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POWER SUPPLY MANAGEMENT SYSTEM DESIGN ON NODE EARLY WARNING SYSTEM FOR PEATLANDS FIRE MITIGATION

Taufiq Muammar, Rahyul Amri, Yusnita Rahayu
Department of Electrical Engineering, Faculty of Engineering, Universitas Riau
Jl. Campus Binawidya Km 12,5 Simpang Baru Panam, Pekanbaru 28293, Indonesia
Email: taufiqmuammar@gmail.com; rahyulamri@yahoo.com, yusnita.rahayu@lecturer.unri.ac.id

Abstract -- *Early warning system is one of the technology to detect land fires by utilizing a network of wireless sensors. Constant data transmission by the sensor nodes consumes a large amount of energy on the nodes' sides that could affect the battery's longevity. This research is done to discover the amount of power consumption and battery longevity during fire emergencies and during non-emergency situation on peatlands. Power saving on the fire detecting system uses an LM35 temperature sensor, ATmega8 micro-controller, and HC-12 transmission module. The overall result of powered by a 9 volt battery during fire emergencies and during non-emergency, the power consumption reaches up to 1 Wh, with various longevity levels of the battery. The implementation of sleep/wake up mode scheduling during fire emergencies and non-emergencies could save battery for 2 hours compared to those without the power saving mode implementation. Power saving during fire emergency could be minimalized by activating the sleep mode activation power-down on the microcontroller and it can also set the data transmission schedule to minimalize data usage during fire emergency, so that the usage of sleep/wake up mode interval scheduling during transmission could minimalize energy consumption and elongate the power supply active period.*

Keywords: *ATMega8; Early Warning System; Power Supply; Sleep/wake-up Scheduling*

INTRODUCTION

The main cause of forest and land fires in Sumatra are influenced by human factors. This is due to their negligence or purposeful activity and the least possible factor is natural phenomenon such as climate, peatlands area, and coal area (Purnomo et al., 2018; Purnomo et al., 2017; Bagaskara et al., 2017). The fires that occur within the last few years have a major impact on the environmental and ecosystem damage, also on the economical field, social damage and it also threatens public health. Thus, is why an intensive observation is needed (Balitbang Provinsi Riau, 2014).

Some of the application on the effort to prevent peatlands fire is by the early warning system, NOAA (National Oceanic Atmospheric and Administration) satellite, GIS (Geographic Information System), and crew-less RC planes (UFVs) (Balitbang Provinsi Riau, 2014). Therefore, in this research, a new early warning system will be developed using the Wireless Sensor Network (WSN) concept. (Nurmaini, S. et al., 2017; Teguh et al, 2015; Amri, 2014; Hariyawan et al., 2014).

The research on designing a monitoring system as early detection of the indication of forest fire by adopting wireless technique using sensors as reference parameter was conducted by Hariyawan et al. (2014). The similar research was being done by Teguh et al. (2015) with measurements of the heat generated and the calculation of the acceleration of fire propagation. Factors that need to be considered in determining the sensor node power supply is when a fire is detected and data is transmitted to the data receiving system, wherein the greater the power supply used will affect the active period of a power supply (Amri, 2014).

One of the important components used in mitigation monitoring systems is wireless sensor nodes (Wirawan et al, 2015). Node sensors are used as a data gathering media that have the ability to detect or transmit data in monitoring a system or an environment such as temperature, humidity, pressure, and others (Anhar et al., 2017).

The hardware implementation of a wireless sensor node consists of several sub-systems that are supplied using resources to be able to transmit data continuously. Continuous transmission of data by wireless sensor nodes leads to substantial energy consumption so as to reduce the lifetime power supply of the sensor nodes. A power supply has an important role in determining the performance of sensor nodes as needed. The larger the power supply used then the module will be able to work as long as needed. Therefore, we need a way to reduce the power consumption of sensor nodes in order to extend the lifetime and fulfill the power requirements of one sensor node. Application of sleep wake-up scheduling mode on the sensor node hardware can reduce power consumption and extend lifetime. Sleep wake-up scheduling is the timing of the sensor on when the node is in active mode and when the node is in sleep mode. Sleep modes can be applied by selecting components of the node that have power saving features. The ATmega8-based microcontroller has several power saving modes including idle, power save, power down, and standby.

