Design of Real-Time Seismic Amplitude Measurement (RSAM) System Using Geophone as the Detection of Seismic Vibration

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Abstrak

Indonesia merupakan salah satu negara dengan gunungapi terbanyak di dunia. Indonesia memiliki 129 gunungapi aktif, 70 buah diantaranya berancaman dan 500 buah tidak aktif. Sejak tahun 1800, paling tidak telah tercatat 600 kali letusan oleh 70 gunungapi di Indonesia. Karena itu, Indonesia dapat dikatakan sebagai negara yang rawan bencana gunung berapi. Pengamatan, pemantauan, pencatatan, penyebaran informasi dan peringatan tanda bahaya terhadap aktivitas gunungapi menjadi salah satu fokus dalam penanggulangan bencana gunungapi. Untuk mendukung hal tersebut diperlukan instrumentasi deteksi aktivitas vulkanik gunungapi. Salah satu instrumentasi yang digunakan untuk memantau aktivitas gunung berapi Gunung Merapi adalah *Real-time Seismic Amplitude Measurement* (RSAM). RSAM adalah sistem pengukuran kontinu dari amplitudo seismik rata-rata absolut dari jumlah stasiun seismik. RSAM menempati peran strategis dalam memantau aktivitas seismik gunung berapi terutama pada saat krisis sebelum letusan. Dalam penelitian ini, perancangan sistem RSAM menggunakan sensor *geophone* untuk mendeteksi getaran seismik. Frekuensi tes yang diberikan dalam penelitian ini termasuk 10 Hz, 30 Hz, dan 50 Hz. Sistem yang telah dirancang bangun dapat mendeteksi frekuensi dengan baik sebagaimana dibuktikan bahwa semakin besar frekuensi uji maka semakin banyak output grafik yang dihasilkan. Selain itu, magnitudo yang dihasilkan juga semakin besar. Pada frekuensi 10 Hz, magnitudo yang dihasilkan adalah 0,997, pada 30 Hz magnitudo yang dihasilkan 1,559 sedangkan pada 50 Hz magnitudo yang dihasilkan adalah 1,962. Sistem RSAM yang dirancang bangun menghasilkan amplitudo yang memiliki hubungan linier dengan besarnya getaran sumber disediakan.

Kata Kunci: *Geophone*, RSAM, Getaran Seismik.

Abstract

Indonesia is one of the most volcanic countries in the world. Indonesia has 129 active volcanoes, 70 of which are threatened and 500 are inactive. Since 1800, at least 600 recorded eruptions by 70 volcanoes in Indonesia. Therefore, Indonesia can be regarded as a country prone to volcano disaster. Observation, monitoring, recording, dissemination of information and warning signs of volcanic activity to be one focus in volcano disaster mitigation. One of the instrumentations used to monitor the volcanic activity of Mount Merapi is Real-time Seismic Amplitude Measurement (RSAM). RSAM is a continuous measurement system of the absolute average seismic amplitude of the number of seismic stations. RSAM occupies a strategic role in monitoring the seismic activity of volcano especially in times of crisis before the eruption. In this research, the RSAM system design using a geophone sensor to detect the seismic vibration. The frequency tests given in this study included 10 Hz, 30 Hz, and 50 Hz. The system that has been designed to build can detect frequencies well as evidenced by the greater the frequency of the test given the more the graph output of the output is produced. In addition, the magnitude produced is also getting bigger. At a frequency of 10 Hz, the resulting magnitude is 0.997, at 30 Hz the resulting magnitude is 1.559 while at 50 Hz the magnitude generated is 1.962 The RSAM system designed to build produces an amplitude that has a linear relationship to the magnitude of the vibration source provided.

Keywords: Geophone, RSAM, Seismic Vibration.

1. Introduction

Indonesia has 129 active volcanoes, 70 of which are threatened and 500 inactive. Therefore, Indonesia is one of the country prone to volcanic disasters. Generally, volcanic activity is started by the extrusion of magma on the lava dome which is accompanied by the partial collapse of the lava dome which causes rock avalanches and pyroclastic avalanches, until a big eruption [1].

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Detection of volcanic activity starting from observation, monitoring, recording, dissemination of information and warning signs of volcanic activity is very important for the prevention of volcanic disasters

One of the instrumentations used to monitor volcanic activity is Real-time Seismic Amplitude Measurement (RSAM). RSAM is a system that provides a continuous measurement of the absolute average seismic amplitude of the number of seismic stations [2]. RSAM occupies a strategic role in monitoring the seismic activity of volcano especially in times of crisis before the eruption. In 2010, the eruption of Mount Merapi was also used as an instrumentation which was used to analyze the seismic activity of Mount Merapi observed by applying the Material Failure Forecast (FFM) method and getting better data on Mount Merapi activity [3]. The RSAM system can be connected with several types of sensors for the detection of seismic volcano vibrations. Geophone is one of the potential sensors to use. Geophone is a sensor that is able to detect seismic vibrations in low frequency and high frequency. In this research, we will design RSAM by utilizing developing and popular micro system that is currently using Arduino and geophone as sensors.

