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Telemetry Temperature Measurement Based on FM Radio Frequency

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Abstract

Telemetry systems have been widely used in industrial machines to continuously monitor movement and data from industrial machinery. However, obstacles occured in areas that have not been reached by cellular or internet signals such as mining areas and oil palm plantations. One machine that requires continuous attention is the Genset engine or power plant. Howevwr, the officers had to be placedon that site or are not effectively. Therefore it is necessary to make remote monitoring and control to determine the condition of the generator, especially the generator temperature, because of the temperature indicator can be known the performance and efficiency of the generator. The information of generator indicates the performance of generator, such as temperature and fuel comsumtion. A monotoring should done remotaly wheneverrural areas are further away from the head master offices. Real time monitoring proposed where able to change and control generator. FM transceiver used to addressing the limitation of protocil communication or rural areas since the GSM signals and internet are not coveraged that areas. Half duplex protocol communication is proposed to manage data exchange between Tx and Rx. The result show that protocol work performing during data transmision in simulation mode, however data lossed at 515 meters due to small power trancmitter is used.

Keywords : *Telemetry*, FSK, *Communication*, *Microcontroller*, *Temperature*

1. Introduction

Telemetry systems have been widely used in industrial machines to continuously monitor movement and data from industrial machinery. Many factories in big cities have used this method to make it easier for technicians to monitor machines in remote areas.
However, obstacles occur in areas that have not been reached by cellular or internet signals such as mining companies and oil palm plantations. Usually this company is in the middle of a forest that is not affordable by cellular technology or wireless internet technology. One of the machines that requires continuous attention is the Genset engine or power plant, usually consisting of 2 units of machines that live alternately to turn on mining and lighting instruments.
To place special officers at the Genset site is not efficient except for routine maintenance and fuel filling (fuel) officers who will arrive periodically. Therefore, it is necessary to make remote monitoring and control to determine the condition of the generator which is the most important, namely the temperature of the generator, because of the temperature indicator can be known the performance and efficiency of the generator. When the temperature rises significantly, it is necessary to immediately take care of the generator.

FM Radio Transmission System

FM transmitter is a device used to emit a modulated signal frequency in the form of electromagnetic waves. The frequency of the carrier signal changes according to the modulating signal, but the amplitude

of the carrier signal remains. The FM radio transmitter system consists of several parts - the basic blocks which have their respective functions as shown in Figure 1
[14].

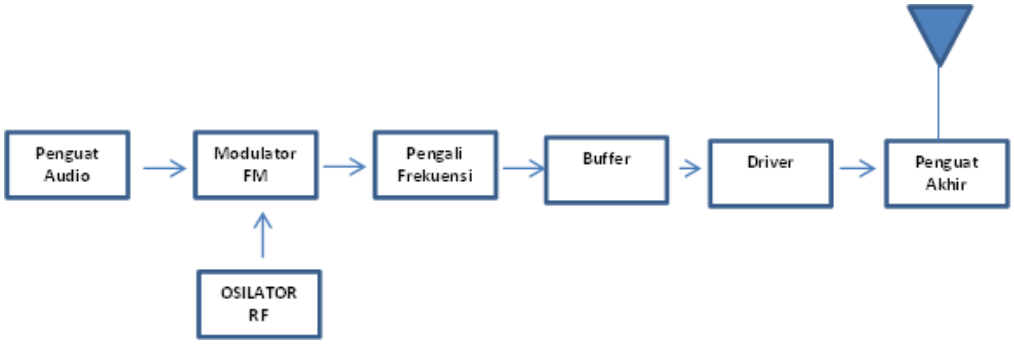

Fig 1. Block Diagram

Radio Communication System for Digital Transmission

In the concept of free space in the obstacle of electromagnetic waves begins with the assumption that a radio frequency link propogation is free from all interference. The carrier wave radio communication system is propagated from the transmitter using the sending antenna. Parts of the transmitter antenna or vice versa convert electromagnetic waves into signals in the receiver section

An analog signal containing original information is called a base band signal. When the baseband signal has a lower frequency, this signal must be shifted to a higher frequency to obtain efficient transmission. This is done by varying the amplitude, frequency or phase of a a carrier signal with a higher frequency called a carrier signal. This process is called modulation, modulation is defined as a process in which some characteristics of the carrier are altered based on the modulation wave. In the modulation system there are two types of analog modulation and digital modulation [1].
Analog signal modulation technique consists of:

a. *Amplitudo Modulation(AM)*
b. *Frekuensi Modulation(FM)*
c. *Phase Modulation (PM)*

