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DISTANCE RANGE TEST OF SW-420 SENSOR-BASED VIBRATION DETECTION SYSTEM

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ABSTRAK

Proses gelombang yang disebabkan oleh getaran dapat dimanfaatkan dalam hal pemantauan struktur bangunan, analisis kebisingan peralatan industri, dan deteksi gempa. Gempa bumi memiliki dampak berbahaya pada manusia karena pergerakan lempeng bumi di bawah permukaan. Berbagai teknologi di berbagai cabang ilmu dikembangkan untuk dapat mendeteksi pergerakan lempeng dengan cepat dan baik. Tulisan ini juga menguji jangkauan sensor SW-420 terhadap sumber getaran. Memahami jangkauan sensor SW-420 sangat penting karena memungkinkan Anda untuk menyesuaikan batas sensitivitasnya sesuai dengan kebutuhan aplikasi. Meskipun informasi ini umumnya tersedia dalam lembar data, memahami jangkauan dapat membantu mengoptimalkan penggunaan sensor untuk deteksi getaran atau guncangan yang lebih akurat. Respon sensor akan dikirim ke mikrokontroler untuk menghasilkan sinyal suara pada buzzer ketika terjadi getaran. Mikrokontroler akan memproses sinyal analog dari sensor menjadi sinyal digital. Semakin jauh jangkauan sensor, semakin baik sensor tersebut dalam mendeteksi getaran. Dalam uji ini, dilakukan uji jangkauan terhadap sumber getaran. Sumber getaran berasal dari objek dengan massa tertentu yang dijatuhkan. Dalam uji ini, diketahui bahwa SW-420 mampu mendeteksi dengan jarak maksimum 200 cm dari sumber getaran.

Kata Kunci: Deteksi, Getaran, Jarak, Mikrokontroler, Sensor

ABSTRACT

Wave propagation due to vibration can be utilized in terms of monitoring building structures, analyzing industrial equipment noise, and earthquake detection. Earthquakes have a harmful impact on humans due to the movement of subsurface plates. Various technologies in various branches of science were developed to be able to detect plate movements early and well. This paper also tests the range of the SW-420 sensor to the vibration source. Understanding the range of the SW420 sensor is crucial as it allows you to precisely adjust its sensitivity limits according to the application's needs. Although this information is generally available in the datasheet, comprehending the range can assist in optimizing the sensor's usage for more accurate detection of vibrations or shocks. The sensor response will be sent to the microcontroller to produce a sound signal on the buzzer when there is vibration. The microcontroller will process the analog signal from the sensor into digital. The farther the range of the sensor, the better it is at detecting vibrations. In this test, a range test is carried out on the vibration source. The source of the vibrations comes from objects with a certain mass that is dropped. In this test, it was found that the SW-420 was able to detect with a maximum distance of 200 cm from the vibration source.

Keywords: Detection, Distance, Microcontroller, Sensor, Vibration

I. INTRODUCTION

Wave propagation is generally caused by the existence of something that moves back and forth; this trait is utilized in the field of engineering, such as in the detection of building structures, strength and stability of objects, the level of industrial noise and earthquake detection (1). In earthquakes, vibrations that appear are often called seismic waves. Seismic waves that appear during earthquakes appear due to the movement of tectonic plates below the surface (2). The energy in the plate exceeds the maximum threshold of the existing rock material, resulting in the release of power in the form of plate movements. Indonesia is on three active plates, namely the Australian Plate, the Philippine Plate, and the Eurasian Plate (3). Each movement of tectonic plates can potentially trigger earthquakes.

Simulation in the form of earthquake disaster mitigation is carried out at every level of education (4, 5, 6). Early earthquake detection technology was developed starting from the data processing system, data communication, data display and sensor as a detection of the magnitude of the earthquake itself (7, 8). Mathematics and computational solutions are also carried out to reduce the impact caused by earthquakes (9,10).

