Analysis of Wireless Fire Detector Application to Detect Peat land Fire Based on Temperature Characteristic

N L Marpaung, R Amri and E Ervianto

1,2,3 Electrical Engineering Department, Universitas Riau, Pekanbaru, Indonesia

E-mail: noveri.marpaung@gmail.com

Abstract. Fires of land and forest happened in Riau, give negative impacts to people and its environment. This research discusses about analysis of Wireless Fire Detector as Early Warning System of Peat-land Fire using LM35 Temperature-Sensor, Transmitter-Module(HC-12), Receiver-Module(HC-12), Arduino-ProMini, to produce outputs on LED, LCD, Buzzer. Peat-land fire Detector works when peat land is burning, so its heat spreads through aluminum stem. This temperature is read by Temperature-Sensor1-Temperature-Sensor4. Output of every sensor is sent to each Transmitter-Module(FU1–FU4) in Arduino-ProMini control block. After that, Transmitter-Modules(FU1–FU4) send the readings of sensor to Receiver-Module(FU5). In one time, only one data is received by Receiver-Module from Transmitter-Module. Then, it goes to Arduino-ProMini and processed to get outputs on LCD that display ID of FU1–FU4, Peat-land Status by three activated LEDs, Peat-land temperature. If Green LED is active, means Peat-land not burned. Its temperature is 0°C–21.9°C. LCD displays SAFE Condition, Buzzer OFF. If Yellow LED is ON, means Peat-land burned underground. Its temperature is 22°C–28.4°C. LCD shows BE-CAREFUL Condition, Buzzer ON. If Red LED is active, means Peat-land burned on the ground. Its temperature is 28.5°C–50°C. LCD displays DANGER Condition, Buzzer ON. This equipment works as its framework.

1. Introduction

Fires of land and forest in Riau has reached 3,700 hectares in few last years. Based on Riau Forestry, almost areas in districts of Riau Province from 4 hectares up to 2,800 hectares, ever happened forest and peat land fires. The negative impacts of forest and peat land fires cause air pollution, smoke misty, people in Riau Province get many diseases, schools and universities are closed, businesslike activities such as restaurants, bank and other trading markets are slack. All of these circumstances ever happened in two weeks in 2015 in Pekanbaru, Riau Province. To overcome this problem, many efforts are needed to avoid any fires of land and forest again in the future. An early warning system can be used to prevent them in advanced. This system is equipped with wireless fire detector to detect any fire in land or forest. Then, the results of the data reading are sent from the burned area to Receiver Modules. So, even every small land fire can be detected and reported to avoid any bigger land or forest fires to the person in charged. This research aims to analyze the wireless Fire Detector as Early Warning System of Peat land Fire using LM35 Temperature-Sensor to produce outputs on LED, LCD, Buzzer.

The scopes of this research are:
1. Maximum Distance of wireless data transmission for each Temperature Sensor can be accepted or not.
2. Range of Wireless Sensor Transmission of Peat land Condition based on Peat land Temperature
3. LM35 temperature sensor is used as temperature detector underground and on the ground of Peat land.
4. Using LCD to display the Temperature, Status and Condition of Peat land.
5. Using three activated LEDs and a Buzzer as indicators of Peat land Conditions.

This problems can be observed by:
1. Determining the Status and Condition of Peat land in three conditions based on the reading of temperatures from the peat land using LM35 temperature sensor.
2. Using LCD to display the Temperature, Status and Condition of Peat land.
3. Using three LEDs and a Buzzer to indicate the Peat land Condition.

2. Literature Review

2.1. Previous study
Reference [2] was Analysis of Controlling Wireless Temperature Sensor for Monitoring Peat-Land Fire to control wireless Temperature Sensor for monitoring Peat-Land fire by using LM35 Temperature Sensor, Transmitter-Module (HC-12), Receiver-Module (HC-12), Arduino Pro Mini to produce outputs on three different LEDs, Condition of Peat land on LCD, Buzzer if Peat land Condition is DANGER Category. Reference [3] was Design of Firing Detector System by peat Land With Woody Peat Types Using It's Heat Characteristics using LM35 Sensor to monitor Peat land fires that has the highest accuracy is ASMC with an accuracy rate of 60%. It took a peat land fire detector design, in order to mitigate catastrophic fires in peat land. The sensor worked by using the heat’s characteristics that generated by burnt peat, read from ATMega8 as the microcontroller and LCD 16*2 as the monitor of temperature sensor.