Coding

The coding technique is very important in data communication because in this process the existing signal is changed to a certain form that is understood by certain equipment. The most widely known signal is an audio signal in the form of sound waves that can be heard by humans, this signal is usually called speech. The speech generated signal has components

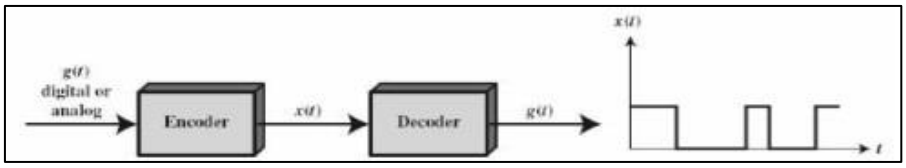

Fig 2. Modulation to Digital Signal Form Process

To make a digital signal, the source g (t) is encoded first into a digital signal x (t). Analog data or digital data will pass through a device called an encoder that is used to encode so as to produce digital signals. The digital signal is used in data transmission activities. While to go to the recipient will be converted back to the original signal, both analog and digital.

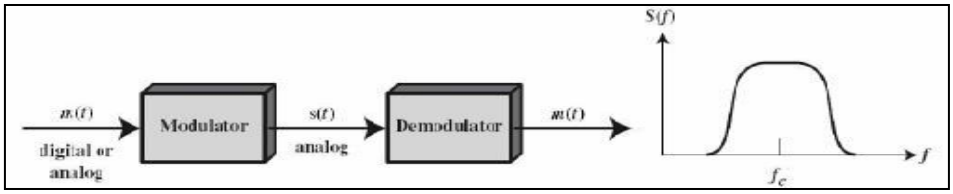

Fig 3 Modulation to Analog Signal Form Process

Communication Protocol

Based on the design in the previous chapter it can be explained in the analysis of this system the data communication protocol system that has been applied as follows:

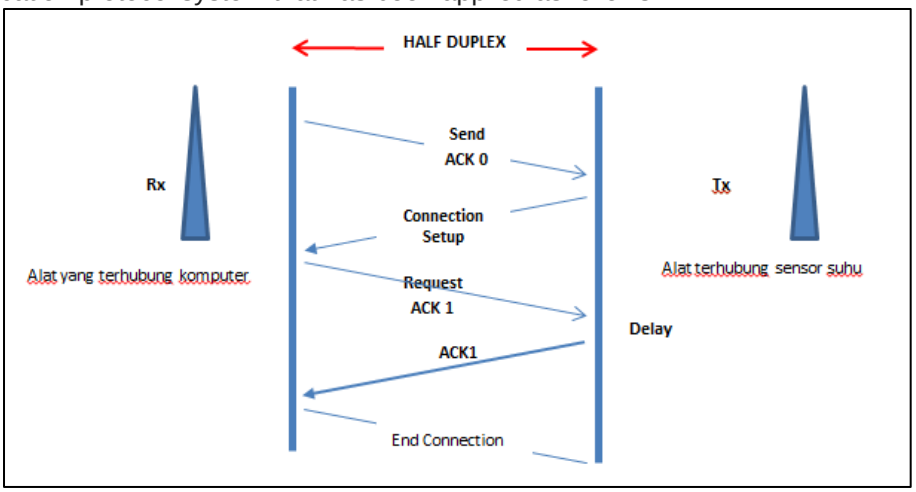

Fig. 4. Communication protocol syystem

The data transmission protocol system that is carried out is the Stop and wait method, which is meant in the initial stage the computer sends the ACK signal by pressing the Get Data button, then the system will work ACK data sent to the recipient, after the ACK signal is received by the recipient the receiver will send data and data closing sign. The sender will wait until this data and and data cover is received.

2. Research Methods

The research was carried out by means of designing tools that would be able to solve the problem of remote control of industrial equipment in areas not covered by cellular and internet signals. For display and simulation of industrial equipment analogous to being in mining and the equipment that will be remote and monitored is a power source generator. The following are the materials, materials, and tools used to conduct :

1. Research Flow

The flow of the study was carried out following the research flow shown by the research flow diagram in Figure 5.

