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Analysis of Controlling Wireless Temperature Sensor for Monitoring Peat-Land Fire

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Abstract*— The problem of forest and peatland fires in Riau has become main topic to prioritize its revamping. Land and forest fires in Riau until reached 3,700 hectares' area, happened in some last years. Forest and peat land fires occurred in the majority of districts in Riau Province, from low category of 4 hectares until 2,800 hectares. This research discusses about analysis of controlling wireless Temperature Sensor for monitoring Peat-Land fire by using LM35 Temperature Sensor, Transmitter-Module (HC-12), Receiver-Module (HC-12), Arduino-ProMini to produce outputs on LED, LCD, Buzzer. Detector of Peat-Land fire works when it is burning, so heat will spread through aluminium stalk and be read by Temperature-Sensor1 upto Temperature-Sensor4. Output of each sensor is sent to each control block of Arduino-ProMini in Transmitter-Module(FU1–FU4). From Arduino-ProMini, it is sent to Receiver-Module(FU5). Receiver-Module only receives one data from Transmitter-Module in one time. Every data is received by Receiver-Module goes to Arduino-ProMini, processed to produce outputs on LCD that shows ID of FU1–FU4, Peat-Land Status, temperature of Peat Land. If LED is Green, Peat-Land not burned, LED shows SAFE Condition, Buzzer Off. If LED is Yellow, Peat-Land burned underground, LED shows BE-CAREFUL Condition, Buzzer On. If LED is Red, Peat-Land burned on the ground, LED shows DANGER Condition, Buzzer On. Temperature 0°C–21.9°C is SAFE Category because Peat-Land not burned. Temperature 22°C–28.4°C is BE-CAREFUL Category because Peat-Land burned underground. Temperature 28.4°C–50°C is DANGER Category because Peat-Land burned on the ground. This equipment works as its frame work.

Keywords*— *LM35 temperature sensor, Microcontroller Arduino pro mini, HC-12 transmitter module, HC-12 receiver module, Output indicators.

I. INTRODUCTION

The problem of forest and peatland fires in Riau has become the main topic to prioritize its revamping. Land and forest fires in Riau happened in some last years, until reached an area of 3,700 hectares. Forest and peat land fires occured in the majority of districts in Riau Province, from low category of 4 hectares until the largest reached 2,800 hectares. Fire data recorded at the Riau Forestry may increase in big size.

The conversion of forest areas including peatlands for the development of palm oil, rubber and sago plantation crops will still occur in Riau in the next few years. This directly causes the amount of carbon in the peatlands to be released into emissions if the peatland is converted, drained and flammable. Although various rules and policies have been issued to support the sustainable use of peatlands, these efforts are still insufficient to prevent conversion and emissions. So, more intensive policies and supervision are required [1].

In terms of supervision, there are many ways that can be applied directly. Supervision by human labor will spend much time and energy if the area to be monitored as wide as Riau Province. However, the development of science and technology in the world is one of the answers to priority issues of Peat Land fires.

The objective of this research is to analyze controlling wireless Temperature Sensor for monitoring Peat-Land fire to provides information about condition of peat-land at that moment through LED, LCD and Buzzer.

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Away location of peatlands which is the site of fire, makes it difficult to monitor continuously. With so much peatland, making it difficult to know which place exactly is burned. This makes it difficult for local communities and governments to monitor directly the circumstances of fire. Only by using satellite then can be found the state of hotspot contained in the peat area.

Unfortunately, hotspot location information obtained by satellite is not exactly location where the Peat Land fires occur. This condition is the reason to monitor directly the condition of Peat Land fires by Riau Forestry. Subject matters based on above conditions as follow:

- The range of wireless sensor network transmission is influenced by the area to be served.
- Network topology is selected with consideration in order to reach the transmission distance above 150 m.
- Selection of wireless sensor technology refers to network topology to be selected.

The benefit of this research is to prepare an area is considered vulnerable to peat fires (as early warning system and early detection system), So that fire and smoke haze can be avoided.

II. LITERATURE REVIEW

A. Previous Study

Reference [2] was designed *Prototype of Telemetry System Based on Temperature Sensor and Smoke Sensor For Monitoring of Land Fire* by using LM35 Sensor and Smoke Sensor type FG200, Microcontroller Atmega 8535, Module RF TXM02 as Transmitter and Module RF TXM01 as Receiver. In this research, Transmitter Module could transmit data with distance 200m in open space. Transmitter sent data to Receiver if sensor has sent temperature 37°C and or detected smoke. So, *buzzer* will On and LCD display is sparkling. Data from sensor is also sent through Converter RS323 to display on PC by serial communication.

