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Earthquake early warning system using ADXL335 accelerometersensor based on IoT

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ABSTRACT

Earthquakes are vibrations that occur on the earth's surface due to the sudden release of energy from within the earth that creates seismic waves. Earthquakes are usually caused by movement of the earth's crust (plates). The frequency of an area, refers to the type and size of earthquakes experienced over a period of time. Often with the development of technology, it provides a solution to minimize the impact of earthquake events. For this reason, an earthquake warning alarm is needed as an early warning and anticipation of the community when an earthquake occurs. Therefore, researchers made a tool which uses the Accelerometer sensor and arduino nano as a controller and is accompanied by the blynk application as an earthquake early warning notification sent via smartphone. This tool is processed using an Arduino Nano microcontroller as a controlling component. The working system of this tool uses an 8 Volt lithium battery installed in series as a voltage source, which will be reduced to 5 Volts with a stepdown module, because by using a battery voltage of 8 Volts and coupled with a lot of load, the Arduino Regulator IC will experience overheating or heat up quickly. This tool has been successfully designed with manual testing to be able to see the sensitivity of the earthquake sensor made, by utilizing seismic waves that arise due to ground movement. This tool successfully detects earthquakes with horizontal and vertical vibrations, and this tool is quite effective because it does not detect vibrations generated in the surrounding environment. Based on the tests carried out, at an accelerometer sensor tilt angle of 90o the system reads an earthquake strength of around 7-10 Richter Scale (SR) with a WASPADA status.

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1. INTRODUCTION

Earthquakes are one of the natural phenomena that can be caused by the shifting of the earth's plates and as a result of human activities(Kelman, 2020). Indonesia is an area where the world's plates meet, so Indonesia often experiences earthquakes. Earthquakes are divided into 2 types, namely tectonic earthquakes and volcanic earthquakes. However, earthquakes can also be caused by human activities, such as nuclear weapons testing, excessive exploitation of nature that damages the structure of the earth's bowels, and so on. So this earthquake disaster must always be watched out for because this disaster is a natural event that cannot be predicted when it will occur and how much impact it will have.Earthquake disasters cannot be predicted when they will come, but their impact can be known and felt by using earthquake early warning alarms(Wald, 2020). Residential areas adjacent to the source of earthquakes are very vulnerable areas. Therefore, efforts are needed to anticipate the impact of earthquake disasters and strategic steps to reduce or minimize the impact of loss or damage that can be caused by earthquakes(Shapira, Aharonson-Daniel, & Bar-Dayan, 2018).

Previous studies have been carried out related to earthquake detection, namely earthquake warning alarms are warnings given to the community around an earthquake to take self-rescue measures when an earthquake occurs(Pu & Zhou, 2019). If it successfully detects an earthquake, it will display information on the LCD in the form of an earthquake status display and the earthquake value on the Richter scale and the buzzer will sound as an alarm signaling an earthquake is occurring and sending information that has been connected to the Blynk application asan earthquake early warning notification that can be seen from a smartphone(Babu & Rajan, 2019).The next research is to make an earthquake detection smart lamp alarm with an IoT-based accelerometer(Banerjee & Madhumathy, 2022). The accelerometer sensor is used to detect movement to determine the amount of vibration that vibrates on the ground which has a voltage output. The method used in the development of this system is prototype. This system is able to provide warnings when an earthquake occurs in the form of flashing lights and sounds issued by a buzzer(Prasojo, Maseleno, & Shahu, 2021).The next research is a home door security system against earthquake disasters based on the Internet of Things. This system can provide notifications to all smartphones by simply installing the application(Fan et al., 2021).Making an earthquake warning alarm device as a vibration signal in the vertical direction and horizontal direction using a spring attached to the surface of the piezoelectric sensor(Iriani & Sundawa, 2023). The next research is using the Hall effect sensor UGN3503 as an earthquake detector with an output in the form of an alarm sound that can work well(Dehghan, Tahmasebipour, & Ebrahimi, 2022). The next research is to use a Faraday position sensor to detect earthquakes and provide an alarm when an earthquake occurs with a Faraday position sensor(Du, Dutta, Kurup, Yu, & Wang, 2020).

