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# Wireless Sensor Network Based Atmega16 Microcontroller as Temperature and Current Monitoring System on Distribution Network Transformatior

B Suprianto<sup>1\*</sup> and S Nidzom<sup>2</sup>

<sup>1</sup> Universitas Negeri Surabaya, department of electrical engineering, Surabaya, Indonesia

<sup>2</sup> Universitas Negeri Surabaya, department of electrical engineering, Surabaya, Indonesia

\*bambangsuprianto@unesa.ac.id

**Abstract.** Distribution transformers is one of the main component in electrical distribution system to customer. This transformers is used to change the input of the transformers from 20 KV to 220 Volt. Distribution transformers often has disruption, and if it is not fixed soon, it will damage transformers and fire it. One of the parameter that indicate disruption in transformers is enhancement of current and temperature of transformers significantly. A monitoring system is needed to avoid damaging the transformers which uses current and temperature as a parameter. A monitoring system can be built by wireless sensor network as the main system which every node can handle more than one sensors that can be controlled from far away. This research aims: (1) to get simulation system of wireless sensor network as a monitoring system based on Atmega 16 microcontrollers, (2) to analyze wireless sensor network as a monitoring system of distribution transformers. Method that is used in this research is Reasearch and Development. Which starts from making the simulator and after that make simulation with the hardware that has been made, and analyze data from simulation. Result of this study showed that: (1) the simualator that has been made is work fine and getting closer with the system in a real world, (2) based on regression analysis, the regresion line is significant to predict Y value (temperature) based on X value (current), which has relation values is 96.2%, with bias and relative error for current values is -0.038 and 2.52%, bias and relative error for temperature values is 1.008 and 1,21%.

## 1. Introduction

One application of wireless technology is the use of sensor controls. Traditional sensor controls still use the cable as the main communication channel, so it takes very long cables to monitor certain areas. The length of the cable is adjusted to the area the sensor wants to install. In the use of this wireless technology, the cable is not needed, every node on the sensor can communicate between nodes with one another, so if desired additional sensor addition is no longer required new installation, just added it.

The network nodes on the wireless sensor network can accommodate multiple sensors at once [1]. The use of wireless sensor networks makes it possible to monitor a wide range of areas, as well as control the actuator from a great distance.

Current Wireless Sensor Networks (WSN) support a wide range of applications, such as tracking a target, home automation and environment monitoring [2]. The widespread use and use of the latest systems using this wireless, should be adapted by existing technology developers.

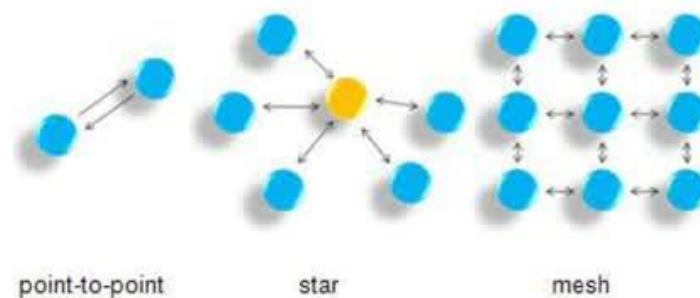
Distribution transformer is one of the main components in an electrical distribution system to the customer. Without the distribution transformer, then the customer will not have electricity due to the operating voltage electricity distribution network is 20 KV or commonly called medium voltage networks, so that the necessary distribution transformers as a transformer lowering the voltage (step-



down) from 20 KV to 220V/380V. Disturbances in distribution transformers lead to disruption of electricity distribution in a region, where disturbances on the distribution transformer is not immediately addressed, the transformer will be damaged [3].

One of the parameters that distribution transformers disorder is the occurrence of temperature rise that is working on the transformer winding temperature exceeds 950 °C in and an increase in flow due to short circuit in the transformer (short circuit). For that, we need a monitoring system that can be used to monitor in real time transformer condition of using a wireless network.

Based on this, it can be formulated some formulation of the problem: (1) how to create a simulation of wireless sensor network system as a monitoring system for transformers distribution network, (2) how the test results WSN simulator as monitoring system transformer distribution network. The purpose of the study includes: (1) to create a simulation system in order to examine the parameters of the distribution network transformer damage, (2) to analyze the results of the test instrument transformer monitoring system distribution network. WSN topology is divided into three, namely: (1) *point to point topology*, (2) *star topology*, (3) *meshtopology*.



**Figure 1.** Topology Wireless Sensor

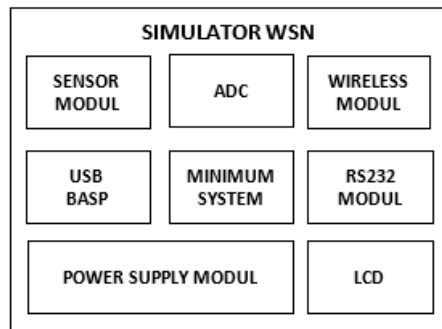
The sensor nodes will be installed near the transformer distribution network, in which amount measured was the temperature and flow. The parameters that the distribution network transformer will burn, is an increase in temperature and increase in flow due to excessive load. Therefore, monitoring is required so that these parameters can be known immediately.

