Design of Internet of Things (IoT)-Based Earthquake Detector With Solar Cell Back Up

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ABSTRACT: *Earthquake detector as an Internet of Things (IoT)-based earthquake detector with solar cell power backup is an innovation to improve the ability to detect earthquakes effectively and in real time. This tool uses a pendulum cone as the main sensor. The way this sensor works is that when an earthquake occurs, the pendulum will move to touch the ring and conduct an electric current to the microcontroller. Earthquake detection data is processed by the ESP8266 microcontroller to provide alarm warnings and send information wirelessly via the Internet network to firebase and then sent to the application on the smartphone. In addition, this tool is equipped with a solar cell as a backup when the main electricity goes out. The test results show that the Internet of Things (IoT)-based earthquake detector can work well according to the design, namely the alarm and notification on the active smartphone when tested. The highest power of the solar panel is on the second day of 8.35 Watts and the lowest power of the solar panel is on the third day of 2.80 Watts. So the design of tools and software can function properly in accordance with the design.*

KEYWORDS: *Earthquake Detector, Internet of Things, Solar Cell*

I. INTRODUCTION

Earthquakes are vibrations that occur on the Earth's surface due to shifts or cracks in the Earth's crust. These earthquakes can cause damage to buildings and pose a threat to humans. Indonesia, which sits at the confluence of three of the world's major tectonic plates, the Eurasian plate, the Pacific plate and the Australian plate, has a high potential risk of earthquakes [1].

In situations of natural disasters, such as earthquakes, one very important automatic device is the earthquake alarm. With this alarm, the worry of an earthquake, especially at night while sleeping, can be reduced. This is because earthquake alarms can provide warnings quickly and make it possible to take the necessary precautions. Based on this idea, a new device, the earthquake alarm, will be developed that will help people to avoid the impact of earthquakes more effectively. Nowadays, frequent earthquakes cause great losses both in terms of material and in terms of loss of life. These earthquakes often occur when people are resting or sleeping at night. This sleeping condition increases the risk of victims being crushed by buildings during an earthquake.

Therefore, an innovative design of an Internet of Things (IoT) Based Earthquake Detection Tool with Solar Cell Back Up was made, to minimize casualties due to earthquakes that can be controlled and monitored using a smartphone anywhere and anytime. In designing this tool, a pendulum is used as an earthquake detector and ESP8266 as a microcontroller. The way this tool works is that the pendulum sends a command to the microcontroller which is then processed to turn on the alarm and notification on the smartphone.

II. OVERVIEW

Earthquakes are natural events caused by the shifting of plates on the Earth's surface, resulting in damage and almost always leading to both material and non-material losses [2]. These events occur due to disturbances within the lithosphere, the Earth's outer layer, where energy accumulates in a layer approximately 100 km thick due to these shifts [3].

Indonesia, located at the crossroads of active tectonic plates, active mountain ranges, and a tropical climate, is particularly prone to natural disasters. The number of disaster victims in Indonesia is significantly higher than in other countries, with recent data showing an increase in the types of disasters, the number of losses, and casualties, classifying Indonesia as a disaster-prone area [4].

In an effort to mitigate the impact of these disasters, Internet of Things (IoT) technology can play a crucial role. IoT aims to extend the benefits of always-on internet connectivity by enabling uniquely identifiable objects to be virtually represented in internet-based systems [5]. This concept envisions a future where everyday objects are equipped with microcontrollers, transmitters for digital communication, and protocols that allow them to communicate with each other and with users, making these objects integral parts of the Internet [6]. IoT operates through automatic interactions between machines that can be connected without intervention, either from close or far distances. The internet serves as a link between these machines, while users act as regulators and supervisors of their operation. The IoT concept offers the advantage of making work faster, easier, and more efficient by allowing objects around us to communicate with each other through networks such as the internet [7].

With the development of IoT, the internet can be utilized for many purposes such as remote control and monitoring systems, by using the internet to connect the control system and the user's mobile phone. By utilizing IoT, a system for remote control monitoring can be built. The monitoring system functions to provide information that occurs wherever it is located [8],[9].

To support the development of IoT-based applications, platforms like Firebase from Google are highly useful. Firebase enables developers to create applications for iOS, Android, and the Web, providing various tools to monitor analytics, report issues, make app improvements, and conduct marketing and product development experiments. By leveraging Firebase, developers can ensure that their IoT applications run efficiently and reliably [10].

Moreover, the use of electronic components such as buzzers in IoT systems is essential. A buzzer is an electronic component in the transducer category that converts electrical signals into sound waves and is commonly known as a beeper. In this research, the buzzer is used as a warning alarm. The working principle of a buzzer is that when an electric current flows through a piezoelectric circuit, mechanical movement occurs, converting electrical energy into sound energy. Piezoelectric buzzers can produce frequencies between 1 kHz and 100 kHz, with an operational voltage range from 3V to 12V [11], [12].

