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Characteristics of Wireless Vibration Sensors for South Aceh Polytechnic Building

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ABSTRACT

Vibration is a back-and-forth movement in a certain time interval that produces waves in a medium. Vibration can occur on a small or large scale. So on a small scale, a vibration sensor is needed to detect certain phenomena such as vibrations of engine capacity and detected pressure. On a large scale, vibration sensors can be used to detect earthquakes and other major phenomena and design a real-time vibration detection system for long distances, so vibration sensor components, controllers, and radio systems are needed. Therefore, researchers made a simple vibration detector using the experimental method. This final project aims to design, realize, and test the characteristics of the MPU 5060 accelerometer vibration sensor that is connected wirelessly. The characteristics of the sensor are tested against the magnitude of the vibration source, the distance of the vibration source, the placement medium, and the detection period. After testing the tool 10 times, it can be concluded that this simple vibration detector functions well and the highest average load results are obtained, namely in the 1-kilogram load test with a value of 1.93026 and the lowest average results are in the ceramic load test with a value of 0.651357.

INTRODUCTION

Vibration is a back-and-forth motion around equilibrium, where equilibrium is a state where an object is at rest if there is no force acting on the object. Vibration has the same amplitude (the distance of the furthest deviation from the midpoint). Motion can be repeated and each repetition of motion can be taken simultaneously, called periodic motion. On a small scale, vibrations are usually caused by human activity facilities and equipment or can also be called mechanical vibrations. These vibrations occur in plucked guitar strings, vibrating vocal cords, and machines working in industry.

On a large scale, vibrations can be in the form of shifting earth plates, explosions, or other physical phenomena. An earthquake is a vibration in the earth that occurs as a result of the sudden release of energy accumulated in rocks that experience Earthquakes are natural phenomena that cannot be avoided. This natural phenomenon occurs due to the sudden shifting of tectonic plates with a force ranging from small to large scale. One of the impacts of an earthquake disaster is damage to a building because the waves in the earthquake cause the soil layer to move.

The building is a place used for work or home in the current era of globalization, the economy is growing rapidly, one of which is a multi-story building. Multi-story buildings function as shopping centers, offices, and faculty buildings. The security factor in multi-story buildings is the main thing in ensuring the safety of building users. To ensure the safety of building users, a security system is very necessary against dangers or disasters that occur and must be implemented together with the security process (Suraya & Novianta, 2013).

One of the events that may occur in a building is a fire, while events that may occur on a city scale are earthquakes and building collapse. To avoid many victims falling due to these events, a building collapse mechanism must be prepared. An early warning system must be built to increase the preparedness of all parties involved. The type of damage that causes buildings to quickly rot is the poor quality of the materials used. Workers who like to be careless in their work and are not careful in terms of work. The cause is an accident that can even cause incidents that can even claim lives.

Based on the problems above, a tool is needed that can detect the fragility of a building, to help determine which buildings are already brittle. Therefore, the author took the final project entitled "Characteristics of Wireless Vibration Sensors for Poltas Buildings".

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LITERATURE REVIEW

Research that has been carried out by previous researchers, both those who researched measuring vibrations for earthquakes and those who conducted research using similar methods and technologies, include: Earthquake Detection Prototype Using Wave Propagation Method On Microcontroller Based Vibration Sensor With Sms Gateway Information (Suraya & Novianta, 2013). Earthquake Location Detection System Using Arduino Mega 2560, SW-420 Sensor, GPS and SMS Notification (Kurniawan et al., 2020). Design Of Web-Based Earthquake Information System Using Raspberry Pi (Ulil Albab et al., 2023). Design and characteristics assessment of wireless vibration sensor for buildings and houses (Suherman et al., 2021). Development and Verification of Wireless Vibration Sensors (Pei et al., 2023). Design Of Automatic Door Locking System Using Knock Vibration Detector (Fadilah et al., 2015). Earthquake Detection System With Piezo Electric Based On At89c51 Microcontroller (Novianta, 2012). Security Door System Using Knock Sensor Based On Arduino Uno (Fitriyani, 2022). Implementation of the Internet of Things on a Wheelchair using the MPU6050 Sensor (Maqfirah et al., 2023). Opening Doors Using Internet Of Things (IoT) Based Face Recognition (Ariansyah et al., 2021). Design of Safety Worker Helmets Based on the Internet of Things (Urmila et al., 2024). Implementation of Vibration Sensor and Pin Lock using Keypad for Charity Box Security (Ilham et al., 2022). Vibration Measurement to Determine Vibration Levels in Variable Speed Transmission Systems of Milling Machines Using Overall Vibration (Ariyanto, 2019). Study of Ground Vibration Measurements in Blasting Operations at PT Semen Baturaja (Persero) Tbk. (Purwaningsih et al., 2023). Whole body vibration measurement according to Permenaker No. 5 of 2018 at PT. A (Andianingsari et al., 2023). Mechanical Vibration Measurement Based on Building Type (Purwanto et al., 2022).