Some people can find out the existence of an earthquake with only a specific force, and the limit of small earthquake strength can only be known for information from the Government Agency (BMKG) because detection tools are still in limited quantities(11). Based on that condition, this study tries to design, build and test simple vibrational detection tools based on SW-420 sensor. This sensor is equipped with an adjustable potentiometer to control sensitivity, and the potentiometer serves as a guide during the calibration process at specific points, involving 20%, 40%, 60%, 80%, and 100%. The SW-420 sensor produces a binary signal, namely 1 or 0, indicating the presence of high or low vibrations. Findings from similar previous research confirm that a sensitivity level of 40% is the most consistent point for detecting vibrations. After identifying the midpoint on the sensor, the next step is to calibrate the sensor using a vibration measuring tool, namely a vibrationmeter. In a similar study on the SW-420 sensor conducted in another article, it was found that the results from a sensitivity level of 40% are recognized as a consistently reliable point for detecting excessive vibrations (12, 13). Distance detection tests were conducted to evaluate the extent to which the sensor can detect vibrations. The hope is that the use of simpler equipment will facilitate usage by specific communities.

A microcontroller is a chip in the form of an IC (Integrated Circuit) that can receive input signals, process them and provide output signals according to the uploaded program (14, 15). The microcontroller input signal comes from the sensor, which is information from the environment. In contrast, the output signal is aimed at the actuator, which can affect the environment. So, the microcontroller can be likened to the brain of a device that can interact with the surrounding environment(16). Arduino uno is a microcontroller board based on the Atmega328, featuring a reset button, as illustrated in Figure 1. The Arduino Uno serves as the central controller, functioning as the data input and output processor for all connected components. The reset button plays a crucial role in initiating the microcontroller's reset process when anomalies occur during programming (2).

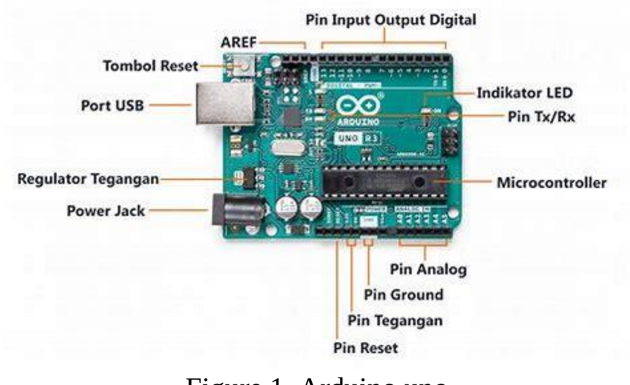

Figure 1. Arduino uno

The SW-420 sensor module is designed for detecting vibrations. The sensor operates by employing a single metal float that vibrates within a tube containing two electrodes when the sensor receives vibrations or mechanical shocks (Figure 2). There are two output modes available: digital output (0 and 1) and analog output (voltage) (17). The SW-420 vibration sensor can produce 15,322, -28.602.4 pulses which are converted to 5-10 Richter Scale (SR) (18).

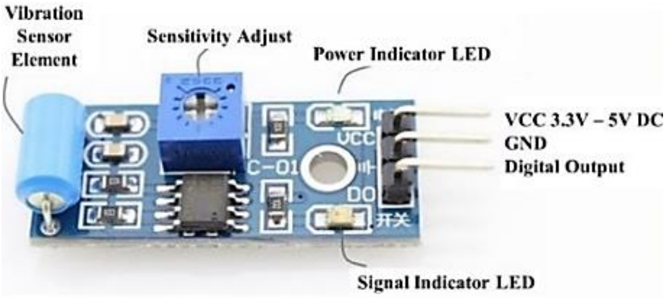

Figure 2. SW-420 sensor module

A buzzer is an electronic component of the transducer family which can convert electrical signals into sound vibrations (19). It is generally used for alarm series in hours, bells, danger warning devices, and so forth. The buzzer earthquake detector is used as one of the components of the tool warning (20).

LCD I2C 16X2 can display as many as 32 characters consisting of 2 lines, each displaying 16 characters. In the design of the earthquake detector, the LCD served to display an earthquake detection warning (21).

II. RESEARCH METHOD

This research commenced with constructing a sensor-based electronic system involving several components. The main components used include the SW-420 sensor as an input for vibration detection, a microcontroller as the system's central processing unit, and outputs as an LCD and a buzzer that functions as an automatic alarm when vibrations occur. This system also incorporates supporting components such as capacitors, resistors, and a power supply. The electronic schematic can be observed in Figure 3.