In this paper, we will examine a study of the power savings in the sensor node hardware in order to improve the power consumption and extend the lifetime of the node sensor with sleep mode setting and sleep/wake-up scheduling data transmission during peat fire emergency or non-emergency.

METHOD

Generally, the design of power saving sensor node to detect peatlands fire can be examined in Fig. 1.

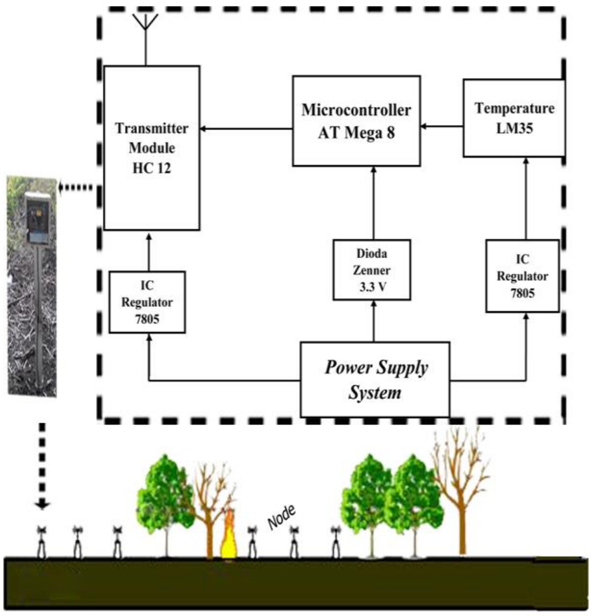

Figure 1. Power Supply Sensor System Node

Fig. 1 is a design of power supply power saving mode for mitigation of peatland fire disasters. The power supply of each node will be adapted according to load requirement conditions. When the node does not detect a fire, the node will be in sleep mode and will wake up when hot temperatures due to fires are detected. In the event of a fire, the node requires a substantial amount of power to send signals to the receiver and signal transmission will be conditioned according to the ability of the power supply to supply the load. Each node deployed, in performing its operations must have good reliability, both in terms of design and in terms of equipment used. Because the reliability of the node will greatly affect the early warning system performance on mitigation of peatlands fire disaster. For clearer examinations, refer to Fig. 2.

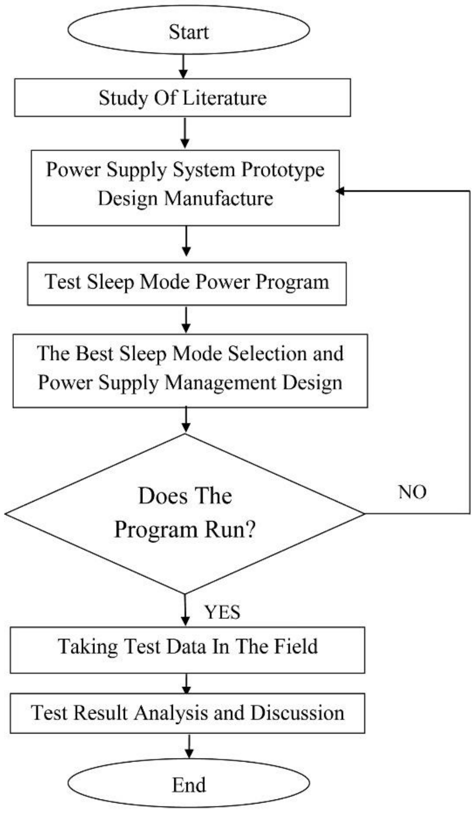

Figure 2. Flow Chart of Research Procedure

Prototype Designing

This prototype uses IC microcontroller ATmega8 as the controls. AVR ATmega8 is also the simplest computer system that can be used as a data processor and has RISC 8-bit architecture that has five features for low power consumption (sleep mode feature). Sleep mode can be activated by setting the SE bit in the MCUCR register on the microcontroller and running sleep instructions. This microcontroller sleep mode test aims to determine the total amount of power consumed by the microcontroller upon entering the sleep mode feature so that the efficiency can be figured out when compared to the normal mode. This prototype uses the LM35 sensor as a fire detector, capable of operating with a voltage of 4 volts up to 30 volts, and the maximum output on the sensor is 1.5 volts with a precision of 0.5 ˚C at 25 ˚C. The developed fire detection prototype has a specification that refers to the research of (Amri et al., 2017) with sensor LM35 and, Wirawan et al. (2015) with hardware that has low power consumption including transmitter module data transmitting equipment using a HC-12 module. Specification of prototype components is listed in Table 1.