Reference [3] was *Wireless Heat Detector for Monitoring Forest Fire Based on Microcontroller*, using data sending system with dengan *Frequency Shift Keying* (FSK) Module. Temperature Sensor LM35 was used to detect temperature. Result of this research stated that when did testing on temperature 50ºC could send data to Receiver Module with distance 100meter. This Module detected heat around it. If it detected temperature more than referense 50ºC so Transmitter Module sent data to Receiver Penerima using wireless system to display on monitor.

Reference [4] did measuring test of 5 samples in Open Space with distance 20m, 40m, 60m, 80m, and 100m. Testing result mentioned that the longest distance was 87m and used LED as a notification from each data sent.

Reference [5] was title *Early Fire Detection System Based on Wireless Sensor Network*, stated that the temperature measurements, could be used as a leading indicator to detect early presence of forest fires.

This study combines methods from the previous research. The research uses four Temperature Sensors LM35, Arduino Pro Mini, four HC-12 Transmitter Module and one HC-12Receiver Module. Sensors detect any fire of lands, under ground or on the ground. The results of sensors are transmitted by four HC-12 Transmitter Module to HC-12 Receiver Module. Receiver receives just one data for any time. Results of research is displayed on LED, LCD and Buzzer.

B. System of Data Transmitting

In this research, System of Data Transmitting uses HC-12 Module as communication module with serial port by *wireless*, that can transmit and receive serial data through air media with frequency 433 MHz and distance up to 1800 meter on open space. HC-12 Module is a Data Transmitter and Receiver Data, but it can not transmit and receive data trough air in the same time because *link half-duplex* only available between Module. This module can be used as a physically cable replacement to substitute *communication cable junction of serial half-duplex*, that carry TTL signal. So, in its using, must uses two HC-12 Modules, whereas they can be arranged as Data Transmitter and Receiver Data separately [6]. HC-12 Module can be seen in Figure 1.

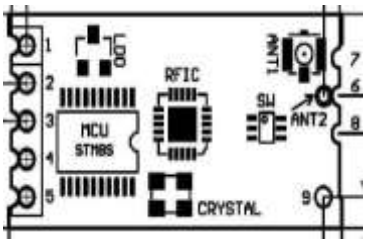

Figure 1: Module HC-12 [6]

Each HC-12 Module works in mode:

- FU1 – Standar Energy Saving Mode with 250000 bps more than air baud rate. Baud rate from serial port can be arranged be any supporting number.
- FU2 – Extrem Energy Saving Mode with 250000 bps, more than air speed. Baud rate from serial port is limited up to 1200 bps, 2400 bps, 4800 bps.
- FU3 – default, General Objective Mode exceeds different air speed, depend on serial port speed. Equivalent maximum distance such as:
  - 1200 bps ~ 1000 m.
  - 2400 bps ~ 1000 m.
  - 4800 bps ~ 500 m.
  - 9600 bps ~ 500 m.
  - 19200 bps ~ 250 m.
  - 38400 bps ~ 250 m.
  - 7600 bps ~ 100 m.
  - 115200bps ~ 100 m.
- FU4 (available on version 2.3 or newest) – Long Distance Mode exceeds air speed which is limited upto 1200 bps because air speed smaller than port speed. Only small packet can be sent like as 60 Byte maximum with interval 2 seconds. This Distance Mode can be raised up to 1800 meter

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Paired HC-12 can create wireless relation work in same mode and with same speed, such as FU1, FU2, FU3, FU4 [7].

C. Arduino Pro Mini

Arduino Pro Mini is microcontroller ATMega 328. This Integrated Circuit (IC) has 14 digital pin input/output (whereas six pins can be used as PWM outputs, six analog inputs, resonator on-board, reset button, and hole for header pin. Six header pins can be connected to FTDI cable or Spark fun board breakout to give USB power and communication board [8].

D. Temperature Sensor LM35

Temperature LM35 Sensor Module is a temperature sensor can give changing output voltage linearity together with happened changing temperature linearity. LM35Temperature Sensor can operate by using source voltage 4 – 30 V_{DC}, to avoid over self heating is used by power supply 5 V. **S**elf heating is heating effect by component itself, consequent of working current through it. Output of LM35 Temperature Sensor is linier scale factor towards the real temperature 10 mV/^{0}C, with maximum range can be measured from -55 ^{0}C upto 150 ^{0}C [9].