On the other hand, the use of renewable energy sources such as solar panels is increasingly important in the development of sustainable IoT devices. Solar panels are devices that convert solar energy into electrical energy through two methods: directly using photovoltaic technology or indirectly by concentrating solar energy. Photovoltaic technology converts sunlight directly into electrical energy through the photoelectric effect, while the concentrating solar energy method uses lenses or mirrors combined with a tracking system to focus the sun's energy to power a heat engine. Solar cells or photovoltaic cells convert sunlight into electrical energy, producing a current used to charge batteries [13]. The integration of solar panels into IoT systems can ensure sustainable and environmentally friendly operations .

III. METHOD

This research uses an experimental methodology to develop and test an earthquake detection device using a conical pendulum. The designed device utilizes the working principle of the pendulum to detect earthquake vibrations. The pendulum is hung on a per and conductor wire so that it can swing freely and touch the boundary ring that has been given an electric current, the purpose of adding a per is so that the sensor can detect shocks vertically or horizontally. The sensor is able to detect changes in the pendulum's position due to ground vibrations that occur during an earthquake. The data obtained from the sensor is then sent to the processing system for analysis and storage. To ensure the accuracy and reliability of the device, a series of tests were conducted by simulating various vibration scenarios similar to real conditions. The results of these experiments will be used to refine the design and improve the sensitivity of the device in detecting earthquakes. The experimental method was chosen because it allows for controlled and systematic testing, so that the results obtained can be accounted for and relied upon in field use. Sensor design can be seen in Fig 1 below.

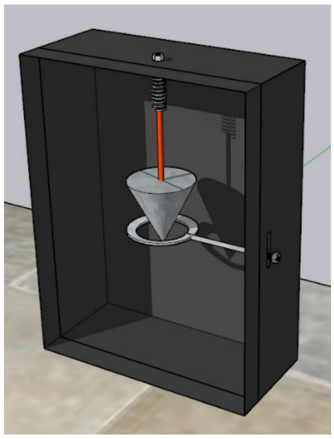

Fig 1. Sensor Gempa Bumi

Figure 2 shows the earthquake detection sensor circuit.

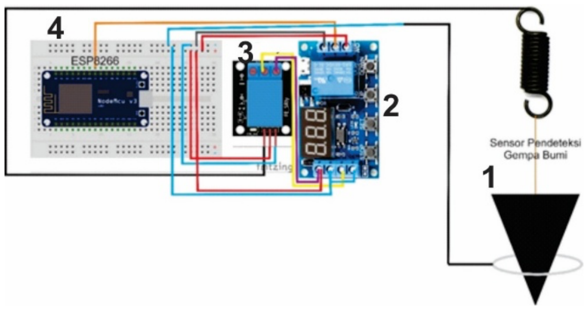

Fig 2 Earthquake Detection sensor Circuit

Description:
1. Earthquake Detection Sensor
2. Timer Delay Relay
3. Relay
4. ESP8266

IV. RESULTS AND DISCUSSION

A. EARTHQUAKE SENSOR CALIBRATION

Earthquake sensor calibration is carried out to determine the performance of the earthquake detection sensor, whether it can work properly in accordance with the design. Testing is done by placing the smartphone as an earthquake meter on the panel box then simulating shocks to calibrate the sensor. The tools used to measure earthquakes are Vibrometer and Vibration Meter applications on android smartphones. The measurement results on the vibrometer apk can be seen in Table 1 below:

Tbl 1. Testing with vibrometer application

NO.	Distance of Pendulum to Ring (mm)	m/s^2	Buzzer Status
1	9	2,2	ON
2	8,5	2,1	ON
3	8	2,0	ON
4	7,5	1,8	ON
5	7	1,7	ON
6	6,5	1,5	ON
7	6	1,4	ON
8	5,5	1,4	ON
9	5	1,2	ON
10	4,5	1,0	ON
11	4	0,9	ON

The measurement results on the vibration meter apk can be seen in Table 2 below:

Tbl 2. Testing with vibration meter application

NO.	Distance of Pendulum to Ring (mm)	Skala Richter (SR)	Buzzer Status
1	9	4,5	ON
2	8,5	4,5	ON
3	8	4,3	ON
4	7,5	4,1	ON
5	7	4,0	ON
6	6,5	3,7	ON
7	6	3,6	ON
8	5,5	3,2	ON
9	5	3,0	ON
10	4,5	2,7	ON
11	4	2,4	ON

Tables 1 and 2 show the results of testing the calibration of the earthquake detection sensor. From the test results in tables 3 and 4, it was found that the highest sensor detected an earthquake at 4.5 SR with a ground acceleration of 2.2 m/s2 and the lowest was 2.4 SR with a ground acceleration of 0.9 m/s2.

B. *POWER SUPPLY TESTING*

Table 3 shows the power graph of the test results on the power supply with load and without load.