Based on current problems, earthquakes are one of the natural disasters that are very dangerous for humans and other living things(Wijkman & Timberlake, 2021).However, it is difficult to know when an earthquake and its aftershocks will occur so that a tool is needed that is able to provide earthquake warnings, thereby reducing the number of victims both material and non-material.

So in this research, we will create a system that is able to provide early warning when an earthquake occurs. In addition, this system will be developed with an Internet Of Things (IoT) based application with an android-based user application. Users will receive notifications that will be sent in real-time by the blynk application(Bhasha, Pavan Kumar, Baseer, & Jyothsna, 2021). In addition to receiving notifications, the system also has other additional features that can remind users to immediately save themselves. This earthquake warning alarm tool uses an IoT-based accelerometer sensor by producing information in the form of a display on the LCD, buzzer, and blynk application. This research implements the Arduino Nano microcontroller as the main controller with various other electronic components such as button modules, accelerometer sensors and buzzers.

The use of arduino nano as a microcontroller that manages all connected components to work as desired(Kondaveeti, Kumaravelu, Vanambathina, Mathe, & Vappangi, 2021). In addition to arduino nano, the research also uses NodeMCU as a device to receive data from arduino nano and send it to the blynk application(Hailan, Albaker, & Alwan, 2023). The use of an accelerometer sensor as a ground vibration detector due to an earthquake. The use of an LCD as a display reading of the earthquake value and the status of the earthquake(Hoque, Hassan, Sadaf, Galib, & Karim, 2015). The use of a buzzer as an early warning alarm when an earthquake occurs(Subashini, Sudarmani, Gobika, & Varshini, 2021). The use of blynk as a notification and monitoring sent via a smartphone(Othman & Zakaria, 2020). The use of 18650 lithium battery as the main voltage source that can last for 18 hours(Zilberman, Ludwig, & Jossen, 2019).

It is hoped that the research design of making an earthquake early warning alarm device using the ADXL335 accelerometer sensor which is able to provide notifications and also as an earthquake early warning monitoring can be useful to the surrounding community at the time of the earthquake and can be a reference material for future authors in making earthquake warning alarm devices.

2. RESEARCH METHOD

2.1 Research Design Steps

The research design of the earthquake early warning system using the ADXL335 accelerometer sensor based on IoT with the blynk application, namely: (a) The accelerometer sensor will send a vibration signal when an earthquake occurs, where the signal sending process is carried out by the arduino nano microcontroller as the main controller in the system(Duggal et al., 2022). (b) Then when the signal is received by the sensor and controlled by Arduino Nano, where the earthquake value will be displayed on the LCD screen display with the reading of the earthquake value and the earthquake status (alert, alert, and awas) that has been programmed on the Arduino IDE(Reddy et al., 2023). (c) Then when the signal is received by the sensor and controlled by Arduino Nano, where the earthquake value will be displayed on the LCD screen display with the reading of the earthquake value and the earthquake status (alert, alert, and awas) that has been programmed on the Arduino IDE. (d) When the buzzer sounds, it means that the tool used is successful and indicates that the earthquake disaster early warning alarm is functioning properly as desired(Lee, Khan, Choi, & Kwon, 2019). (e) Furthermore, the NodeMCU also sends information to the blynk application, which is used as a notification and monitors earthquake conditions(Chethan, Jayaraj, Jatinjayasimha, & Srihari, 2021). (The buzzer will sound as a warning alarm to inform the public that if an earthquake occurs, they can evacuate to a safer place.

a. Hardware Design

The hardware design begins with the creation of a system block diagram. The block diagram for this design can be seen in Figure 1.