This study uses Temperature Sensors LM35, Arduino Pro Mini, HC-12 Transmitter Module and HC-12 Receiver Module. Sensors can detect Status of Transmitted Data in certain range for different Temperature Sensors, before peat land burned or when peat land burned, for Experiment Tests with obstacles like buildings and trees. This research also test two conditions of Peat land based on their own temperature range. Results of research are displayed on LED, LCD and Buzzer.

2.2. Research Components
Many components are used in this research, such as:
1. Arduino Pro Mini is one type of microcontrollers. This research uses ATMega328P Arduino Pro Mini that has 14 digital pins input/output in one chip of Integrated Circuit (IC). Using this chip, can make connection to FTDI cable to give USB power and can make communication board. This research uses five ATMega328P Arduino Pro Mini. [4].
2. LM35 Temperature Sensor is a temperature sensor module can produce output voltage which is change linearity based on the change of temperature in linear too. LM35 output is in linear scale factor towards the real temperature of 10 mV/°C and can be measured with maximum range from - 55°C up to 150°C. Maximum output voltage of LM35 is 1.5 Volt with 0.5°C accuracy on 25°C temperature. Error level of sensor for 25°C room temperature measurement and no more 2°C, can be calculated by using Equation 1.[5]
\[ \text{Temp (°C)} = \frac{V_{out} (in \text{ mV})}{10\text{mV}} \]  
(1)
3. HC-12 Module is communication module in serial port using wireless. This module can send and receive serial data through air media with 433 MHz frequency and up to 1800 meter for transmitting distance in open space. HC-12 Module is Data Transmitter/Receiver Module but it cannot transmit and receive data in the same time because it just has link half-duplex between modules. This research uses four HC-12 Modules as Transmitter Modules and one HC-12 Modules as Receiver Module. [6, 7]
4. Liquid Crystal Display (LCD) is one type of display media using liquid crystal as main display. This study uses 16x2 LCD.
5. Light Emitting Diode (LED) as indicator lamp with three different colours (Red, Yellow, Green).
6. Buzzer as alarm to indicate in BE CAREFULL Condition or DANGER Condition.
3. Research Methodology
Methods in this are:
1. Literature study.
2. Designing a prototype circuit.
3. Applying designed circuit into a prototype.
4. Testing of Component Activation from each component such as Power Supply, LM35 Temperature-Sensor, Transmitter-Module (HC-12), Receiver-Module (HC-12), Arduino Pro Mini Microcontroller, LED, LCD, and Buzzer.
5. Transmission Distance Testing from Transmitter to Receiver, before peat land burned.
6. Data Transmission Testing from Transmitter to Receiver, when peat land is burned.
7. Measuring temperature characteristic of Peat land.

Flowchart of the research is shown in Figure 1.

This research is done by injected four aluminum bars into ground up to 60cm depth in different Peat land areas, whereas Temperature Sensor and ATMega328P Arduino Pro Mini are attached to each aluminum bar. All of these Temperature Sensors detect the land temperatures in different area. Each Temperature Sensor sends its temperature data from Transmitter Module (FU1 – FU4) to Receiver Module through Arduino Pro Mini on each aluminum bar. Receiver Module sends each temperature
data from FU1 – FU4 to other Arduino Pro Mini, to be processed and display it into LCD. Arduino Pro Mini also controls the activated LED and Buzzer depend on the Peat land Status.

4. Results and Discussion

4.1. Testing of transmission distance before peat land burned

Testing of transmission distance before peat land burned is done to know the Peat land condition, whether it is burned or not. Testing is done in the midday in good weather and no windy. In this case, number 1 is set up to state that Peat land is not burned. Number 1 is sent in 8 bits respectively. Data Testing of transmission distance before peat land burned is shown in Table 1.

| Channel | Transmitted Data | Environmental Condition | Status of Transmitted Data | Distance (Meter) |
|---------|------------------|--------------------------|----------------------------|-----------------|
| FU1     | 1111 1111        |                          | ACCEPTED                   | 50 - 130        |
|         |                  |                          | NOT ACCEPTED               | 140             |
| FU2     | 1111 1111        |                          | ACCEPTED                   | 50 - 270        |
|         |                  |                          | NOT ACCEPTED               | 280             |
|         |                  | Experiment tests :       | NOT ACCEPTED               |                 |
|         |                  | –Buildings               |                            |                 |
| FU3     | 1111 1111        | –Trees                   | ACCEPTED                   | 50 - 460        |
|         |                  |                          | NOT ACCEPTED               | 470             |
| FU4     | 1111 1111        |                          | ACCEPTED                   | 50 - 870        |
|         |                  |                          | NOT ACCEPTED               | 880             |