METHOD

Design Scheme

Overall, the process of this vibration detection system begins with reading sensor data with input in the form of vibrations caused by objects dropped from the same height with different falling object weights from each test. The MPU 6050 sensor will read the movement that occurs, and the results are sent via radio waves to be viewed on a receiving device that has been connected to a computer as a display media.

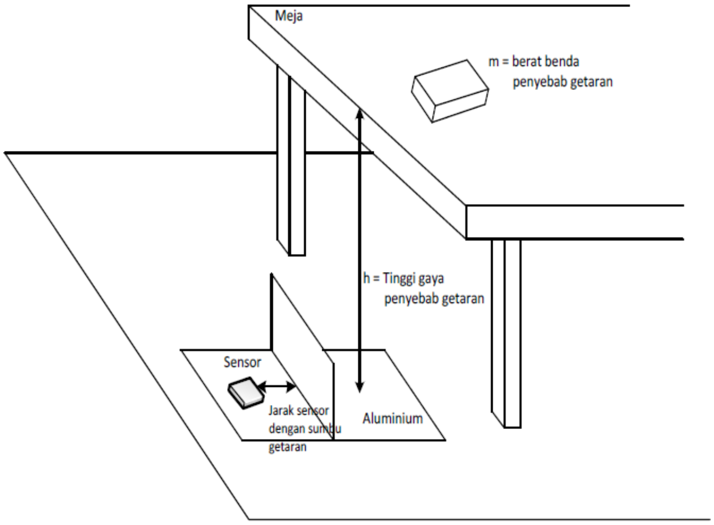

Figure 1. Tool Sketch

Software Design Flowchart

The software on the ATmega328 microcontroller is designed following the flowchart in Figure 2. The microcontroller periodically accesses sensor data and sends it to Excel to get the results displayed on the computer.

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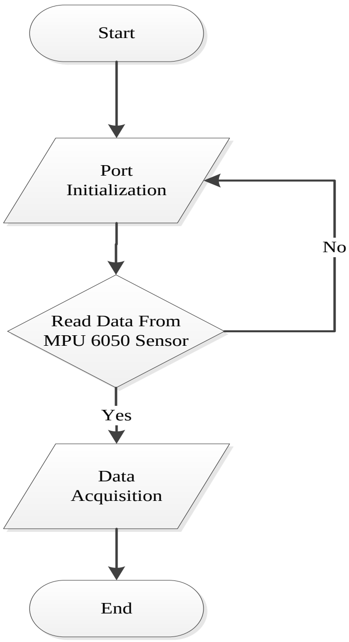

Figure 2. Program Flow Diagram

From Figure 2 above, it can be seen that when the system starts running, the infrared sensor which functions as a detector if there is a banana that you want to slice, will process the input by giving a command to the Arduino and then continue by turning on the Starter Dynamo which will rotate to slice the banana according to the program. will be created and uploaded to the Arduino board.

RESULT

The results of the tool series

The vibration detector for the police building uses the MPU 5060 sensor. Based on where the components are connected and can turn on the vibration detector for the police building if the load is dropped near the MPU 5060 sensor, the value will be read in the Excel application if the load is not dropped, the value will not appear.

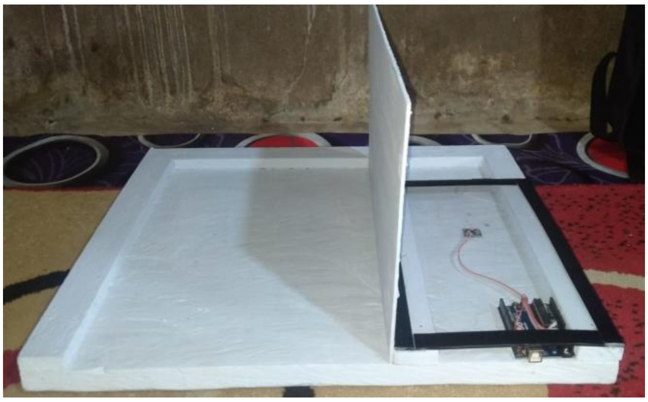

Figure 3. Overall Tool Set

For us to produce a tool design that works according to the desired expectations based on the program that has been created, tool testing is carried out in stages starting from testing the MPU 6050 sensor, testing the Arduino Uno circuit to the MPU 5060 sensor, and the entire tool circuit.