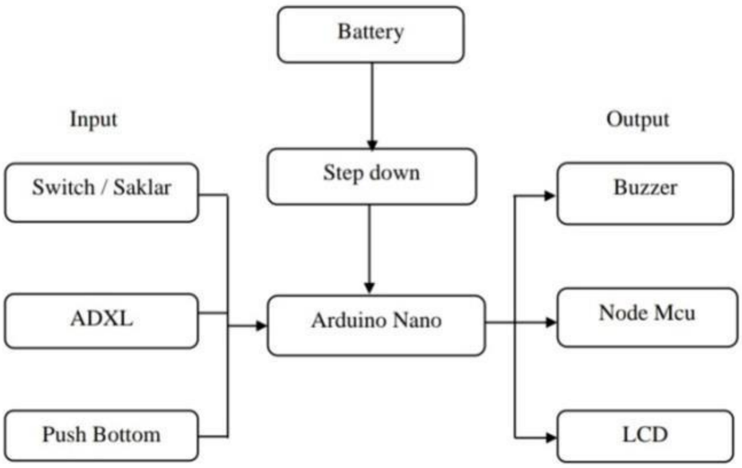

Figure 1. System Block Diagram

In the block diagram above, how the system works starts from Arduino nano. Arduino nano as an input and output data processor to process system work starts when power is provided from the battery to the step down module to reduce the voltage to 5 Volts, then the output voltage from the step down module is given to Arduino nano, so that it gets a power supply(Rahayu, Widlan, & Bramantyo, 2022).Furthermore, all components connected to the arduino nano will be able to work according to the program that the user has designed.

b. Arduino Nano Design with Accelerometer Sensor

The design of this section, the accelerometer sensor operates at a voltage of 2.2-3.6 Volts with a typical voltage of 3.3 Volts (Vdd). The output of the ADXL335 accelerometer sensor is an analog voltage which presents acceleration data in units of gravity (g)(Ghazali & Rahiman, 2022).The X legout of the accelerometer sensor is connected to the A leg1 of the Arduino nano. The Y legout of the accelerometer sensor is connected to the A leg2 on the arduino nano, and the Z legout of the accelerometer sensor is connected to the A3 on the arduino nano.

Arduino Nano design with 12C LCD, In this design, the LCD already uses an I2C module so that fewer jumper cables are used and the circuit is more efficient(Damala & Patnaik, 2023). Where the serial data pin (SDA) on the LCD is connected to leg A4 serial data on arduino nano, the serial clock pin (SCL) on the LCD is connected to leg A5 serial data on arduino nano, there is an LCD to ground (GND) and there is a V pinCC on the LCD to 5V voltage. The I2C LCD functions to display the value of the 3 axes that come from the ADXL 335 sensor(Rajan, 2021).

Arduino Nano Design with Switch, Stepdown and Battery, In this design, it can be seen that the stepdown module, switch, and battery are connected to the Arduino nano. For the switch component, leg 1 is connected to the negative input (-) and leg 2 is connected to the negative pole on the battery. For stepdown components on the positive input foot (+) connected to the positive pole on the battery. The stepdown component in this circuit functions as a voltage drop on the battery(Swastika, Hendriyati, & Cahyadi, 2021).Where the battery used is 18650 lithium battery In this case(Chuang, Yao, & Wu, 2020), it takes 2 batteries installed in series of 8 Volts, while the required voltage is only 5 Volts, so the stepdown is here to reduce the voltage from 8 Volts to 5 Volts. The positive (+) output leg of the stepdown is connected to the Vin leg on the arduino nano, and the negative (-) leg of the stepdown is connected to the GND leg on the arduino nano.

Arduino Nano design with NodeMCU ESP8266, In the design of this section, NodeMCU is used as a wi-fi module only not as a microcontroller(Kodali, Pathuri, &

Rajnarayanan, 2020).On pin D2 NodeMCU as TX is connected to pin D3 arduino nano. On pin D3 NodeMCU is connected to pin D2 arduino nano as RX . The circuit can be seen in Figure 2 the overall circuit.

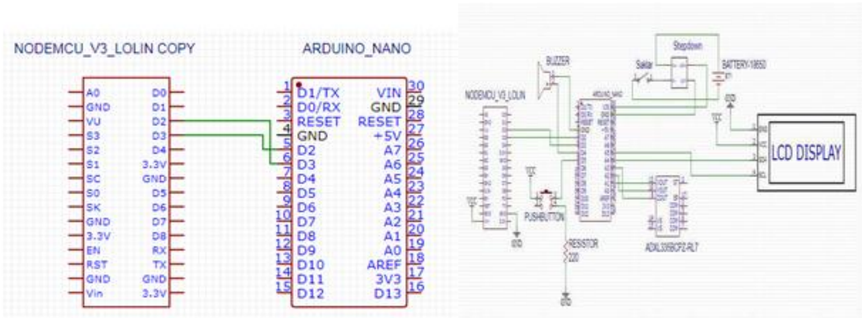

Figure 2. Overall circuitof the earthquake early warning system

Software Design, At this stage of software design, starting with the creation of a flowchart in accordance with Figure 9. The software design is divided into two, namely the design of the Arduino program, and the design of the Blynk application(Apriani, Oktaviani, & Sofian, 2022). Where the arduino program functions to make commands on each device so that it can work as desired(Budiyanto et al., 2022).Blynk serves to send warning notifications if there is an earthquake in an area(Balamurugan et al., 2022).