From Table 1, can be said that testing of transmission distance before peat land burned for Experiment Tests with obstacles like buildings and trees, is performed to get the Status of Transmitted Data for the same data of 1111 1111. Transmitted Data for FU1 is in ACCEPTED Status if transmission distance in 50m – 130m and NOT ACCEPTED when transmission distance in 140m and more. FU2 shows ACCEPTED Status of Transmitted Data if transmission distance is in 50m – 270m, more than that, Transmitted Data is in NOT ACCEPTED Status. For Channel FU3 and FU4, data can be transmitted if transmission distances are 50m – 460m and 50m – 870m, respectively. So, ACCEPTED Status will be seen in Status of Transmitted Data of Channel FU3 and FU4. Data in Channel FU3 and FU4 cannot be sent if transmission distances starts from 470m or more and 870m or more, respectively. In this case, NOT ACCEPTED Status will be shown in Status of Transmitted Data from Channel FU3 and FU4.

4.2. Testing of transmission distance when peat land burned

Testing of transmission distance when peat land burned is done to get information about the Status of Transmitted Data for the same data of 3333 3333, for Experiment Tests with obstacles like buildings and trees. Number 3 is set up to state that Peat land in burned condition. This testing is performed on the midday, good weather and no windy. Testing of transmission distance when peat land burned, can be seen in Table 2.

| Channel Number | Transmitted Data | Environmental Condition | Status of Transmitted Data | Distance (Meter) |
|----------------|------------------|--------------------------|----------------------------|-----------------|
| FU1            | 3333 3333        |                          | ACCEPTED                   | 50 - 130        |
|                |                  |                          | NOT ACCEPTED               | 140             |
| FU2            | 3333 3333        |                          | ACCEPTED                   | 50 - 270        |
|                |                  | Experiment tests :       | NOT ACCEPTED               | 280             |

From Table 2, can be seen that testing of transmission distance when peat land burned for Experiment Tests with obstacles like buildings and trees, is performed to get the Status of Transmitted Data for the same data of 3333 3333. Transmitted Data for FU1 is in ACCEPTED Status if transmission distance in 50m – 130m and NOT ACCEPTED when transmission distance in 140m and more. FU2 shows ACCEPTED Status of Transmitted Data if transmission distance is in 50m – 270m, more than that, Transmitted Data is in NOT ACCEPTED Status. For Channel FU3 and FU4, data can be transmitted if transmission distances are 50m – 460m and 50m – 870m, respectively. So, ACCEPTED Status will be seen in Status of Transmitted Data of Channel FU3 and FU4. Data in Channel FU3 and FU4 cannot be sent if transmission distances starts from 470m or more and 870m or more, respectively. In this case, NOT ACCEPTED Status will be shown in Status of Transmitted Data from Channel FU3 and FU4.
Based on Table 2, Status of Transmitted Data for FU1 and FU2 are ACCEPTED if transmission distances in 50m – 130m and 50m – 270m, respectively, when peat land burned. NOT ACCEPTED Status of Transmitted Data for FU1 and FU2 when transmission distance in 140m or more and 280m or more, in the same condition. When peat land burned, Channel FU3 and FU4 shows ACCEPTED Status of Transmitted Data if transmission distance are in 50m – 460m and 50m – 870m, sequentially. On the other hand, NOT ACCEPTED Status will be shown in Status of Transmitted Data of Channel FU3 and FU4 if transmission distance in 470m or more and 880m or more, in the same condition. Testing of Peat land Temperature is done to know the temperature reading from land, when Peat land is Not Afire, Burned under Ground and Burned on The Ground. Testing Data of Peat land Temperature is shown in Table 3.

| Channel Number | Transmitted Data | Environmental Condition | Status of Transmitted Data | Distance (Meter) |
|----------------|------------------|------------------------|----------------------------|-----------------|
| FU3            | 3333 3333        | Buildings –Trees       | ACCEPTED                   | 50 - 460        |
|                |                  |                        | NOT ACCEPTED               | 470             |
| FU4            | 3333 3333        |                        | ACCEPTED                   | 50 - 870        |
|                |                  |                        | NOT ACCEPTED               | 880             |

Based on Table 2, Status of Transmitted Data for FU1 and FU2 are ACCEPTED if transmission distances in 50m – 130m and 50m – 270m, respectively, when peat land burned. NOT ACCEPTED Status of Transmitted Data for FU1 and FU2 when transmission distance in 140m or more and 280m or more, in the same condition. When peat land burned, Channel FU3 and FU4 shows ACCEPTED Status of Transmitted Data if transmission distance are in 50m – 460m and 50m – 870m, sequentially. On the other hand, NOT ACCEPTED Status will be shown in Status of Transmitted Data of Channel FU3 and FU4 if transmission distance in 470m or more and 880m or more, in the same condition. Testing of Peat land Temperature is done to know the temperature reading from land, when Peat land is Not Afire, Burned under Ground and Burned on The Ground. Testing Data of Peat land Temperature is shown in Table 3.