Table 1. Prototype Components Specification

Component	Voltage	Current
ATmega8	3.3 v	3.6 mA
Sensor LM35	5 v	60 µA
Modul HC-12	5 v	100 mA

The design of prototype in this research has 4 main blocks which are: LM35 sensor, ATmega8 micro-controller, HC-12 transmitter module and power supply system, as shown in Fig. 3.

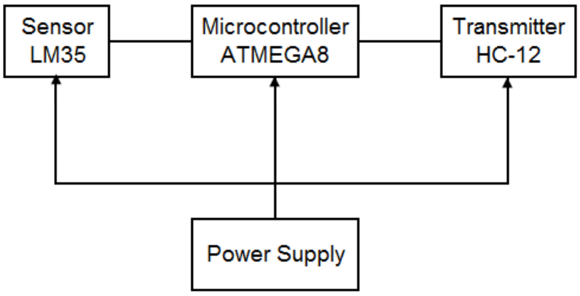

Figure 3. Block Diagram of Peatland Fire Detector

The efforts to save power on the prototype by utilizing the sleep mode feature found on the equipment. The design of the power management system will be enabled on the prototype to be able to save power during a fire and when there is no fire to stay active longer. To save power when there is no fire, the best sleep mode on the microcontroller is enabled to turn off the modules from the microcontroller that is not used and in the event of a fire time setting will be applied when transmitting data. The activation of sleep mode and transmission time setting will be set with BASCOM AVR program. Flow diagram of a power supply management system is shown in Fig. 4.

Fig. 4 shows the flowchart performance of the power supply management system to be applied in the field. At the time the prototype is turned on, the LM35 will instantly check high temperatures around the prototype. When the temperature check is not higher than 45º C, ATmega8 will go into power down mode and the transmitter module is off. The microcontroller remains in power down mode as long as it is not activated by the interrupt command. The interrupt will awaken the existing power down mode when the LM35 sensor detects high temperatures.