MPU5060 Sensor Testing

Sensor testing is done to find out which sensors are working properly, MPU 5060 sensor testing is done with analog data.

Testing steps are as follows:

1. Connecting the MPU 5060 sensor to the Arduino Uno board
2. Connecting the Arduino Uno board to the computer via a USB cable

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3. Creating a program by uploading it to the Excel application

Arduino Uno Testing To MPU 5060 Sensor

Arduino Uno testing is carried out to determine the vibration value results that are working well.

Overall Tool Test Results

The results of the wireless vibration characteristic test for the Poltas building. As seen in table 1.

Table 1. No-Load Condition Measurement

Sample Data	Axis			Result	Time
	x	y	Z		
1	0,02	0,01	1,01	1,0102	11:05:04
2	0,02	0,01	1,01	1,0102	11:05:05
3	0,01	0,01	1,01	0,0447	11:05:06
4	0,01	0	1,02	1,0200	11:05:06
5	0,01	0,01	1,01	3,1654	11:05:06
6	0,01	0,01	1,01	0,0001	11:05:06
7	0,01	0,01	1,01	0,0001	11:05:07
8	0,01	0,01	1,02	0,0001	11:05:07
9	0,01	0	1,01	0,4494	11:05:07
10	0,01	0,02	1,01	1,0102	11:05:07
Average	0,012	0,009	1,012	1,77104	

From the no-load condition measurement table test, the average resultant value obtained from 10 measured samples was around 1.77104.

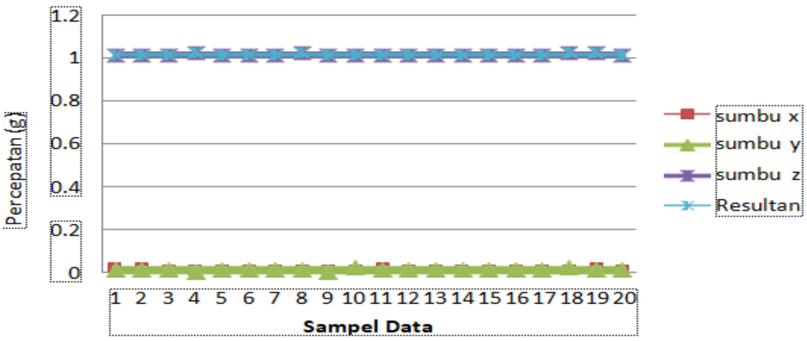

Figure 4. No-load condition graph

Without load, the maximum deviation that occurs on the x, y, and z axes ranges around 1.02 g as shown in Figure 4, with the z-axis dominating the highest value.

Table 2. 1kg Load Measurement

Sample Data	Axis			Result	Time
	x	y	Z		
1	0	0	1	1	10:24:39
2	0,12	0,03	1,14	1,1466	10:24:39
3	0,02	0,02	1,01	1,0103	10:24:39
4	0	0,01	1,01	1,0100	10:24:39
5	0	0,1	1	1,0049	10:24:39
6	0	0,02	1,01	1,0101	10:24:39
7	0	0,01	1	1,0049	10:24:39
8	0	0,01	1	1,0049	10:24:39
9	-0,01	0,01	1,01	1,0968	10:24:40
10	-0,01	0,01	1	0,0141	10:24:40
Average	0,012	0,022	1,018	1,93026	

From the test of Table 2 measuring a 1-kilogram load, the average resultant value of the 10 measured samples was approximately 1.93026.

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Table 3. 2kg Load Measurement

Sample Data	**Axis**			**Result**	**Time**
	x	y	Z		
1	0,01	0,02	1,01	1,01024749	20:10:36
2	0	0,02	1	1,00019998	20:10:36
3	0,01	0,03	1,01	1,01024749	20:10:37
4	0,01	0,02	1	1,00024997	20:10:37
5	0,01	0,03	1,01	1,01024749	20:10:37
6	0,01	0,02	1,01	1,01024749	20:10:38
7	0,01	0,02	1,01	1,01024749	20:10:38
8	0,01	0,02	1	1,01024749	20:10:38
9	0,01	0,03	1	1,00049988	20:10:38
10	0,01	0,02	1	1,00024997	20:10:39
Average	0,009	0,023	1,005	1,00626847	20:10:39

From the test of Table 3 measuring a 2-kilogram load, the average resultant value of the 10 measured samples was approximately 1.00626847.