Maximum output of LM35 is 1,5 Volt, with accuracy 0.5^{0}C on temperature 25^{0}C. Reading error of sensor on measurement with 25^{0}C room temperature but no more 2^{0}C, can be calculated by using formula in Equation 1.

$$Temp(℃) = V_{out}\ mV/10\ Mv \quad (1)$$

III. MATERIAL & METHODOLOGY

A. Data

In this research, data was collected by measuring of peat land temperature by using LM35 Temperature Sensor which is put on HC-12 Transmitter Module. Four Temperature Sensors (TS1 – TS2) are used to detect land fire. The reading of each sensor is sent to each Microcontroller Arduino Pro Mini (PM1 – PM4) to be processed, before transmit it to HC-12 Receiver Module by each HC-12 Transmitter Module (FU1 – FU4). Only one data can be received in one moment from each FU1 – FU4 to HC-12 Receiver Module. Data from Receiver goes to Microcontroller Arduino Pro Mini (PM5). Then the data is processed to produce output in LED, LCD and Buzzer. Testing is done in Open Space and the Real Condition.

There are three LEDs are used : Green, Yellow and Red. If Green LED ON so, Peat Land Status is Not BURNED, LCD shows SAFE condition, Buzzer OFF. If Yellow LED ON so, Peat Land Status is BURNED condition, LCD shows BE CAREFULL condition, Buzzer ON. If Red LED ON so, Peat Land Status is BURNED condition, LCD shows DANGER condition, Buzzer ON.

Temperature from 0°C to 21,9°C is SAFE Category because Peat Land is not burned. Temperature from 22°C to 28,4°C is BE CAREFUL Category because Peat Land started tobe burned underground. Temperature from 28,4°C to 50°C is DANGER Category because Peat Land burned on the ground

B. Method

Methods in this research are:

1. Make design of a prototype.
2. Apply designed circuit in a prototype.
3. Measure peat land temperature.
4. Transmit data of Peat Land temperature to Receiver.
5. Reading Peat Land temperature from Receiver will be processed of Microcontroller Arduino ProMini so it can produce outputs on LCD, LED and Buzzer, depend on the value of temperature.

Diagram block in this research, can be seen in Figure 2.

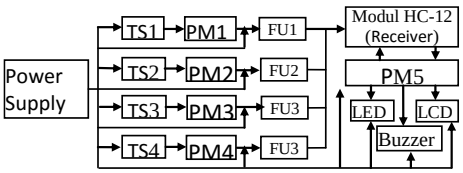

Figure 2: Diagram block of research.

IV. RESULTS AND DISCUSSION

Testing of Sent Distance Data in Open Space, can be seen in Table 1.

Table 1: Testing of sent distance data in open space

Channel Number	Sent Data	Environmental Condition	Status of Sent Data	Distance (Meter)
FU1	Number "2"	Open Space	Received	50
			Received	100
			Received	150
			Received	200
			Received	250
			Not Received	300
FU2	Number "2"	Open Space	Received	50
			Received	100
			Received	150
			Received	200
			Received	250
			Received	300
			Received	350
			Received	400
			Received	450
			Received	500
			Not Received	550
FU3	Number "2"	Open Space	Received	50
			Received	100
			Received	150
			Received	200
			Received	250
			Received	300
			Received	350
			Received	400
			Received	450
			Received	500
			Received	550
			Received	600
			Received	650
			Received	700
			Received	750
			Received	800
			Received	850
			Received	900
			Received	950

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			Received	1000
			Not Received	1050
FU4	Number “2”	Open Space	Received	50
			Received	100
			Received	150
			Received	200
			Received	250
			Received	300
			Received	350
			Received	400
			Received	450
			Received	500
			Received	550
			Received	600
			Received	650
			Received	700
			Received	750
			Received	800
			Received	850
			Received	900
			Received	950
			Received	1000
			Received	1100
			Received	1200
			Received	1300
			Received	1400
			Received	1500
			Received	1600
			Received	1700
			Received	1800
			Not Received	1850

From Table 1, can be seen that sent distance data by Transmitter in Open Space has many categories due to Channel Number. Channel 1 (FU1) can send data from distance 50m – 250m. Sent data can be read/received well in this range by Receiver Module. If distance exceeds 250m, so data cannot be transmitted or received.

For Channel 2 (FU2) can transmit data from 50m – 500m. Transmitted data can be read/received well in this range by Receiver Module. If distance exceeds 500m, so data cannot be transmitted or received.

On Channel 3 (FU3) can send data from distance 50m – 1000m. Sent data can be read/received well in this range by Receiver Module. If distance exceeds 1000m, so data cannot be transmitted or received.