2. Fundamental Theory

2.1 Type of Volcanic Eruption Material

The initial symptoms of volcanic eruption are monitored with the seismic of the volcano. Symptoms of increased activity starts from the emergence of chronological series of volcanic earthquakes, lava and hot clouds. Seismic development is interpreted as a reflection of the migration of magma from depth to surface until the eruption occurs. The release of magma to the surface of the earth in different forms. Among Volcanic Gas, lava, lava flow pyroclastic and pyroclastic fall (rain ash). Lava is a high-temperature magma liquid that flows to the surface through volcanoes. Lava is able to flow away from its source. While lava is a stream of mud and rock so that the ability to flow is not too far [4].

2.2 *Real-time Seismic Amplitude Measurement* (RSAM)

RSAM is the output of the average amplitude recorded at a certain time using Earthworm software. The principle of RSAM is that the signal that enters the digitizer is rectified, meaning that the negative signal is reversed to positive, after that it is sampled and then on average every 10 minutes. Thus, the RSAM actually

measures the energy of all earthquakes recorded at seismic stations without distinguishing the type of earthquake [5]. The magnitude of the vibration of earthquakes shown in Equation 1 below:

$$M = MA = \log A - Log\ Ao \qquad (1)$$

Where M is Magnitude, A is the amplitude on a seismogram based on 'Wood Anderson'(gain 2800×) seismograph, Ao is the minimum amplitude for seismogram 'Wood Anderson, the magnitude depends on the distance of the epicenter [6].

3. Methodology

The RSAM design is started by selecting electronic design components, digital communication and digital signal processing. The RSAM module has been designed that is connected with a geophone sensor and tested on a laboratory scale before being tested on a field scale. The computerized RSAM system diagram block is shown in Figure 1.
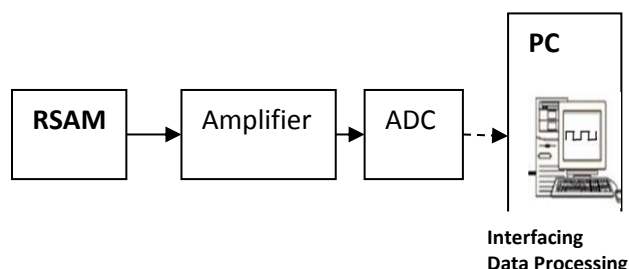

Figure 1. Block computerized RSAM system diagram

Initial RSAM testing is carried out on a laboratory scale. Laboratory scale testing is carried out at the RSAM signal output using the PC Multimeter link, to determine the geophone response that is provided to the artificial vibration. The vibration response testing system uses an Audio Frequency Generator (AFG) that is connected to the vibration source, which is a speaker that is modified with an amplifier. Frequency variations are used ranging from 10 Hz to 50 Hz with an increase of 5 Hz. In the next step, still at the stage of laboratory scale testing, interface testing is done for computerization. The interface display is shown in Figure 2.
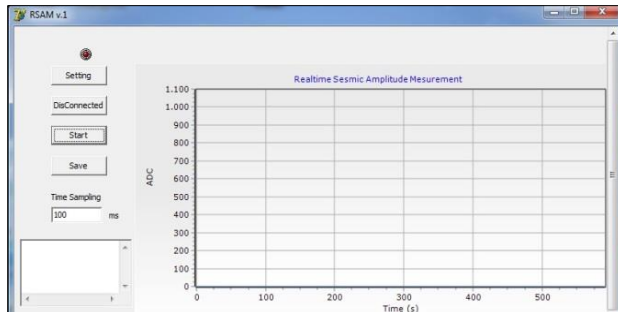
Figure 2. RSAM system interface

Data analysis is done by calculating the magnitude, namely the scale of strength measured by the vibrations that happen. In the formulation of quantities, a basic Richter scale formulation is used as shown in Equation 1.

4. Results and Discussion

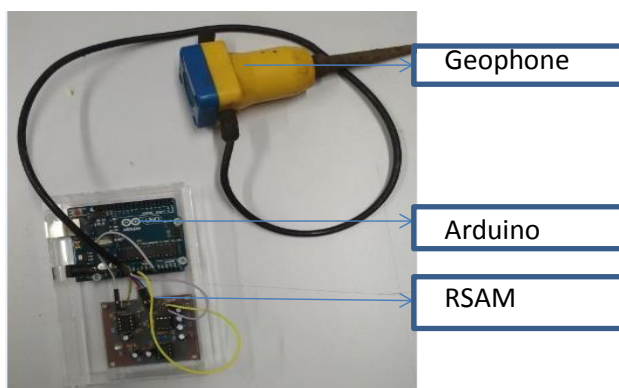Photographs of the RSAM system electronic circuit design are shown in Figure 3 below.