Table 4. 3kg Load Measurement

Sample Data	**Axis**			**Result**	**Time**
	x	y	Z		
1	0,01	0,02	0,99	0,99025249	20:16:38
2	0,04	0,02	0,96	0,9610411	20:16:38
3	0,01	0,04	1,05	1,05080921	20:16:39
4	0,01	0,03	1	1,00049988	20:16:39
5	0,01	0,02	1,01	1,09818031	20:16:39
6	0,01	0,03	1,01	1,01049493	20:16:39
7	0,01	0,02	1	1,00024997	20:16:39
8	0,01	0,02	1,01	1,09818031	20:16:39
9	0,01	0,03	1,01	1,01049493	20:16:39
10	0,01	0,02	1	1,00024997	20:16:40
Average	0,013	0,025	1,004	1,02204531	

From the test of Table 4 measuring a 3-kilogram load, the average resultant value of the 10 measured samples was approximately 1.02204531.

Table 5. 5kg Load Measurement

Sample Data	**Axis**			**Result**	**Time**
	x	y	Z		
1	0,01	0,02	0,99	0,99025249	20:20:49
2	0,02	0,09	1,15	1,15368973	20:20:49
3	0	0,02	1,04	1,04019229	20:20:49
4	0,21	0,01	1,19	1,20842873	20:20:50
5	0,01	0,03	0,85	0,85058803	20:20:50
6	0,02	0,01	0,09	0,09273619	20:20:51
7	0,01	0,03	1,01	1,01049493	20:20:51
8	0,01	0,02	1	1,00024997	20:20:51
9	0,01	0,02	1	1,00024997	20:20:51
10	0,01	0,03	1,01	1,01049493	20:20:52
Average	0,031	0,028	0,933	1,93573773	

From the test of Table 5 measuring a 5-kilogram load, the average resultant value of the 10 measured samples was approximately 1.93573773.

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Table 6. 6kg Load Measurement

Sample Data	Axis			Result	Time
	x	y	Z		
1	0,01	0,03	1	1,00049988	20:30:37
2	0,01	0,03	1	1,00049988	20:30:37
3	0,01	0,02	1,01	1,01024749	20:30:38
4	0,01	0,03	1	1,00049988	20:30:38
5	0	0,02	1,01	1,010198	20:30:38
6	0,01	0,02	1	1,01049493	20:30:38
7	0	0,02	1,01	1,010198	20:30:39
8	0,01	0,02	1,01	1,01024749	20:30:39
9	0	0,03	1	1,0004499	20:30:39
10	0,01	0,03	1	1,00049988	20:30:40
Average	0,007	0,025	1,004	1,00538353	

From the test of Table 6 measuring a 6-kilogram load, the average resultant value of the 10 measured samples was approximately 1.00538353.

Table 7. Measurement of 500 gr Load

Sample Data	Axis			Result	Time
	x	y	Z		
1	0,01	0,01	1	1,0001	15:18:58
2	0,01	0,02	1	0,0244	15:18:58
3	0,01	0,01	1	1,0001	15:18:58
4	0,01	0,01	1	1,0001	15:18:58
5	0,02	0,02	1,01	1,0103	15:18:58
6	0,01	0,01	1,01	1,000	15:18:58
7	0,01	0,01	1	1,000	15:18:58
8	0,01	0,01	1	1,000	15:18:58
9	0,01	0,01	1	1,000	15:19:58
10	0,01	0,01	1,01	1,000	15:19:58
Average	0,011	0,012	1,003	1,9035	

From the test of Table 7 measuring a 0.5-kilogram load, the average resultant value of the 10 measured samples was approximately 1.9035.

Table 8. Measurement of 3 ounce Load

Sample Data	Axis			Result	Time
	x	y	Z		
1	0,01	0,01	1	1,0009	15:13:46
2	0,01	0,01	1	1,0009	15:13:46
3	0	0,01	1	1,0004	15:13:46
4	0,01	0,01	1,01	1,0109	15:13:46
5	0,01	0,01	1	1,0009	15:13:47
6	0,01	0,01	1,01	0,0141	15:13:47
7	0,01	0,01	1	1,0009	15:13:46
8	0,01	0,01	1,01	1,0100	15:13:46
9	0,01	0,01	1	0,0141	15:13:46
10	0,01	0,01	1,01	1,0203	15:13:46
Average	0,009	0,01	1,004	0,80734	

From the test of Table 8 measuring a 0.3-kilogram load, the average resultant value of the 10 measured samples was approximately 0.80734.