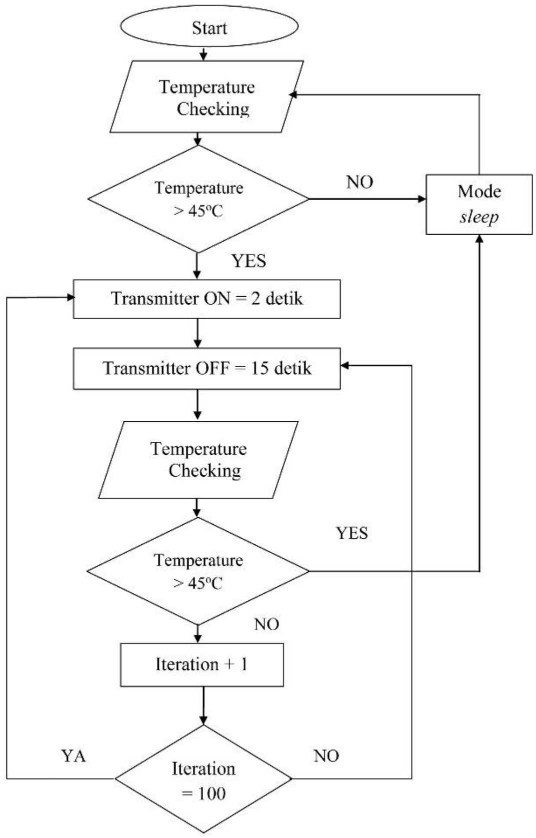

Figure 4. Sleep/Wake-up Scheduling Diagram

When the temperature detected is greater than 45º C, ATmega8 will activate the transmitter module for 2 seconds. Then after that, the microcontroller will give the transmitter module a command to temporarily turn off the transmitter module for 25 minutes. For 25 minutes there will be a temperature check every 15 seconds interval. So the purpose of the transmitter module turned on for 2 seconds is so that the microcontroller can really identify that the high temperature is a fire. So for 25 minutes, the transmitter module is turned off temporarily, the microcontroller is still receiving the signal transmission from LM35 with normal active mode condition. If within 25 minutes (iteration = 100) in 15 seconds interval while checking the temperature the microcontroller still get the signal of a temperature greater than 45 oC, the microcontroller will revive the transmitter module for 2 seconds. According to research done by Amri et al., (2017), high temperatures greater than 45 oC will be detected within the radius of 1 meter for 25 minutes. So, if within 25 minutes of checking the temperature every 15 seconds interval there is no high temperature greater than 45 oC, then the microcontroller will shift to power down mode. This will continue over and over until the supply power used is unable to supply the prototype.

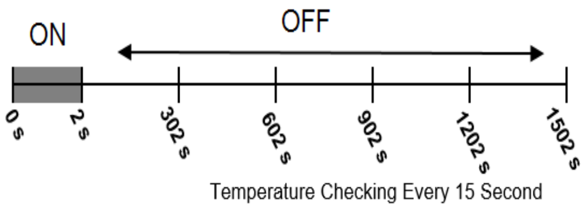

Figure 5. Temperature Checking Interval

Fig. 5 shows the temperature checking interval when heat is detected. By allowing the transmitter module to temporarily save power, it can reduce excessive power consumption. This is because the big use of power will affect the power supply used (Amri, 2014). In line with the research done by Kurniati (2016), the largest use of energy in wireless sensor networks is at the time of data transmission. For the calculation, the energy used is multiplied by the time during which the equipment run. When power is measured in watts per hour, as shown in the following equations (1), (2) and (3):

$$W = P \times t \quad (1)$$

Whereas:
P : Power (watt)
t : time (s)
W : Energy (Joule)

If the amount of energy transfer is constant, the above equation could be simplified to:

$$P = V \times I \quad (2)$$

Whereas:
P : Power (watt)
V : Voltage (Volt)
I : Currents (Ampere)

$$L = \frac{1}{2}(P_1 + P_{n+1})t \quad (3)$$

Where:
L : energy consumption
P_1 : first energy consumption parameter (watt)
P_{n+1} : energy consumption on the next parameter (watt)
T : Time span from P_1 to P_{n+1} (minutes)

Data Retrieval Method

Within this study, the utmost important factor to be tested is the current (I) and voltage (V) which are supplied by the power supply because it affects the length of supply power to the sensor, microcontroller, and transmitter module when placed in the field. The energy source used during this test using batteries (Balitbang Provinsi Riau, 2014). The test is done by measuring the equipment every 1x60 minutes until the battery can no longer supply power to the prototype. The measurement methods performed are shown in Fig. 6.

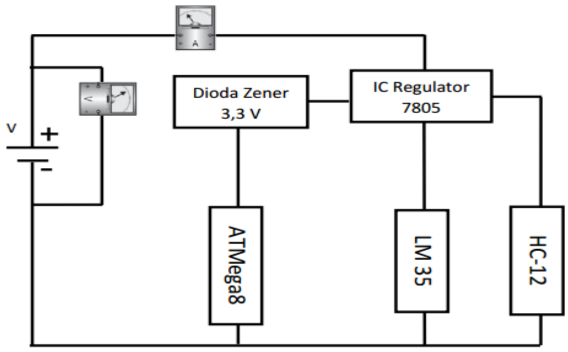

Figure 6. Voltage And Current Measuring Method On The Prototype On the Field

Fig. 6 shows the method of measuring the voltage and current in the event of a fire emergency and no emergency. The process of collecting current and voltage data in the field is done with several scenarios. First, test the power on ATmega8. Second, prototype testing without power consumption management and testing with power consumption management system when no fire occurs. Third, prototype testing without a power management system and prototype testing with a power consumption management system in the event of a fire.