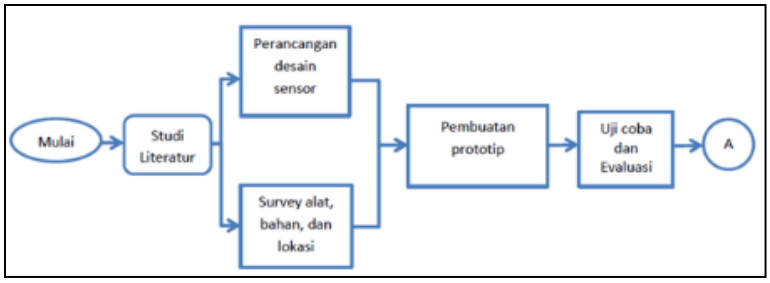

Fig 4 Reearch Flow Diagram

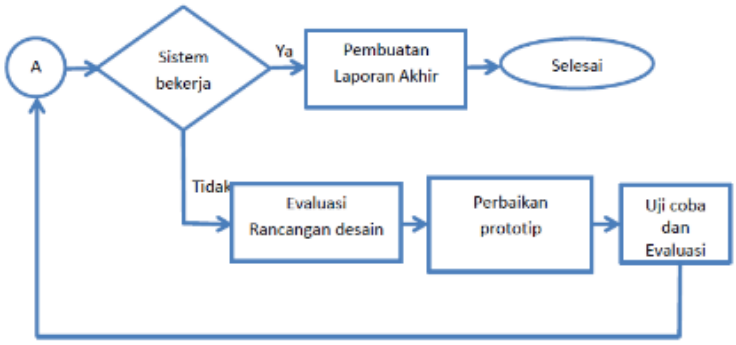

Fig. 5. Research flow diagram

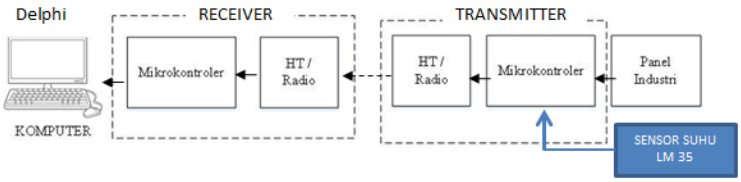

Fig. 6. Prototipe Tools Flow Diagram

The prototype of the tool that will be made according to Figure 6 generally has a function as a monitoring tool. A tool that functions as a monitor means a tool in real time can monitor the machine situation remotely for the decision to take action.

Before stepping on the previous electronic circuit, the block diagram between modules in the field will be displayed again as follows :

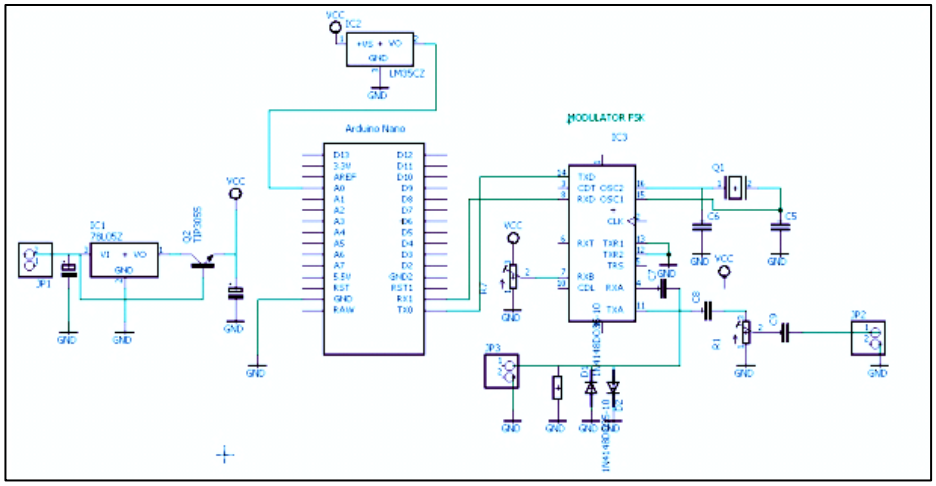

Fig 6. Electronic Data Transmitter System Scheme

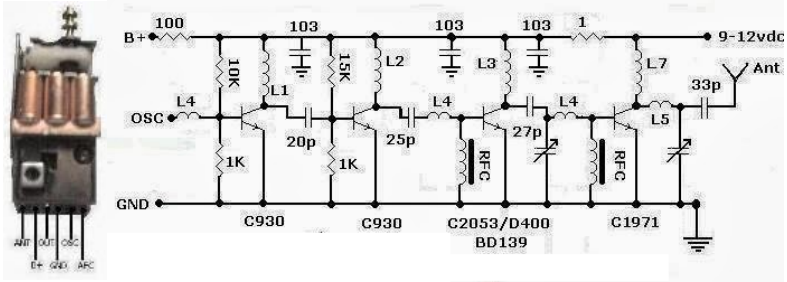

Fig. 7. FM Transmitter Electronic Scheme

As explained in the previous section, the topic to be discussed is temperature telemetry in the industrial panel system to represent a telemetry system performance. From the blog diagrams and sequence schemes above it can be explained that the planned system consists of 2 parts, namely the transmitter and the receiver. The transmitter or sender part of the data is on the side of the industry panel or generator while the receiving part is in the computer that receives and processes the data.

