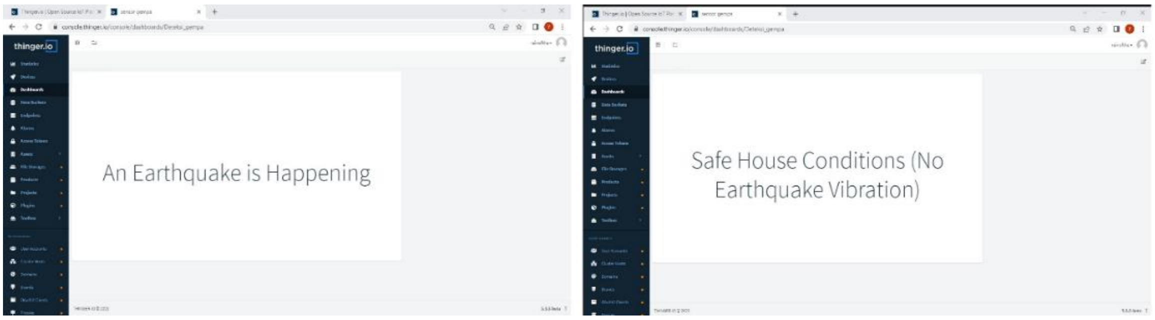

Figure 3. Scenario of earthquake sensor testing results using IoT integrated email

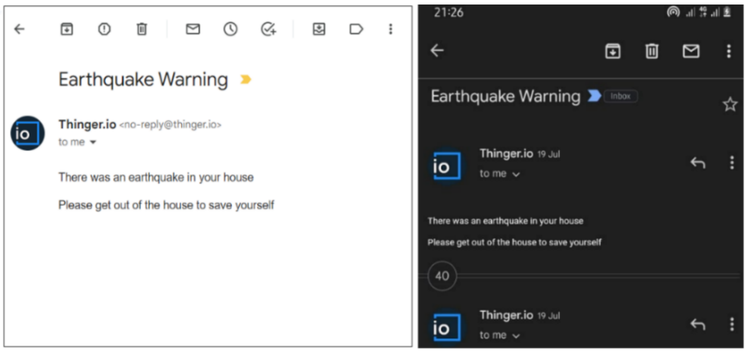

Figure 4. Test results using IoT integrated email for Android

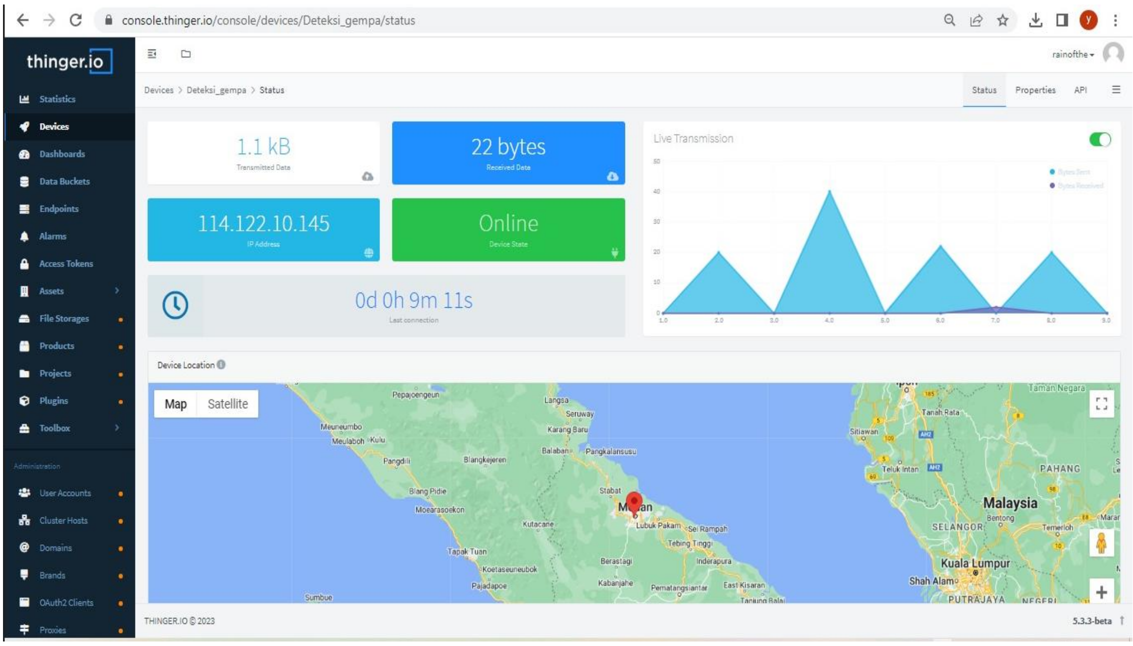

Figure 5. Web display of test results using IoT integrated email

4. CONCLUSION

Based on the test results above and the discussion, it can be concluded that the following home security system based on the IoT has been successfully made and functions properly as expected. This system works with the result of movement or gaps in door a with a distance of the magnetic sensor from the reed switch of approximately 2.5 cm, where the system will activate the security system or security in the form of sounding an alarm. Then when an earthquake occurs, two scenarios will occur. The first sensor will send a notification to an integrated email on an Android smartphone ordering to leave the house, then the second scenario, the alarm will also ring loudly so that the home owner can be prepared to seek help and leave the existing location.

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