Radio Waves-Based Landslide Mitigation System

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Submission date: 05-Nov-2020 10:48AM (UTC+0700)
Submission ID: 1436577218
File name: 3rd_ICoFA_2020_CR_1.docx (452.31K)
Word count: 2708
Character count: 13851

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Abstract. Indonesian territory has a high potential for geological disasters such as volcanic eruptions, earthquakes, landslides, tsunamis. To provide disaster protection it is necessary to carry out mitigation which is a preventive action to minimize the negative impact of natural disasters that occur. In areas where the GSM network is large enough, the disaster information system is being replaced by the advanced technology developed by the GSM protocol. However, if there is a telecommunication disruption and when all the regular communication infrastructure is down as well as geographic conditions are not covered by the public network. So one of the effective media in an effort to create an ideal information system is radio communication, which is widely used by Amatir Radio members who are widespread in Indonesia which can be accessed by all levels of society with a wide range. So this research was conducted by utilizing the VHF spectrum radio wave transmission with a frequency of 144 MHz as a transmission medium to convey information signals on landslide disaster mitigation for the community. From the system integration measurements were taken to obtain the value of the ground motion sensor and the range of radio wave transmission.

1. Introduction

The Indonesian territory is in the position of a complex geological order between three earth plates namely Indo-Australia, Eurasia, and the Pacific which continues to move through geological processes namely sedimentation, lifting, bending, and fracturing. This causes the Indonesian territory to have a high potential to be affected by geological disasters, namely volcanic eruptions, earthquakes, landslides, tsunamis, etc. Intending to protect from geological disasters, and reducing the number of casualties and loss of property that may arise, it is necessary to mitigate geological disasters.

Mitigation is the process of trying various preventive measures to minimize the negative impacts of natural disasters that are anticipated to occur in the future in an area. There is a tendency to focus more on mitigation rather than post-disaster responses.

In countries where the GSM network (mobile telephone) is quite large, traditional calling systems have been replaced by advanced technology developed by the GSM protocol. However, if there is a telecommunications disruption via mobile phones during a disaster, or a disruption in the electricity network, in the absence of regular communication, or when all communication infrastructure falls (Emergency Communication). So one of the effective media in the effort to create an ideal information

system is radio communication, which is widely used by Amateur Radio members who are widespread in Indonesia.

Radio is an electronic media that is not only cheap but can also be accessed by all levels of society, even the reach of radio broadcasts to all corners of remote areas with minimal facilities.

Radio communication is a communication relationship that uses air media and uses radio waves as a carrier signal. The radio can still run only by using a battery rock, in the AM Frequency Band (Amplitude Modulation), SW (Short Wave), or FM (Frequency Modulation) besides, the outside radio with the Frequency Band SW can still be on the air, for delivering emergency news on during distress, natural disasters, search and rescue (SAR).

The rapid growth of the internet and television does not necessarily make the reach of radio listeners then lose interest and decrease. Of course, radio is still one of the favorite choices that occupy a special place in the hearts of the people of Indonesia.

2. Literature Study

2.1 Radio Wave

A radio wave is a wave that has the smallest frequency or the longest wavelength. Radio waves exist within a wide frequency range and range from a few Hz to gigahertz (GHz / power 9 order). And usually also produced from a series of insulators in electronic devices. And the spectrum of radio waves separated into frequency bands or wavelengths. In radio wave transmission there are two bodies, namely the transmitter (TX) and receiver (RX), both of which have an antenna device that is used to send and receive electromagnetic waves. Antenna functions to convert electrical signals into electromagnetic signals then radiate them and can also function to receive electromagnetic signals and convert them into electrical signals [1].