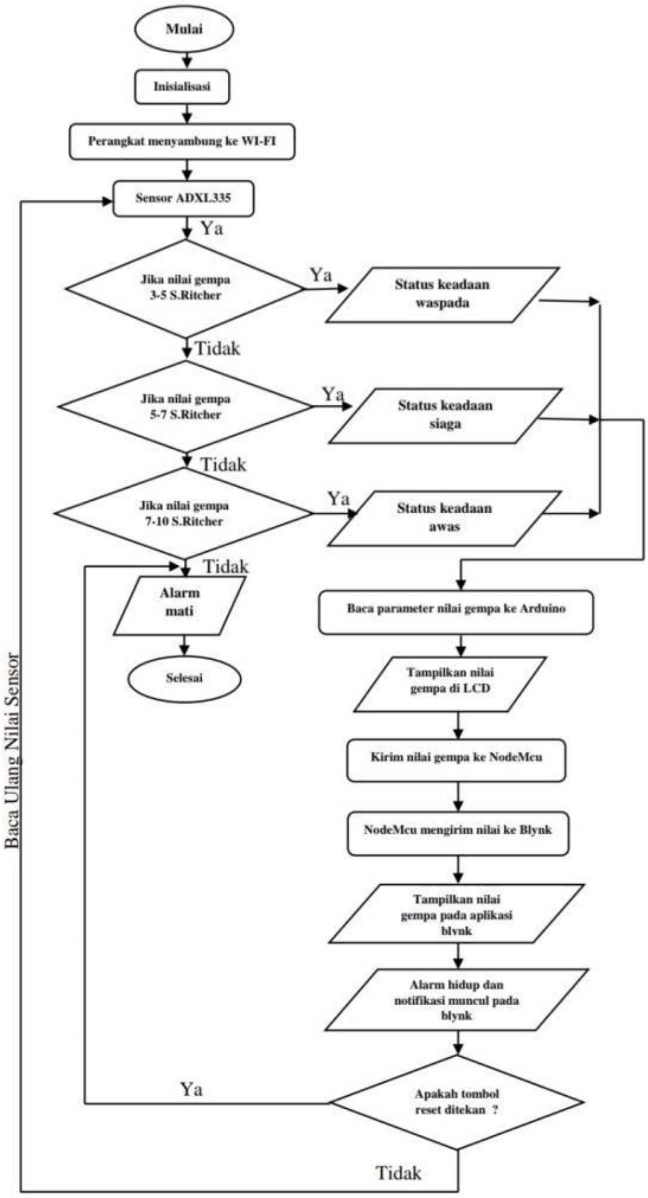

Figure 3.Software Design Flowchart

b. Testing Method

The workings of the earthquake detection system with the slope method on the surface of the earth starting from initialization and initial values determine the input and output parameters of each variable. Then proceed with connecting the device to wi-fi. There is an ADXL335 sensor as a component to be able to read the value of earthquake vibrations, followed by reading the earthquake value to arduino nano as the main controller in the system(Khandelwal, Ramtekkar, Chauhan, Bhute, & Kouthekar, 2022). After the arduino nano, it continues by displaying the earthquake value on the LCD. After knowing the magnitude of the earthquake value detected by the accelerometer sensor where the NodeMCU as access sends the earthquake value to blynk which is connected via wi-fi on the smartphone device.

If the earthquake is detected by the accelerometer sensor and it is known that the earthquake parameters are 3-5 Ritcher Scale, the buzzer will sound as a sign of an early warning alarm of an earthquake, and a notification will appear on blynk and with the status of an alert state on the earthquake. Likewise, on parameters 5-7 Ritcher Scale and 7-10 Ritcher Scale received by the accelerometer sensor, the warning alarm will sound according to what has been programmed in the arduino IDE software and a notification will appear on the blynk application. In addition to the notification, the blynk application also monitors the state of the earthquake and also as a reset button to turn off the alarm and display to its original state.