RESULTS AND DISCUSSION

Test Results of The First Scenario

The measurement with sleep mode feature aims to ensure BASCOM program can operate on ATmega8 microcontroller and utilize sleep mode feature that consumes low power. This test is done by giving a voltage of 3.3 volts on the microcontroller. Testing sleep mode on the microcontroller, there are measurements of voltage and current during standby mode, ADC noise reduction, idle, power down, and power save mode. The measurement is listed results in Table 2.

Table 2. Sleep Mode on ATmega8 Microcontroller Test Results

Sleep Mode	Voltage	Currents
Standby	3.35 v	0.289 mA
ADC Noise Reduction	3.37 v	0.5 mA
Idle	3.35 v	0.63 mA
Powerdown	3.35 v	0.287 mA
Powersave	3.35 v	0.289 mA

Table 2 shows the measurements of voltage and current of the microcontroller when programmed in sleep mode. All voltages that are read when measuring by sleep mode indicate the required number needed by a microcontroller. The working voltage of the ATmega8 microcontroller is 2.7 volts to 5.5 volts (Atmel, 2015). The current value that consumes the highest power when a sleep mode is in an idle mode of 0.36 mA. While sleep mode test with the lowest consumption is in power down mode of 0.287 mA. The microcontroller operates according to the performance function of each sleep mode on ATmega8. This is demonstrated by the best sleep mode feature in power down mode because power down has the most lethal feature (Atmel, 2015). This shows that the measured value has the same number as the previous research. So with this test, all the current values flowing on the microcontroller can be suppressed to not exceed 1 mA.

Test Result of the Second Scenario

At this stage, testing is done when it does not occur fire in the peatlands, by testing without management system and using the management system. Test results can be seen in Table 3 and Table 4.

Table 3. Prototype Measurement Results without Management System During non-fire Emergency.

No	Time (minutes)	Voltage Volt	Currents mA	Power mW
1	0	8.89	32.2	286.258
2	60	7.55	29.1	219.705
3	120	7.08	27.2	192.576
4	180	6.63	24.9	165.087
5	240	5.96	22.7	135.292
6	300	5.29	20.22	106.9638
7	360	4.46	17.53	78.1838

Table 3 shows the initial voltage magnitude of the prototype is of 8.89 volts with the current passing through 32.2 mA. Known initial prototype power consumption when no fire occurs is of 286.26 mW. The amount of power consumption in the prototype will decrease in line with the power absorption done by the prototype. Prototype conditions are no longer able to absorb battery energy at the time of 7th measurement. So when the prototype is powered by a 9 volt battery with the supply capacity of 325 mAh in the conditions of non-fire emergency with the usual mode, the prototype can only last for 6 hours. The magnitude of the battery energy absorbed by the prototype for every 60 minutes for 6 hours of a battery supplying the prototype consumes power with a total of 1.002 Wh.

Table 4. Prototype Measurement Results with Management System During non-fire Emergency

No	Time (minutes)	Voltage Volt	Currents mA	Power mW
1	0	8.88	26.5	235.32
2	60	8.26	23.7	195.762
3	120	7.66	21.9	167.754
4	180	7.28	20.5	149.24
5	240	6.61	19.2	126.912
6	300	5.83	17.5	102.025
7	360	5.17	13.8	71.346
8	420	4.98	11.15	55.527
9	480	4.49	9.75	43.7775

In Table 4, it shows the prototype test results when sleep mode is activated when the conditions detected are non-fire emergency. On measurements that have been done, the initial voltage value is 8.88 volt and the current passing through it is 26.5 mA, it is found that the initial power consumption on the prototype is of 235.32 mW and prototype can survive for 8 hours with a total energy absorbed from battery by prototype when during non-fire emergency equals to 3, 1.008 Wh.

In the tests that have been done, there are similarities in the amount of power consumption absorbed from the battery capacity of 325 mAh, with the average range of 1 Wh. However, there is a difference in the duration of energy absorption in the test method that has been done. Whereas with the of use a power management system, the energy consumption is more efficient by a 2-hour difference compared to without the use of management system. With the use of equation 3, it is obtained the amount of energy absorbed by the prototype every 60 minutes show in Fig. 7.