Figure 1. TX and RX Radio Wave Transmission

Electromagnetic waves are waves that have electric and magnetic properties simultaneously. The relationship between wavelength (λ), frequency (f) and velocity (v) is as follows [1]:

$$\lambda = \frac{v}{f} \quad (1)$$

Where:
λ = Wavelength (m)
f = Frequency (Hz)
v = Speed (m / s)

From this equation it can be seen that the wavelength depends on the speed of a medium. If the medium is a vacuum, then [1]:

$$v = c = 3 \times 10^8 \text{ m/s} \quad (2)$$

So :

$$\lambda = \frac{c}{f} \quad (3)$$

Where :

λ = Wavelength (m)
C = Speed of light (3x108 m / s)
f = Frequency (Hz)

In designing an antenna, there is a certain frequency range from which the working frequency or center frequency (Fc) can be determined, namely [1]:

$$F_c = F_L + \left(\frac{F_H - F_L}{2}\right) \quad (4)$$

Where :

F_c = Center frequency (MHz)
F_L = Lower frequency (MHz)
F_h = Top Frequency (MHz)

2.2. Frequency Shift Keying (FSK)

Frequency Shift Keying Frequency Shift Keying (FSK) or sending signals through frequency shifting. This method is a form of modulation that allows the modulation wave to shift the output frequency of the carrier wave. This shift occurs between predetermined prices and the output wave which has no intermittent phase. In this modulation process, the frequency of the carrier wave varies according to the presence or absence of a digital information signal. FSK is the most popular modulation method. In this process the carrier wave is shifted up and down to obtain bit 1 and bit 0. These conditions are called space and mark, respectively. Both are data transmission standards that comply with CCITT recommendations. FSK is also independent of the transmitter on-off technique, as predefined. The presence of a carrier wave is detected to indicate that the transmitter is ready. In the case of using multiple transmitters (multi transmitters), each of which can be identified by its frequency. The principle of carrier wave detection is generally used to detect system failures. The form of modulated Carrier FSK is similar to that of FM modulation. Conceptually, FSK modulation is FM modulation, only here there is no variation / deviation or frequency, there are only 2 possibilities, namely More or Less (High or Low, Mark or Space). Of course, detection (retrieval of the Carrier content or the demodulation process) will be easier, the possibility of error (error rate) is very minimal. Generally, the FSK modulation type is used for data communication with a relatively low Bit Rate (transmission speed), such as for Telex and Modem-Data with a bit rate of not more than 2400 bps (2.4 kbps). The form of the FSK modulation signal can be seen in Figure 2.

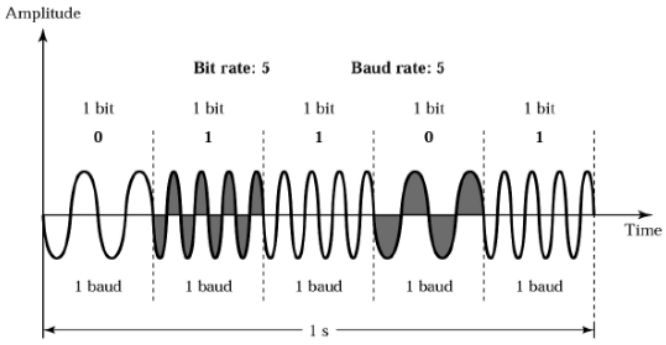

Figure 2. FSK modulation

2.3. Ground Motion Sensor

A ground motion sensor or also known as an accelerometer is a tool used to measure acceleration. Velocity acceleration and coordinate acceleration are two different things. Coordinate acceleration is the range of the change in velocity, while acceleration is the acceleration measured from the original. In landslide prediction, the accelerometer can measure the slope and act as a geophone.

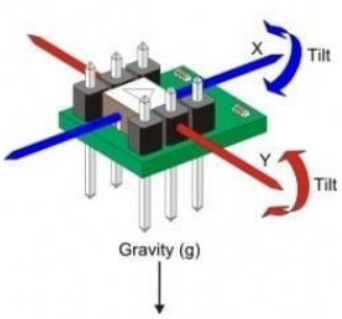

Figure 3. Ground Motion Sensor
(Source:https://http://sensornetwork.mipa.ugm.ac.id/2018/08/22/113/)

The gyroscope sensor features on the MPU6050 are as follows:

- Digital output X-, Y-, and Z- axis with angle of inclination 24
- User-programmable range ±250, ±500, ±1000, and ±2000 degrees/second
- tegrated 16 bit ADC
- Operating current 3.6 mA
- User selft-test
- Digitally-programmable ow-pass filter
- Improved low-frequency noise performance

Figure 4. MPU6050 Modul
(Source: https://playgrond.arduino.cc)

2.4. VHF (Very High Frequency)

VHF (Very High Frequency) communication is the main communication used on aircraft, to communicate with outside parties (towers or other aircraft). VHF communication can be used for voice communication (voice) and data. Just like HF communication, VHF communication uses radio waves as the intermediary. The frequency used for VHF communication is 118,000 MHz to 136,975

MHz. The thing that distinguishes HF, VHF communication works line of sight. This is because VHF waves cannot be reflected by the ionosphere layer. Therefore VHF communication can only be used for communication over a short distance [5].

The transmitter of a device working on the VHF (Very High Frequency) spectrum is an HT radio frequency that has a freer, farther and wider transmitting range than the UHF transmitter range with a frequency level between 136MHz to 174MHz. However, this HT radio frequency cannot function properly if it is used in places with lots of obstructions, such as high-rise buildings, walls, or trees.

Figure 5. Transceiver VHF
(Source: https:// momototoy.com/wp-content/uploads/2016/07/handy-talky.jpg)

2.5. Arduino Uno

Arduino is a microcontroller board based on ATmega328. Arduino has 14 input / output pins of which 6 pins can be used as PWM outputs, 6 analog inputs, a 16 MHz crystal oscillator, USB connection, a power jack, an ICSP head, and a reset button. Arduino is able to support a microcontroller; can be connected to a computer using a USB cable or supply with an AC to DC adapter or use a battery to start it. (FeriDjuandi, 2011)

Figure 6. Arduino Uno
(Source: https://www.robotistan.com)

3. Methods and Materials

The steps to design and realize this research are shown in Figure 1, as follows.

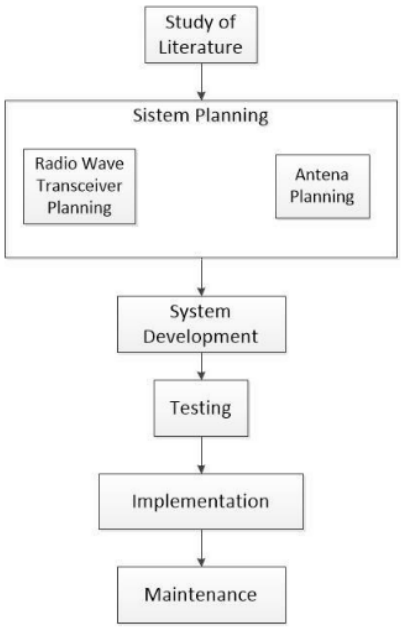

Figure 7. Research Methods

As shown in Figure 7 above, it can be explained as follows:

3.1. Study of literature

This step is carried out to examine matters relating to the design and testing of systems based on research or work of others that have been done and theories that support the characteristics of the transmission of radio waves, sensors, and antennas and Arduino control systems, from the research hypothesis, states that all these parameters have an inseparable relationship in a wireless communication system because they support each other.

3.2. System planning

The design is a process carried out to design the antenna that will be made by the desired function. The design must be done carefully to facilitate the manufacture of antennas.

3.2.1. Radio Wave Transceiver Planning

In planning the transceiver sensor system the system parts include: the control system using Arduino, the sensor system uses the accelerometer, the transceiver consisting of the transmitter system (TX) and the receiver (RX) uses the Handy Talky (HT) module that works at VHF frequencies and the last is Yagi antenna system that will radiate disaster mitigation information signals to free space.

The overall system block diagram can be shown in Figure 8 below.