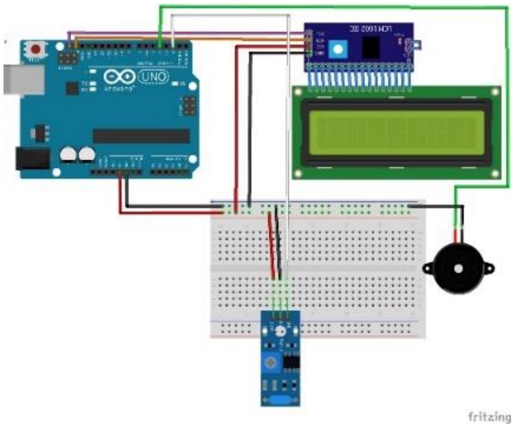

Figure 3. Electronic schematic

The sensor will detect and respond to the vibrations occurring in its vicinity, which are subsequently processed by the analog-to-digital converter (ADC) integrated within the microcontroller. It will then issue a command to turn the buzzer 'ON' when there is an input signal from the sensor and conversely, turn it 'OFF' when no input signal is detected. The stages of research conducted by the author can be seen in the Figure 4.

The process of developing this tool begins with creating a program using Arduino Idea software specifically designed to develop microcontrollers. The microcontroller will run the program according to the language that has been programmed into it. After this stage, a series of series tests are carried out to evaluate whether the system can function according to the language flow that has been inputted into it.

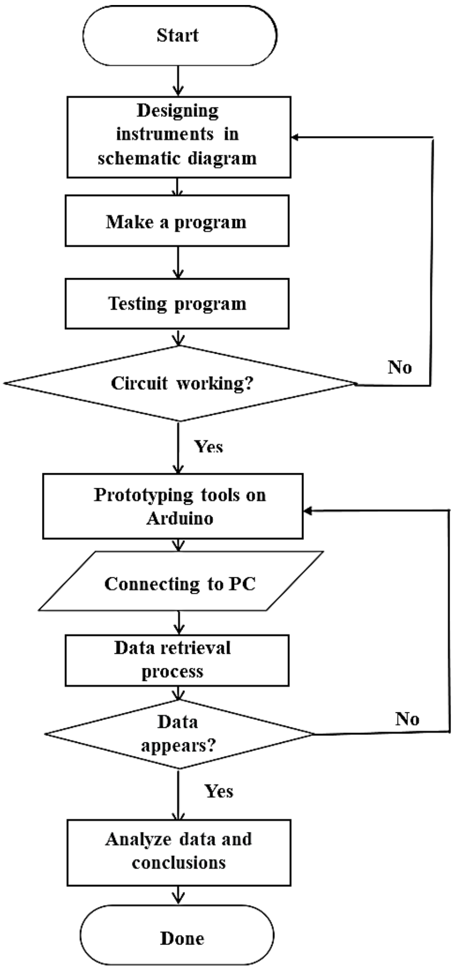

Figure 4. Flow of research stages

Furthermore, a variation of distance variations is carried out as a first step in testing the earthquake detection system that has been designed and built. In this stage, the generated data will be analyzed to determine the minimum and maximum distance the system can detect. Testing the distance of the sensor's range to the source of vibration is carried out with the scheme described in Figure 5.

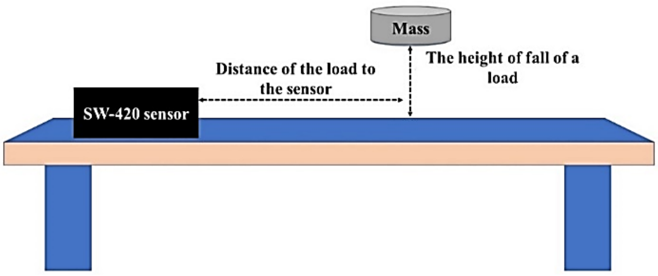

Figure 5. The experimental procedure involving the release of a load

An object with a certain mass and a certain height is dropped onto the surface at a horizontal distance from the sensor location. To test the impact, horizontal distance variations were applied in the range between 40 to 200 cm and vertically constant at a height of 50 cm for one type of object mass. The masses of objects used as vibration sources have weights ranging from 200 grams, 400 grams, 600 grams, 800 grams, to 1000 grams.