**Table 3. Testing Data of Peat land Temperature.**

| Peat land Temperature (°C) | Status     | Temperature Range (°C) | Condition   |
|----------------------------|------------|------------------------|-------------|
| 0 - 20                     | NOT AFIRE  | 0 - 21.9               | SAFE        |
| 22 - 27.7                  | BURNED*    | 22 - 28.4              | BE CAREFUL |
| 27.8 - 50                  | BURNED **  | 28.5 - 50              | DANGER      |

Whereas :

- * : Burned under ground
- ** : Burned on the ground

Based on Table 3, Peat land temperature from 0°C – 20°C and it is NOT AFIRE, can be said that Peat land in SAFE Condition, because Peat land temperature is in Temperature Range of SAFE Condition (0°C – 21.9°C). If Peat land is BURNED underground and its temperature in 22°C – 27.7°C, so Peat land is in BE CAREFULL Condition because its temperature in Temperature Range of BE CAREFULL Condition (0°C – 28.4°C). If Peat land temperature in 22°C – 27.7°C and it is BURNED on the ground, so Peat land is in DANGER Condition because its temperature in Temperature Range of DANGER Condition (0°C – 28.4°C).

5. **Conclusion**

1. Data can be transmitted and ACCEPTED in distance range of FU1 from 50m-130m, FU2 from 50m-270m, FU3 from 50m-460, FU4 from 50m-870m, before peat land is burned or when peat land is burned with obstacle like buildings and trees. For same condition, if Transmitted Data over the distance range of all Temperature Sensors, so NOT ACCEPTED Status of Transmitted Data will be shown for each Temperature Sensors (FU1 –FU4).

2. If Green LED is Active (ON), means Peat land is not burned with its temperature range is 0°C–21.9°C. In this condition, LCD displays SAFE Condition, Buzzer is OFF. In this case, Temperature-Sensor1 until Temperature-Sensor4 can send temperature value from 50m – 890m.

3. If Yellow LED is ON, means Peat land burned underground with its temperature range is 22°C–28.4°C. In this time, LCD shows BE-CAREFUL Condition, Buzzer is ON. In this case, Temperature-Sensor1 until Temperature-Sensor4 can send temperature value from 50m – 890m.
4. If Red LED is Active (ON), means Peat land is burned on the ground with its range temperature is 28.4°C–50°C, LCD displays DANGER Condition, Buzzer is ON.

Acknowledgments
Authors would give thanks to Institution of Research and Community Service (Lembaga Penelitian dan Pengabdian kepada Masyarakat) Universitas Riau for funding this research in 2017.

References
[1] Research Centre Riau Province 2014 “Research of Peat Land Fire Preventive System Throug Electromagnetic Reflection Wave Prediction in Riau Province” Research Centre Pekanbaru
[2] Noveri, L.M., Rahyul A., Edy E., Nurhalim D.A. 2018 “Analysis of Controlling Wireless Temperature Sensor for Monitoring Peat-Land Fire” International Journal of Electrical, Energy and Power System Engineering Vol.1 No.2 e-ISSN: 2654-4644 pp 16-21
[3] Rahyul A., Noveri, L.M., Edy E., Nurhalim 2017 “Design of Firing Detector System by Peat Land with Woody Peat Types Using It's Heat Characteristics” Published in: Instrumentation, Control, and Automation (ICA) 5th International Conference Yogyakarta Indonesia DOI: 10.1109/ICA.2017.8068427 IEEE.org IEEE Xplore Digital Library | IEEE-SA | IEEE Spectrum
[4] Team Arduino 2014 “Arduino Pro Mini, Spark Fun Electronics” https://creativecommons.org Retrieved 12 Juni 2017 at 5 pm
[5] Texas Instruments 2015 “LM35 Precision Centigrade Temperature Sensor” Texas Instruments Incorporated unpublished Texas
[6] Dziku 2016 “HC-12 433MHz Wireless Serial Communication Module Configuration” Electronics Lab, https://quadmeup.com Retrieved June 12, 2017 at 3pm
[7] Elecrow 2012 “HC-12 Wireless Serial Port Communication Module” https://www.elecrow.com Retrieved June 12, 2017 at 2 pm
[8] Arduino Team 2014 “Arduino Pro Mini” Spark Fun Electronics https://creativecommons.org Retrieved June 12, 2017 at 5 pm