a) Transmitter Section Work system

The transmitter section consists of a temperature sensor, an ATMEGA microcontroller with an arduino nano board which is connected to an LM 35 temperature sensor and FSK TCM 3105 modulator. The input data comes from the LM 35 temperature sensor which is directly connected to the object measured by temperature. The output data from the LM 35 is in the form of an analog signal and then fed to the Analog input of the ATMEGA microcontroller located on the A0 pin of Arduino. In the microcontroller occurs analog signal processing into digital signals in the form of serial data with baudrate 1200 bps which is then sent to the FSK modulator IC TCM 3105. Modulator in accordance with its function is to modulate the digital signal into a voice signal so that it can be fed to the FM transmitter to be transmitted or transmitted to the place far away. In this FSK transmission system the sound signal is superimposed on the FM carrier signal. If it is heard normally, the signal that appears is just a tone sound signal, logic 0 is represented by a low tone sound and a high logic is represented by a high tone sound.

b) Receiver Section Work System

The receiver section consists of an FM Radio receiver, FSK Demodulator, and Computer. The working system is the FSK signal that is the Tone 2 frequency signal received by the radio receiver representing the digital signal 0 and 1 then entering the FSK demodulator then the FSK demodulator will convert the voice signal into a digital signal again with a baudrate of 1200 bps. This digital signal is then inserted into

the serial port of the microcontroller using the Serial to USB converter converter. This serial data is then received by the computer and displayed on the User Interface using the Delphi developer application.

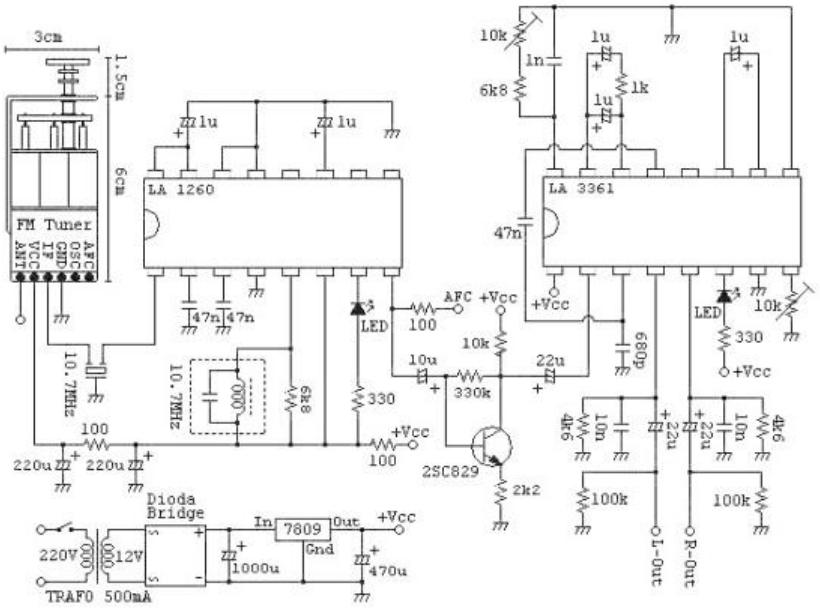

Fig 8. Receiver Schematic

2. Testing Tools

The next test is to test the tool with comparative data. The test is done by comparing the temperature data of the measurement results using a regular thermometer that is juxtaposed with data from the device. The following is the test data presented using a thermometer.

It is assumed that the farthest test distance is 550 meters which is the Line Off Sight distance because the transmitter position is higher than the receiver position.

3. Microcontroller Software Planning

Software is built using C software with arduino developers. The need to create software on the device so that the tool can process the conversion of analog signals into digital signals. The following is described the coding of the microcontroller using C format according to the arduino developer tool :

3. Results and Discussion

Temperature Measurement

Based on the trials that have been conducted, the average measurement results are presented in the table below :