Tbl 3 Power Supply Testing

NO	Testing	Without Load (VDC)	With Load (VDC)
1	First Test	5,01	4,8
2	Second Test	5,01	4,9
3	Third Test	5,02	4,9
4	Fourth Test	5,01	4,9
5	Fifth Test	5	4,9
6	Sixth Test	5,01	4,8
7	Seventh Test	5,02	5
8	Eighth Test	5,01	4,9
9	Ninth Test	5,02	5
10	Tenth Test	5,01	4,9

From the test results in table 3, it shows that the voltage generated by the power supply is in accordance with the design and needs of 5v. It can be seen that when a load is applied, the voltage tends to drop slightly from the no-load value.

C. STEPDOWN TESTING

Table 4 shows the XL4015 stepdown test to determine the performance of the stepdown module.

Tbl 4 Stepdown Testing

NO	Testing	Input (VDC)	Output (VDC)
1	First Test	14,32	4,9
2	Second Test	14.32	4,9
3	Third Test	14,30	4,8
4	Fourth Test	14,32	4,8
5	Fifth Test	14,31	4,9
6	Sixth Test	14,31	4,9

7	Seventh Test	14,32	4,8
8	Eighth Test	14,31	4,8
9	Ninth Test	14,31	4,8
10	Tenth Test	14,30	4,8

From the test results in table 4, it shows that the XL4015 stepdown can reduce the voltage well and consistently in accordance with the design and needs of the tool.

D. Solar Panel Testing and Analysis

Figure 3 shows the power comparison graph of the test results on the solar panel on the first, second and third days.

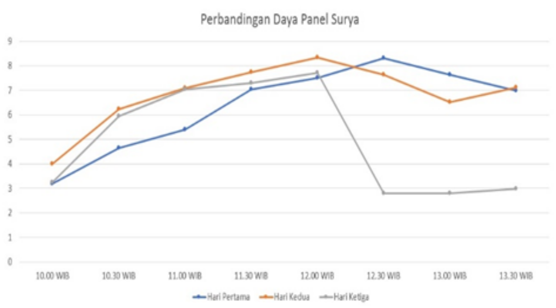

Fig 3 Solar Panel Testing and Analysis

From the results of the first, second and third day of measurements taken at 10:00 am to 1:30 pm, the highest power was generated on the second day of measurements at 12:00 am which amounted to 8.35 Watts due to the weather conditions being sunny so that the intensity of sunlight received by the solar panels was high. The lowest power generated by the solar panel is the third day at 12.30 am, which is 2.80 Watts because the weather conditions are cloudy so that the intensity of light received by the solar panel becomes dim because it is covered by clouds.

E. *Overall Testing of the Device*

This test is carried out on the tool based on a simulation of the overall tool working system, whether it can work according to the program or not, if it is appropriate then the buzzer will be active and notification on the smartphone. Testing is done by giving shocks to the tool.

Tbl 5. Overall Testing of The Device

Shake Testing	Delay (Second)	Buzzer Status	Notification on Smartphone
First Test	3	On	On
Second Test	3	On	On
Third Test	3	On	On
Fourth Test	3	On	On

The test results in Table 5 show that the device has functioned properly according to the program, the earthquake detector can detect shocks and send information to the microcontroller to activate the buzzer and send notifications to the smartphone.

There is a delay in smartphone notifications for 3 seconds, There are several reasons why notifications on smartphones on IoT-based devices can experience delays, this can occur due to several factors such as limited network capacity, slow application performance on smartphones, configuration adjustments, configuration errors or bugs and delays in sending data. The notification display on the smartphone can be seen in Figure 4.

Fig 4 Notification Display

V. Conclusion

In this design, the earthquake detector can work in accordance with the program and design by using a pendulum as an earthquake detection sensor. at the most sensitive setting, this tool starts working at an earthquake of 2.4 SR with a ground acceleration of 0.9 m / s and the largest and largest setting works at 4.5 SR with a ground acceleration of 2.2 m / s. However, there is a 3 second delay in smartphone notifications, this is due to limited network capacity, slow application performance on smartphones, configuration adjustments, configuration errors or bugs and delays in sending data.

From the measurement results of the power supply and XL4015 stepdown, different results are obtained but the situation is still in a stable condition because the relay and other loads function properly according to the design. The highest power generated by the solar panel occurred on the second day at 12:00 am which amounted to 8.35 Watt, this can occur because the sky is clear and the intensity of sunlight received by solar panels is very high. And the lowest power occurred on the third day at 12:30 am which amounted to 2.80 Watts, this can occur because the sky is cloudy so that the intensity of sunlight received by solar panels decreases.

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Muhammad Atha Firdaus S.T, is an engineering graduate who has completed his studies at Pakuan University Electrical Engineering Study Program. Born in Semarang, March 18, 2001. Who is also active in vocational organization activities, namely the Pakuan University Electrical Engineering Student Association. In this research, the author concentrates on the use of tools that are useful and easy to understand by utilizing the Internet of Things (IoT) and Renewable Energy.