Furthermore, the sensor's sensitivity was tested by moving it at a specific velocity, as described in Figure 6. The sensor was moved back and forth at a constant distance and for a predetermined period of time.

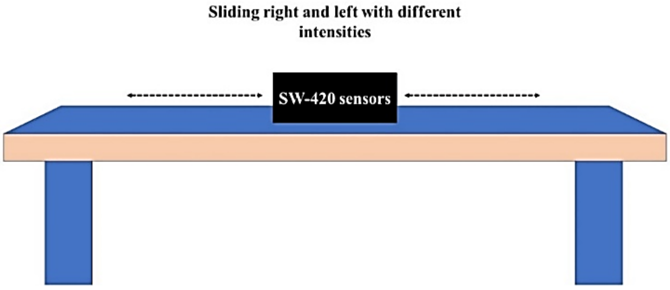

Figure 6. The experimental method shifted

Measurement of shear speed on the sensor at a distance range between 20 to 60 cm can be categorized based on how often the sensor is experiencing alternating motion within 1 second. Shear speed is considered low if the sensor experiences alternating movements once in 1 second. If, in 1 second, there are two alternating movements, the speed is considered moderate. Meanwhile, the speed is considered high if the sensor experiences alternating movements four times in 1 second. The analogy used in this situation is to compare the phenomenon of earthquake intensity with different levels of strength.

Once the schematic diagram with the Arduino program has been checked and executed, the next step involves assembling the device based on the schematic onto the Arduino kit and connecting it to a PC.

III. RESULTS AND DISCUSSION

Figure 7. is an electronic of the vibrating system with a SW-420 sensor. This arrangement encompasses pivotal components such as the SW-420 vibration sensor, operational amplifier, microcontroller, LED indicator, and buzzer. The primary objective of this system is to discern vibrations and provide visual and auditory feedback in response to vibrational events.

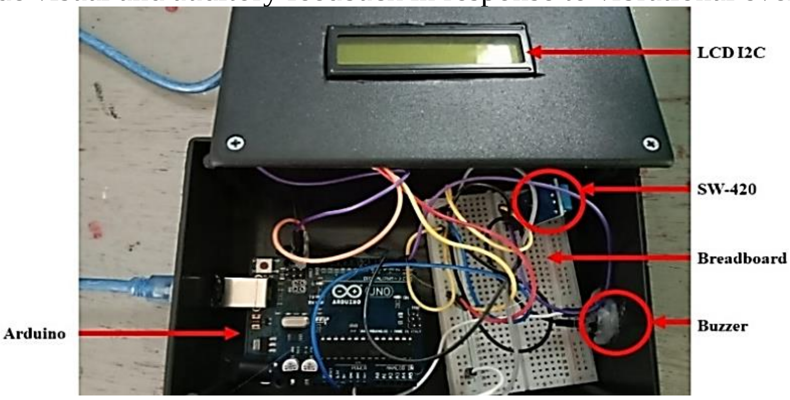

Figure 7. Electronic system

When applying the maximum horizontal distance measurement of the vibrating source to evaluate the performance of the sensor, the electronic system with the vibration sensor was placed horizontally on a flat surface, according to Figure 8. This placement was chosen for optimality of detection and stability during the measurement of the maximum horizontal distance and sliding speed.

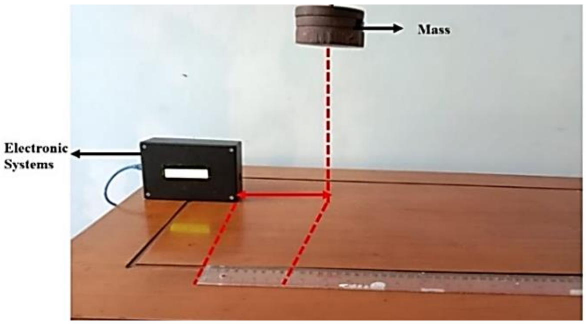

Figure 8. Testing of experimental methods

The initial stage in the effort to understand the horizontal range of distance that can be detected by the sensor involved conducting a series of tests. The data obtained from these tests was subsequently analyzed and presented in the form of a graph in Figure 9. The graph represents the results of the tests, indicating the maximum horizontal distance that the sensor is capable of detecting.