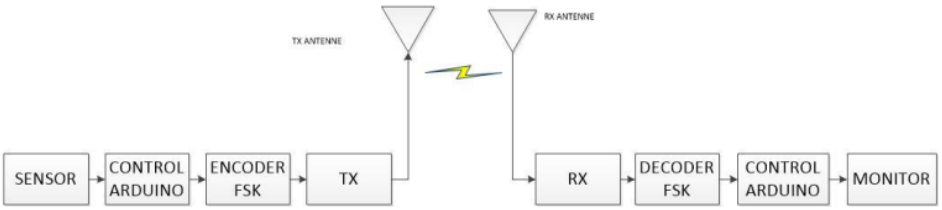

Figure 8. Radio Wave Transceiver Block Diagram

The block diagram description above is as follows:

a. The sensor uses an accelerometer, to detect ground movement.
b. FSK (Frequency shift Keying) encoder uses TCM 3105 IC, to convert digital data generated by the sensor to a serial data form that will be superimposed on a VHF transmitter (TX) carrier signal.
c. TX is a transmitter device using Handy Talky (HT) as a VHF transmitter at a frequency of 144 MHz, to transmit digital sensor data from the FSK encoder to the receiver (RX).
d. The TX antenna uses Yagi, a polarization liner antenna that functions to radiate sensor data into the air.
e. The RX antenna using Yagi is a liner polarization antenna that functions to capture electromagnetic (EM) waves from the TX antenna's radiation results to be transmitted to the receiver (RX).
f. RX is a receiver device using Handy Talky (HT) as a VHF receiver at 144 MHz frequency, to receive digital sensor data from the TX antenna system.
g. The control uses Arduino, to translate sensor data from the FSK decoder in the form of digital serial data to be translated and passed on to the monitor.
h. The monitor is a set of tools for measuring and displaying data transmission results.

4. Result and Discussions

Based on the design that was carried out in the previous stage, a schematic design of this radio wave-based mitigation device circuit was designed. The schematic image of the circuit is shown in Figure 9. While the complete series image is shown in Figure 10.