Table 1. Average measurement temperature

Temperature	Measurement Data Difference									Average Difference
24,5	0.03	0.01	0.05	0.05	0.01	0.08	0.07	0.03	0.03	0,0400
31,5	0.15	0.02	0.07	0.04	0	0.05	0.05	0.04	0.04	0,0511
36	0.1	0.07	0.11	0.03	0.09	0.11	0.03	0.03	0.08	0,0722
40	0.09	0.02	0.06	0.09	0.01	0.04	0.09	0.05	0.04	0,0544
45	0.15	0.01	0.05	0.08	0.08	0.08	0.08	0.03	0.05	0,0678
51	0.05	0	0.05	0.15	0.05	0.03	0.1	0.03	0.05	0,0567
56	0.44	0.15	0.13	0.18	0.17	0.17	0.12	0.12	0.18	0,1844
61	0.06	0.11	0.09	0.05	0.09	0.01	0.14	0.1	0.03	0,0756
70	0.03	0.04	0.07	0.02	0.01	0.08	0.03	0.07	0.05	0,0444
75	0.06	0.1	0.13	0.02	0.17	0.17	0.17	0.17	0.17	0,1289
	1	**5**	**10**	**30**	**50**	**100**	**300**	**500**	**510**	
Jarak Pengukuran										

Based on these results a graph of the average measurement of the measured temperature is presented :

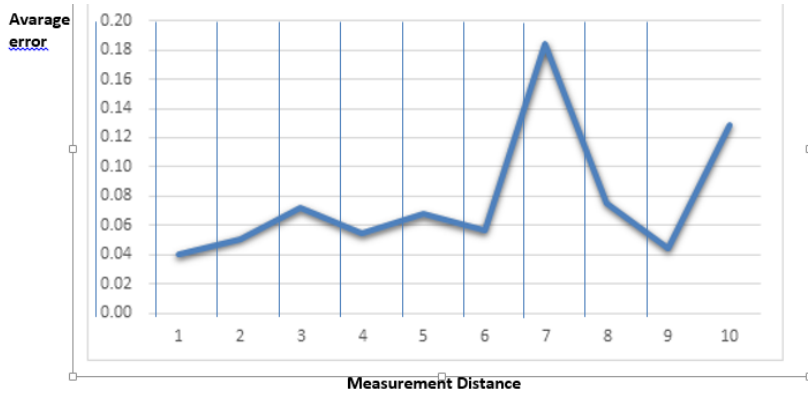

Fig 9. Graph Average Value of Temperature

From the graph and table it can be seen that the test results do not exceed the value of 0.08 or if written in the percentage none exceeds 8%. The average difference in this data is very small, which is below 10% so that it can be stated that the test tool has fulfilled the requirements to be used as a measuring tool because the tool value and calibration value are very close (error below 10 percent).

1. Path Loss

The following is a table of antenna and transmitter parameters followed by power loss data based on measurement results. The measurement tool used is Power Meter and Field Strength Meter.

Table 2. Power loss data measurement

Transmitter and Receiver Distance	Transmitte r Power	Strength Signal in Receiver
10 m	1 Watt	-21,80
30 m	1 Watt	-25,00
50 m	1 Watt	-27,75
100 m	1 Watt	-35,65
300 m	1 Watt	-50,25
500 m	1 Watt	-75,85
510 m	1 Watt	-81,25
515 m	1 Watt	-100,15
520 m	1 Watt	-115,30

The parameters used are as follows:
- Transmitter power: 1 Watt = 30dBm
- Receiver Power: 20 dBm
- Test distance, 10 meters, 30 meters, 50 meters, 100 meters, 300 meters, 500 meters, 515 meters

Because testing at a location that is free of building interference is used the Path Loss Free Space formula:

$$FSPL = 20\log_{10}(d) + 20\log_{10}(f) + 20\log_{10}\left(\frac{4\pi}{c}\right) - G_t - G_r$$

Table 1. Free space path loss measurement

Transmitter and Receiver Distance	Path Loss
10 m	-17.560 dB
30 m	-8.018 dB
50 m	-3.581 dB
100 m	2.44 dB
300 m	11.98 dB
500 m	16.42 dB
510 m	16.59 dB
515 m	16.68 dB
520 m	16.76 dB

4. Conclusion

Based on the discussion above, the following conclusions are obtained that the prototype tool has been able to display and report remote measurements using communication protocols as described in Chapter 3 and the discussion, namely Stop and Wait. If the data has not been received, the recipient is still waiting and just sends information quickly after all data has been sent. In the tool used can be integrated between the transmitter and the Arduino microcontroller module, in this trial using a small power transmitter with a distance of up to 600 meters obtained results of lost data at a distance of 515 meters. This can happen because data transmission requires very good quality to be able to send data to the recipient.

Constraints in transmission will result in missing data or data errors. Thus the transmitter reaches 5 watts but the frequency distortion around the area is quite high (television signals, radio communications, and electromagnetic fields from Wifi) will cause limited electric power or power equipment. Comparison between the test equipment is a digital thermometer with a test instrument showing a small data gap. This shows the system is right in measuring the data. Able to access this research data because it makes a credible temperature monitoring module.

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