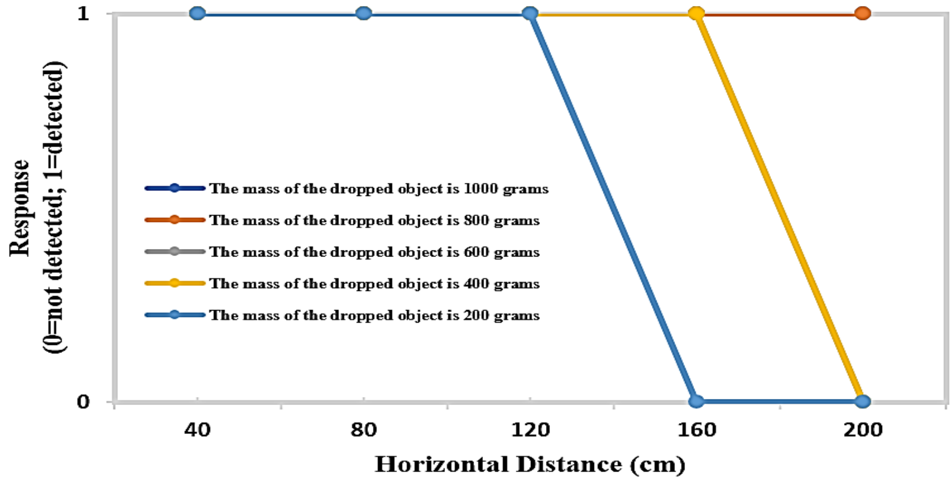

Figure 9. Graph of test results

At the lowest mass (200 grams), the system can detect maximum vibrations at a distance of 120 cm, while for a mass of 400 grams, the system can detect vibrations up to a maximum distance of approximately 160 cm. The system can detect vibrations at distances of up to 200 cm for other test masses.

The subsequent testing phase involves recording seismic intensity by measuring the lateral (left-right) motion of the sensor at a specific velocity. This depends on the frequency of the sensor's lateral motion within a one-second interval at varying distances ranging from 20 to 60 cm. Findings from previous similar research confirm that a sensitivity level of 40% is the most consistent point in detecting vibrations. The acquired data from this testing phase is documented in Table 1.

Table 1. Intensity of shift

Distance (cm)	Intensity	Response
	Low	Not detected
20 cm	Mid	Detected
	High	Detected
	Low	Not detected
30 cm	Mid	Detected
	High	Detected
	Low	Not detected
40 cm	Mid	Not detected
	High	Detected
	Low	Not detected
50 cm	Mid	Not detected
	High	Detected
	Low	Detected
60 cm	Mid	Detected
	High	Detected

The observed data in Table 1 indicates that the sensor is capable of measurements with a higher level of accuracy, especially at increasing distances, particularly up to 60 cm, and at high levels of movement intensity. Conversely, when the distance decreases and the movement intensity decreases, the sensor's ability to measure may experience limitations, resulting in a decrease in accuracy and precision.

IV. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

Based on the test results, the SW-420 vibration sensor demonstrates optimal sensitivity when exposed to nearby vibration sources, significant dropped masses, and moderate intensity of displacement. The sensor's response remains consistent even at high displacement intensities, reflecting its reliable detection capabilities. Evaluation criteria involve response range, precision in response measurements, precision in repeated measurement results, and accuracy compared to true values. This sensor performs well in detecting vibration variations in accordance with the specifications outlined in the SW-420 Sensor datasheet. With characteristics such as optimal sensitivity, precision, and accuracy, the sensor delivers reliable performance consistent with the expectations elucidated in the datasheet.

The vibration signal detection process can respond from all directions, encompassing both vertical and horizontal orientations, with 360-degree coverage. This earthquake detection system, which is based on vibration sensors and microcontrollers, can also be used to detect very subtle vibrations. Using a power bank as a backup power source can provide electricity during power outages during earthquakes.

In addition to earthquake detection, the sensitivity of the SW-420 vibration sensor can also be applied to other purposes, such as triggering anti-shock devices, theft prevention alarm systems, smart vehicles, and motorcycle alarms.

4.2 Recommendation

It is recommended that future research to integrate vertical tests to evaluate the effect of falling loads. In addition, for testing the intensity of the shift, it is recommended to use an automated system as an alternative to the manual technique that has already been done.

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