Figure 3. Electronic module of the RSAM system

The hardware system consists of RSAM electronic modules arranged in a series of Analog to Digital Converter (ADC) using Arduino. The RSAM series is associated with geophone as a seismic sensor.

The computerized RSAM system is tested early to detect whether the system can obtain data correctly. The results of the initial testing in this research are shown in Figure 4.
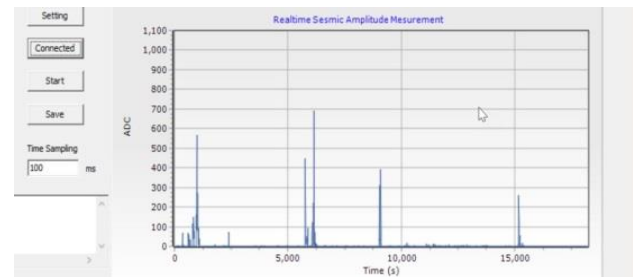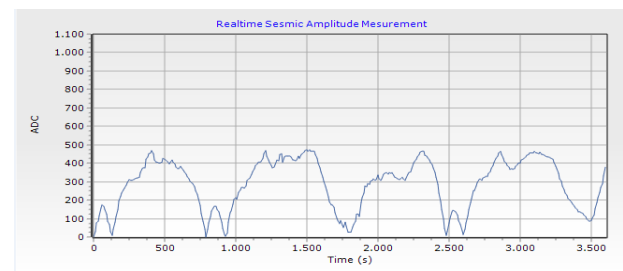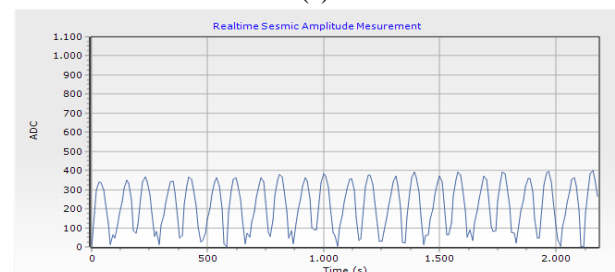

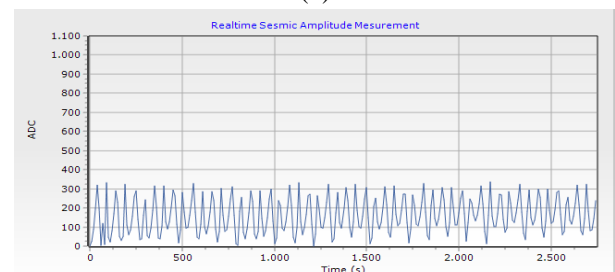**Figure 4**. Graph of Initial RSAM System Test Results

The graph shown in Image 4 is a RSAM system response graph with triggered vibrations. From the graph, the response of the RSAM system is given vibration that is quite good, it is seen in the data acquisition that is carried out by the 100 ms system so that the response is fast. Furthermore, the RSAM system is designed that is tested with frequency variations, at low, medium and high frequencies. The frequency variations used are 10 Hz, 30 Hz and 50 Hz. **Figure 5** below shows a frequency response graph at each given frequency.

(a)

(b)

(c)

Figure 5. Test Results for Response Frequency (a) 10 Hz, (b) 30 Hz and (c) 50 Hz

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From the tests conducted, it can be seen that the frequency response has a relative track according to the input frequency is given it, that is the greater the frequency of the test that is given the more wave envelopes produced.

The magnitude of the resulting graph is calculated using Equation 2.1. while the magnitude obtained is shown in Table 1

Table 1. The magnitude of vibration with respect to the variation in frequency given

Input frequency (Hz)	The magnitude of the Richter scale
10	0.997
30	1.559
50	1.962

From the table above it can be seen that the greater the source of vibration given the greater the amount produced. This proves that the RSAM system designed to build with geophone is able to detect vibrations well

5. Conclusion

Geophone as a vibration sensor on the RSAM system can detect vibrations well. At the frequency of testing the resulting wave envelope increases and the size also increases. At a frequency of 10 Hz, the resulting magnitude is 0.997, at 30 Hz the resulting magnitude is 1.559 while at 50 Hz the magnitude generated is 1.962

Suggestion

In future studies it is recommended to increase the test frequency with more than one sensor point.

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