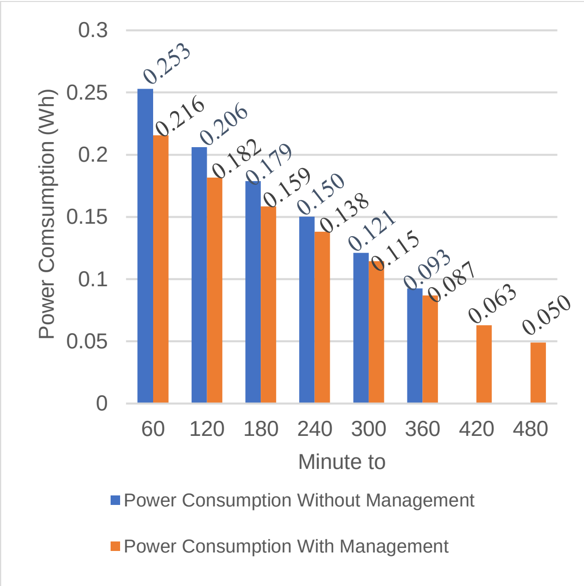

Figure 7. Graph of Comparison of Prototype's Power Consumption When High Temperature of Fires are not Detected

Fig. 7 shows the comparison of power consumption when no fire occurs when the microcontroller is utilized without enabling the sleep mode feature, and by enabling the sleep mode feature. Wherein the implementation of sleep mode can save power consumption of the prototype when there is no fire with efficiency as shown in Table 5.

Table 5. Energy Efficiency and Lifetime Span when No Fire Occur

Condition	Lifetime (hour)
Without Sleep Mode	6
With Sleep Mode	8
Efficiency	25%

Table 5 shows the percentage of power consumption efficiency and battery resilience when no fire occurs. Prototype without sleep mode is much faster in draining the supply of a 9 volts battery compared to the prototype with the implementation of sleep power down mode. So it can be concluded that by activating the devices on the node without the actual need for it, it can cause excessive waste of energy supply. Prototype efficiency when no fire occurs can be amounted up to 25%.

Test Result of The Third Scenario

At this stage, testing is done during peatland fire conditions, without using a management system and using a management system. Test results are shown in Table 6 and Table 7, respectively.

Table 6. Prototype Measurement Results Without using Management System

No	Time (minutes)	Voltage Volt	Currents mA	Power mW
1	0	8.89	39.9	354.711
2	60	7.58	34.8	263.784
3	120	6.87	31.7	217.779
4	180	6.08	29.5	179.36
5	240	5.35	27.2	145.52
6	300	4.54	18.4	83.536

Table 6 shows the results of the prototype the power consumption measurements during a fire without management system. Using a 9 volt prototype battery, it can only last for 5 hours. The magnitude of power at the first rate reached 354 mW with a decrease in energy consumption which is quite sharp along with the use of a large amount energy because, in the event of a fire, the transmitter module continuously transmits data. The use of battery energy consumed by the prototype during continuous transmission can be calculated with the same 2.5 equation, with a power consumption of 5 hours time span of 1.026 Wh.

Table 7. Prototype Measurement Results by using Management System

No	Time (minutes)	Voltage Volt	Currents mA	Power mW
1	0	8.89	33.5	297.815
2	60	7.95	30.9	245.655
3	120	7.02	28.1	197.262
4	180	6.54	24.9	162.846
5	240	5.86	18.1	106.066
6	300	5.54	15.3	84.762
7	360	5.24	12.3	64.452
8	420	4.38	9.2	40.296

Table 7 shows the measurement results of the magnitude of the power consumption at the time of detection high temperature generated by fire by setting the transmission time when the transmitter module transmits the data. The power consumption during the first measurement is 297,815 mW with a flowing current of 33.5 mA and the same voltage as in the previous test. Visible use of energy in the battery during the event of a interval sleep / wake-up scheduling. It a fire can last for 7 hours with a power consumption of 1.030 Wh. This is in line with Wirawan (2015), that prolonging the inactivity of the transmitter module will greatly reduce the use of power in the transmitter module during data transmission since the large energy requirements consumed by equipment for data transmission and long distances can also drain energy supply from the battery drastically.