3. RESULTS AND DISCUSSIONS

3.1 System Testing Results

a. ADXL335 Accelerometer Sensor Testing

Based on the degree of tilt, the value of the earthquake on the Ritcher Scale (SR) was obtained at Table 1.

Table 1. Accelerometer Sensor Testing

Tilt angle	Earthquake Status	Earthquake Value
0°	-	0 SR
15°	Alert	2-3 SR
30°	Alert-Alert	3-5 SR
45°	Alert-Watch	5-7 SR
90°	Watch out	7-10 SR

The angle of inclination determines the earthquake value and the change in earthquake status. This can be seen in Figures 4.

Figure 4. Earthquake value status

3.2 Discussion

Berdasarkan beberapa pengujian yang telah dilakukan dengan memanfaatkan teknologi arduino alat ini bekerja sesuai dengan apa yang telah diprogramkan pada Arduino IDE. Selain teknologi arduino, alat ini juga dapat dikembangkan dengan pengembangan teknologi pada sensor yang dapat mendeteksi ketika terjadi gempa pada getaran yang diujikan.

a. ADXL335 Accelerometer Sensor Testing

This accelerometer sensor test aims to determine whether this sensor can work as desired and will be able to detect earthquake vibrations or not. This test is placed on a flat surface and safe from interference with the position put to sleep (in the initial position). Then this test is carried out by changing the tilt angle from the initial position to a position of 90 degrees. This tilt angle itself is done to determine the value of the earthquake.

b. NodeMCU ESP8266 Wi-Fi Module Connectivity Testing with Blynk App

This test is done by connecting the NodeMCU component to connect to the wi-fi on the smartphone. The trick is to get an auth token in the blynk application and will go to the email registered on blynk, if you get an auth token then the devices are connected to each other.

c. Testing on LCD

Testing on the LCD is done by providing a voltage of 5 Volts to the battery as a voltage source to run this tool. The results shown on the LCD screen display as in Figures 15, 16, 17, 18 show that this tool is functioning properly.

d. Testing the Buzzer

Testing on the buzzer is done by providing a voltage of 4.53 Volts when it gets a high signal, the buzzer will sound. And when it gets a low voltage signal of 0 Vol, the buzzer will turn off. This buzzer test is used as a warning alarm when an earthquake occurs.

e. Testing on Pushbutton

Testing the push button is done by applying a voltage of 5 Volts. The push button is used to reset the device back to its original position. The push button can only work when it is pressed with logic 1 and has a voltage of 5 Volts. When an earthquake occurs and the buzzer has sounded, then to restore this tool and turn off the alarm by pressing the reset button on the blynk application.

f. Lithium18650 Battery Testing

Testing the 18650 lithium battery used as a voltage source in the earthquake warning alarm system. The batteries used are 2 pieces mounted in series with a voltage of 8 Volts. However, the voltage used in the tool is only 5 Volts, so a stepdown is needed as a voltage drop so that the voltage used does not exceed the predetermined limit. Where the battery capacitance used is 2200 mAH with the total current obtained in the digital multimeter 0.12 A to 120 mA. Then the capacitance value of 2200 mAH divided by the total current of 120 mA results in 18.33 H. Thus we know the battery used can last for 18 hours.

When an earthquake occurs, the ADXL335 sensor sends a signal to the Arduino and is forwarded to the NodeMCU to be connected to the Blynk application. If an earthquake occurs, the display on the LCD will show the reading of the earthquake value and the status of the alert condition and a notification will appear on the Blynk application of changes in the earthquake value and condition status in the same earthquake as on the LCD and Blynk display. It was found that this tool has functioned properly in accordance with what has been programmed on the Arduino IDE. So, this tool can be tested if an earthquake actually occurs. By using this tool, people can know or take action if an earthquake occurs in their place.

4. CONCLUSION

Earthquakes are one of the natural disasters that we cannot predict when they will occur, therefore Penelitim conducted a study which uses the ADXL335 accelerometer sensor which is used to detect ground vibrations caused by earthquakes and uses lithium batteries as a voltage source so that this earthquake early warning alarm tool can work even during power outages, this battery can also last long enough and is made of environmentally friendly materials. So that with this earthquake detection device, it can anticipate residents to be prepared if an earthquake is detected.

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