Channel 4 (FU4) can send data from distance 50m – 1800m. Transmitted data can be read/received well in this range by Receiver Module. If distance exceeds 1800m, so data cannot be transmitted or received.

Testing of Sent Distance Data in real condition, is shown Table 2.

Table 2: Sent distance data in real condition

Channel Number	Sent Data	Environmental Condition	Status of Sent Data	Distance (Meter)
FU1	Number “2”	Experimental Test : - Buildings - Trees	Received	50
			Received	100
			Received	130
			Not Received	140
FU2	Number “2”	Experimental Test : - Buildings - Trees	Received	50
			Received	100
			Received	150
			Received	200
			Received	250
			Received	270
			Not Received	280
FU3	Number “2”	Experimental	Received	50
		Test : - Buildings - Trees	Received	100
			Received	150
			Received	200
			Received	250
			Received	300
			Received	350
			Received	400
			Received	450
			Received	460
			Not Received	470
FU4	Number “2”	Experimental Test : - Buildings - Trees	Received	50
			Received	100
			Received	150
			Received	200
			Received	250
			Received	300
			Received	350
			Received	400
			Received	450
			Received	500
			Received	550
			Received	600
			Received	650
			Received	700
			Received	750
			Received	800
			Received	850
			Received	870
			Not Received	880

From Table 2, can be seen that sent distance data by Transmitter in Real Condition on Experimental Test with Buildings and Trees, have many categories due to Channel Number. Channel 1 (FU1) can transmit data from 50m – 130m. Transmitted data can be received well in this range by Receiver Module. If distance exceeds 130m, so data cannot be transmitted or received.

For Channel 2 (FU2) can send data from 50m– 270m. Sent data can be received well in this range by Receiver Module. If distance exceeds 270m, so data cannot be transmitted or received.

On Channel 3 (FU3) can transmit data from 50m – 460m. Transmitted data can be received well in this range by Receiver Module. If distance exceeds 460m, so data cannot be transmitted or received.

Channel 4 (FU4) can send data from 50m – 870m. Sent data can be received well in this range by Receiver Module. If distance exceeds 870m, so data cannot be transmitted or received.

Testing of Tool totally for DANGER Category, can be seen in Table 3.

Table 3: Testing for tool totally for danger category

Environ-mental Condition	Distan-ce (Meter)	Display of LCD			LED			Buzzer
		ID	Tempera ture (°C)	Category	Green	Yellow	Red	
Experimental Test: - Buildings - Trees	50	FU1	28,2	Burned	–	–	√	ON
		FU2	28,7	Burned	–	–	√	ON
		FU3	29,3	Burned	–	–	√	ON
		FU4	29,9	Burned	–	–	√	ON
	100	FU1	28,2	Burned	–	–	√	ON
		FU2	28,7	Burned	–	–	√	ON
		FU3	29,3	Burned	–	–	√	ON
		FU4	29,9	Burned	–	–	√	ON
	140	FU1	28,2	Burned	–	–	√	ON
		FU2	28,7	Burned	–	–	√	ON
		FU3	29,3	Burned	–	–	√	ON
		FU4	29,9	Burned	–	–	√	ON
	150	FU1	-	-	–	–	√	OFF