Within the tests that have been done, there are similarities in the amount of power consumption which is absorbed from the battery with a capacity of 325 mAh, in the average range of 1 Wh. However, there is a difference in the duration of consumptive absorption in the test method that has been done. Whereas using the power consumption management system it is proven to be more efficient for 2 hours compared without using management system.

Fig. 8 shows a comparison of power consumption for every 60 minutes when the prototype detects a fire. The same comparison occurs compared to the previous comparison, that the use of sleep/wake-up scheduling is able to efficiently save power on the prototype. The implementation of sleep/wake-up scheduling with the transmission time setting can last longer compared to the test done by activating the transmitter module continuously. The result of the research shows that by scheduling the data transmission on transmitter module, it is able to perfectly save the use of power so that it can increase the active period of the battery. In line with research done by Kurniati (2016), a large power consumption at the sensor node is at the time of data transmission. So by regulating the use of transmitter module in sending data, it can reduce excessive power consumption.

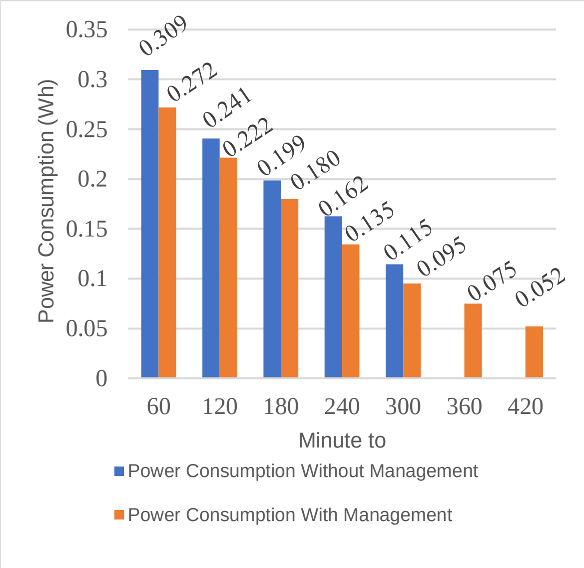

Figure 8. Energy Consumption Comparison Graph of the Prototype when High Temperatures due to Fire are Detected

Table 8. Energy Efficiency During the Event of Fire

Condition	Lifetime (hour)
Without sleep/wake-up Scheduling	5
With sleep/wake-up scheduling	7
Efficiency	28.57%

Table 8 shows the percentage results of power consumption efficiency and battery resilience capability on the prototype during a fire. By setting time to avoid continuous data transmission. With different energy consumption every minute, when using the transmission time settings, it affects the ability of the battery in supplying the prototype. So the resilience of the battery when transmitting data continuously have a much lower lifespan than the resilience of the battery when utilized with transmission time settings. So it can be concluded with lower energy consumption on the prototype when doing data transmission non-continuously can reduce the consumption of large, inefficient power and can save energy usage for a long time. The energy efficiency in the event of a fire is 28.57%. This will certainly be different when the capacity of the battery used is greater because the greater the power supply capacity used can also greatly improve the quality of the prototype's active life (Amri, 2014).

CONCLUSION

Research on the design of power supply management system at node early warning system of peatland fires produces a comparison of power consumption data and the lifetime of power supply during a fire and no fire.

Prototype using power supply management system consumes less energy during no fire emergency situation than a prototype not using power supply management system. Likewise, during a fire, the implementation of sleep/wake-up scheduling mode can utilize energy use more efficiently on the power supply.

By the usage of batteries with the same capacity, power consumption on the prototype is generated of 1 Wh. The difference is in the active period of the battery when supplying the equipment, where the use of the battery is more sparing by 2 hours when using sleep/wake-up schedule mode.

The use of power supply management system is more efficient and durable when transmitting data with the use of time interval sleep/wake-up schedule. It is able to minimize the large energy consumption and able to prolong the active period of a power supply. The longer the interval time specified, the longer the power supply is able to stay active.

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