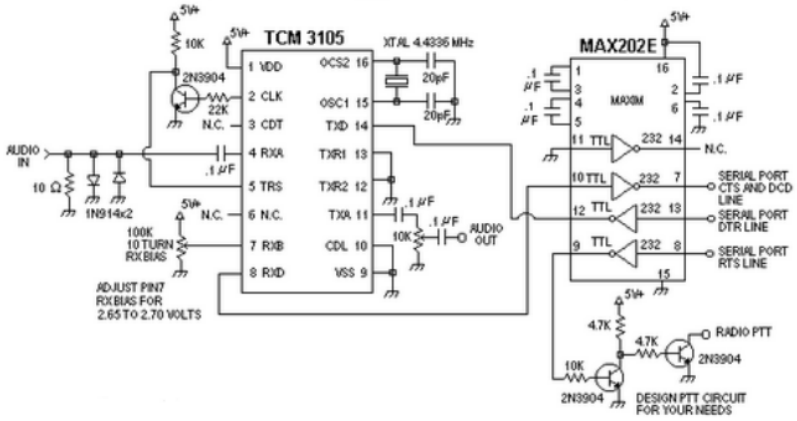

Figure 9. Circuit Schematic FSK TCM 3105

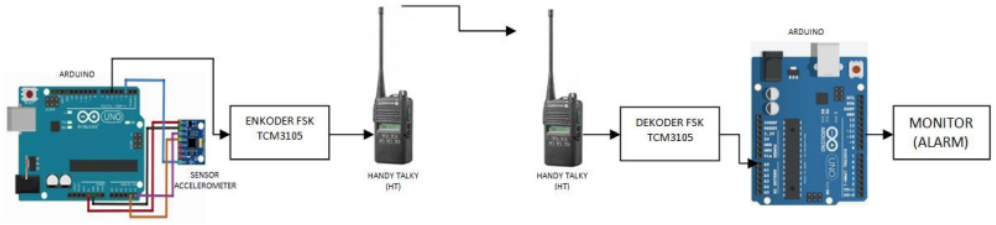

Figure 10. Complete Circuit Schematic

Accelerometer measurement

Measurement and testing of this tool uses the Inertial Measurement Unit (IMU). The IMU is an electronic device that measures and reports the craft's speed, orientation, and gravitational force, using a combination of an accelerometer and a gyroscope, sometimes also a magnetometer. IMUs are commonly used to maneuver aircraft, including unmanned aerial vehicles (UAVs), among many, and spacecraft, including satellites and landers. Recent developments have allowed for the production of IMU-enabled GPS devices. An IMU allows a GPS receiver to work when GPS-signals are not available, such as in tunnels, inside buildings, or when electronic interference is present. A wireless IMU is known as WiMu. The IMU is a major component of the inertial navigation system used in aircraft, spacecraft, boats, and missiles among others.[1]. Inertial Measurement Unit (IMU) is a unit in an electronic module that collects angular acceleration and linear acceleration data, which are then sent to the main processing unit, which in this system is run by Arduino UNO. The results of measurements using the IMU are shown in table 1 and table 2.

Table 1. Accelerometeter Sensor Data from IMU in Stable Conditions

No	Time (s)	Axis X	Axis Y	Axis Z
1	0,1	84	244	11592
2	0,2	152	316	11760
3	0,3	104	392	11680
4	0,4	256	308	11672
5	0,5	124	348	11572
6	0,6	76	356	11648
7	0,7	208	232	11708
8	0,8	124	268	11752
9	0,9	76	328	11576
10	1	168	256	11708

Based on the data recorded in the IMU for a stable state, on the measurement for the accumulated time of 0.1 second with a time span from 0.1 second to 1.0 second, it was recorded that on the X-axis, Y-axis and Z-axis there were no significant changes in values. Whereas in table 3.2 shows the condition of the accelerometer sensor when it is unstable

Table 2. Accelerometer sensor data table from the Inertial Measurement Unit (IMU) in unstable conditions (there are shocks)

No	Time (s)	Axis X	Axis Y	Axis Z
1	0.1	380	10908	7140
2	0.2	480	10972	7004
3	0.3	400	11072	6888
4	0,4	68	-10792	7908
5	0,5	-44	-10892	7616
6	0,6	52	-10784	7820
7	0,7	-9484	232	8432
8	0,8	-9520	228	8428
9	0,9	8592	484	9444
10	1	8596	396	9296

From the table, it is recorded that the measurement for the accumulated time of 0.1 second with a time span from 0.1 second to 1.0 second, it is recorded that on the X-axis, Y-axis and Z-axis there is a significant change in value. Measurement of radio wave transmission using Handy Talky (HT) for TX and RX with specifications:

RF power : 2 Watt
Antenna : circular polarization (Helical)
TX and RX positions : Line Of Sight (LOS / without obstruction)

Table 3. Transmission Range of 144 MHz VHF Radio Waves

No	Distance (m)	Signal to Noise Ratio (dB)	Transmission signal reception
1	200	40	Good
2	400	35	Good
3	600	20	Good
4	750	17	Voice (tone) is not clear
5	800	15	Voice (tone) is not clear
6	850	12	Voice (tone) is not clear
7	900	9	Voice (tone) is not clear
8	950	7	Voice (tone) is not clear
9	1000	4	Voice (tone) is not clear
10	1050	2	Voice (tone) is not clear

From table 3 it is shown that the maximum range for accelerometer sensor transmission is 600 meters where the sensor data is still read clearly, more than 600 meters of sensor data cannot be read clearly.

5. Conclusion

This research produces a prototype for natural disaster mitigation with VHF radio wave transmission media at 144 MHz using an integrated Arduino UNO module with a TCM 3105 decoder-encoder module, and an Accelerometer Gyroscope MPU-6050 sensor. This prototype has been tested in the field with good performance.

6. Future Work

In further research, a mitigation system using a multisensor at a wider radius can be developed, the latest version of the Arduino series and integration with artificial intelligence for predicting potential earthquake damage.

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