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		FU2	28,7	Burned	–	–	√	ON
		FU3	29,3	Burned	–	–	√	ON
		FU4	29,9	Burned	–	–	√	ON
	200	FU1	-	-	–	–	√	OFF
		FU2	28,7	Burned	–	–	√	ON
		FU3	29,3	Burned	–	–	√	ON
		FU4	29,9	Burned	–	–	√	ON
	250	FU1	-	-	–	–	√	OFF
		FU2	28,7	Burned	–	–	√	ON
		FU3	29,3	Burned	–	–	√	ON
		FU4	29,9	Burned	–	–	√	ON
	270	FU1	-	-	–	–	√	OFF
		FU2	28,7	Burned	–	–	√	ON
		FU3	29,3	Burned	–	–	√	ON
		FU4	29,9	Burned	–	–	√	ON
	300	FU1	-	-	–	–	√	OFF
		FU2	-	-	–	–	√	OFF
		FU3	29,3	Burned	–	–	√	ON
		FU4	29,9	Burned	–	–	√	ON
	350	FU1	-	-	–	–	√	OFF
		FU2	-	-	–	–	√	OFF
		FU3	29,3	Burned	–	–	√	ON
		FU4	29,9	Burned	–	–	√	ON
	400	FU1	-	-	–	–	√	OFF
		FU2	-	-	–	–	√	OFF
		FU3	29,3	Burned	–	–	√	ON
		FU4	29,9	Burned	–	–	√	ON
	450	FU1	-	-	–	–	√	OFF
		FU2	-	-	–	–	√	OFF
		FU3	29,3	Burned	–	–	√	ON
		FU4	29,9	Burned	–	–	√	ON
	460	FU1	-	-	–	–	√	OFF
		FU2	-	-	–	–	√	OFF
		FU3	29,3	Burned	–	–	√	ON
		FU4	29,9	Burned	–	–	√	ON
	500	FU1	-	-	–	–	√	OFF
		FU2	-	-	–	–	√	OFF
		FU3	-	-	–	–	√	OFF
		FU4	29,9	Burned	–	–	√	ON
	550	FU1	-	-	–	–	√	OFF
		FU2	-	-	–	–	√	OFF
		FU3	-	-	–	–	√	OFF
		FU4	29,9	Burned	–	–	√	ON
	600	FU1	-	-	–	–	√	OFF
		FU2	-	-	–	–	√	OFF
		FU3	-	-	–	–	√	OFF
		FU4	29,9	Burned	–	–	√	ON
	650	FU1	-	-	–	–	√	OFF
		FU2	-	-	–	–	√	OFF
		FU3	-	-	–	–	√	OFF
		FU4	29,9	Burned	–	–	√	ON
	700	FU1	-	-	–	–	√	OFF
		FU2	-	-	–	–	√	OFF
		FU3	-	-	–	–	√	OFF
		FU4	29,9	Burned	–	–	√	ON
	750	FU1	-	-	–	–	√	OFF
		FU2	-	-	–	–	√	OFF
		FU3	-	-	–	–	√	OFF
		FU4	29,9	Burned	–	–	√	ON
	800	FU1	-	-	–	–	√	OFF
		FU2	-	-	–	–	√	OFF
		FU3	-	-	–	–	√	OFF
		FU4	29,9	Burned	–	–	√	ON
	850	FU1	-	-	–	–	√	OFF
		FU2	-	-	–	–	√	OFF
		FU3	-	-	–	–	√	OFF
		FU4	29,9	Burned	–	–	√	ON
	870	FU1	-	-	–	–	√	OFF
		FU2	-	-	–	–	√	OFF
		FU3	-	-	–	–	√	OFF
		FU4	29,9	Burned	–	–	√	ON
	900	FU1	-	-	–	–	√	OFF
		FU2	-	-	–	–	√	OFF
		FU3	-	-	–	–	√	OFF
		FU4	-	-	–	–	√	OFF

From Table 3, can be seen that temperature reading 28,2°C from Temperature Sensor1 (FU1) with data sent distance from 50m– 270m, shows BURNED Category, Red LED and Buzzer are ON.

Temperature reading 28,7°C from Temperature Sensor2 (FU2) with data sent distance from 50m– 270m, shows BURNED Category, Red LED and Buzzer are ON.

Temperature reading 29,3°C from Temperature Sensor3 (FU3) with data sent distance from 50 meter – 270 meter, shows BURNED Category, Red LED and Buzzer are ON.

Temperature reading 29,9°C from Temperature Sensor4 (FU4) with data sent distance from 50m– 270m, shows BURNED Category, Red LED and Buzzer are ON.

Based on result in Table 3, so Peat Land Status is in DANGER Condition.

V. CONCLUSION

For Open Space, temperature Sensor1 (FU1) can transmit data from 50 m – 250 m, Temperature Sensor2 (FU2) can send data from 50 m – 500 m, temperature Sensor3 (FU3) can transmit data from 50 m – 1000 m, temperature Sensor4 (FU4) can send data from 50 m – 1800 m.

For Real Condition on Experimental Test such as buildings and trees, Temperature Sensor1 (FU1) can send data from 50 m – 130 m, Temperature Sensor2 (FU2) can transmit data from 50 m – 270 m, Temperature Sensor3 (FU3) can send data from 50 m – 460 m, Temperature Sensor4 (FU4) can transmit data from 50 m – 870 m.

If Green LED ON so, Peat Land Status is Not BURNED, LCD shows SAFE condition, Buzzer OFF. If Yellow LED ON so, Peat Land Status is BURNED condition, LCD shows BE CAREFULL condition, Buzzer ON. If Red LED ON so, Peat Land Status is BURNED condition, LCD shows DANGER condition, Buzzer ON.

Temperature from 0 °C to 21,9 °C is SAFE Category because Peat Land is not burned. Temperature from 22 °C to 28.4 °C is BE CAREFUL Category because Peat Land started to be burned underground. Temperature from 28,4 °C to 50 °C is DANGER Category because Peat Land burned on the ground.

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