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Table 9. Ceramic Load Measurement

Sample Data	**Axis**			**Result**	**Time**
	x	y	Z		
1	0,01	0,01	1,01	1,01009	09:46:50
2	0,02	0,01	1,01	1,01024	09:46:50
3	0,03	0,01	1	1,00049	09:46:50
4	0,02	0,01	1,01	1,01024	09:46:50
5	0,02	0,01	1,01	1,01024	09:46:51
6	0,02	0,01	1,01	0,14352	09:46:51
7	0,02	0,01	1,01	0,14352	09:46:51
8	0,02	0,01	1,01	0,14352	09:46:52
9	0,01	0,01	1,01	1,01009	09:46:52
10	0,03	0	1,01	0,03162	09:46:52
Average	0,02	0,009	1,009	0,651357	

From the test of Table 9 measuring a Ceramic load, the average resultant value of the 10 measured samples was approximately 0.651357.

Table 10. Box Load Measurement

Sample Data	**Axis**			**Result**	**Time**
	x	y	Z		
1	0,02	0,01	1	1,00025	09:51:00
2	0,02	0,01	1	1,00025	09:51:00
3	0,02	0,02	0,99	0,9904	09:51:01
4	0,02	0,01	1,02	1,02025	09:51:01
5	0,02	0,01	1,01	1,01025	09:51:01
6	0,02	0,01	1,01	1,01025	09:51:02
7	0,02	0,01	1	1,00025	09:51:02
8	0,02	0,01	1,01	1,01025	09:51:02
9	0,03	0,02	1,01	1,01064	09:51:02
10	0,02	0,01	1	1,00025	09:51:03
Average	0,021	0,012	1,005	1,0053	

From the test of Table 10 measuring a Box load, the average resultant value of the 10 measured samples was approximately 1.0053.

DISCUSSION

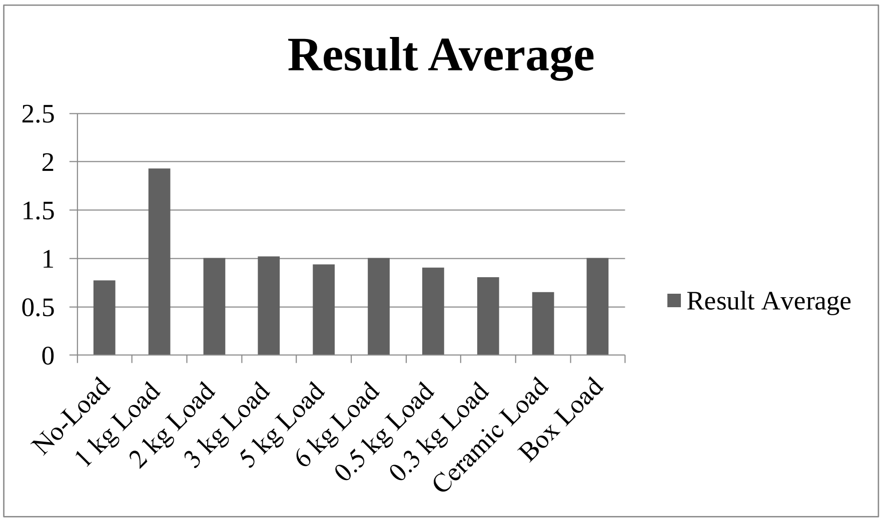

Figure 5. Comparison graph of the results of 10 tables

From the test results for 10 conditions, namely without load, 1-kilogram load, 2-kilogram load, 3-kilogram load, 5-kilogram load, 6-kilogram load, 0.5-kilogram load, 0.3-kilogram load, ceramic load, and also box load, the highest

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average result was obtained by the 1-kilogram load test with a value of 1.93026 and the lowest load was obtained by the ceramic load with a value of 0.651357. as seen in figure 5 above.

CONCLUSION

After carrying out the design and system manufacturing tools which are then continued with the testing stage, the following conclusions can be drawn:

1. The MPU 6050 sensor can be used as a vibration detector by connecting several other supporting components.
2. From the results of the sensor resistance test when the object is dropped, it can withstand a simple load.
3. From the results of the no-load condition measurement experiment using the MPU 6050 sensor, the average resultant value was 0.77104, while for the 1kg measurement the average was 0.93026, the 2kg load was 1.006, and the 3kg load was 1.02204531.
4. For the ceramic load sample from the data acquisition analysis (DAQ) results were obtained at 0.651357, and for the box load measurement, the average result was 1.0053.

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