In this simulator will be made a draft design that consists of blocks of sequence: (1) unit of power supply, (2) the output of LCD, (3) USB ASP, (4) the circuit's minimum system, (5) RS232 module, (6) ADC module, (7) wireless modules, (8) sensor module. The simulator draft design is as follows (figure 2). The simulator will use two sensors ACS712 current sensor and LM35 temperature sensor. These sensors will be read by microcontroller and will be received by the PCD. Specifications of the sensors are as follows:

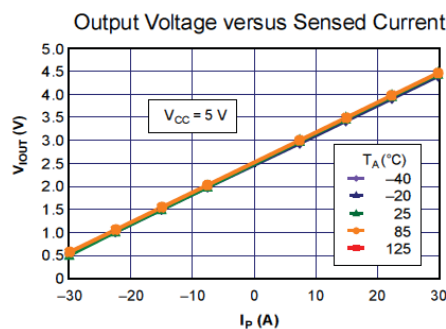
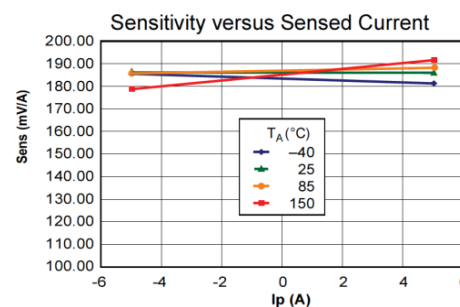
### 1.1 ACS712 current sensor

In the distribution network transformer, the most common disturbance is the short circuit. If the installation is a great power, short-circuit current could be huge [4]. The first parameter that will be burned transformer is a very large increase in current. The greater the voltage transformer, the greater the short-circuit current.

In this WSN simulator will be used with the type ACS712 current sensor in which the sensor is working to detect both DC and AC currents up to 5A. Sensors work at a voltage of 5 volts DC.

**Figure 2.** Draft Simulator WSN**Figure 3.** ACS712 Current Sensor

In accordance with the datasheet that this sensor has the characteristics of any increase in a current of 1A, then there will be a rise in the output voltage of 185 mV, or it can be said that these sensors have a sensitivity of 185mV/A. In this sensor, when not loaded (not used) it will output 2.5 volts in state 0A. Data sheet can be seen in the relationship between the output voltage and current to be detected:

**Figure 4.** Output Voltage Vs Sensed Current**Figure 5.** Sensitivity Vs Sensed Current

In this WSN simulator, which is used to measure the temperature of the transformer is using LM35 temperature sensor. One of the parameters that will burn the transformer is the rise in temperature in the transformer oil serves as a coolant.

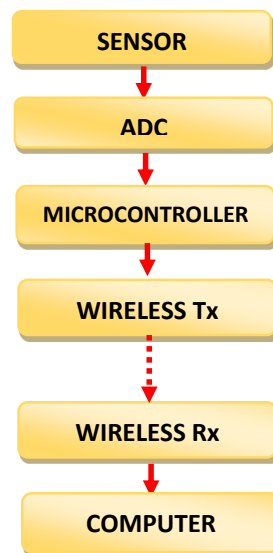
Transformer insulation system on the distribution network, used to work at a temperature of 650C and winding hottest spot winding temperature 800C above ambient temperature of 300C [5,6]. In the event of damage to the transformer, there will be rise in temperature in the transformer oil. The oil in the transformer becomes hot due to several reasons: (1) because the spark generated within the transformer, between windings or between the windings and iron patio of the transformer, (2) because of a short circuit occurring between the windings, (3) for one phase disconnected, (4) because of its iron core becomes too hot, (5) due to an oil leak in the vessel or in the pipes [4,7].

One of the parameters that can be used that are problematic transformer is the transformer oil temperature rise. It is necessary for the holding of monitoring the oil temperature in the transformer [8].

The parameters of the two mentioned above, namely the increase of current caused by a short circuit, and an increase in the temperature of the transformer oil, from here it can be concluded that the distribution network transformer works well or not. To measure the amount of current, using the type ACS712 current sensor that can measure up to a current of 30A and to measure the temperature of the transformer oil using LM35 temperature sensor, which can measure temperatures up to 1500C. Data from these sensors is sent wirelessly to a computer for processing and display [9,10].

## 2. Methods

This study included into this type of research and development which stage in the research is a simulator tool manufacture, testing, data analysis and the results of testing tools. Making the WSN simulator refers to the working principle as follows:



**Figure 6.** Block Diagram Simulator WSN

Simulator consists of several circuit blocks that are separated from each other, consisting of: (1) power supply module, (2) minimum module system, (3) the sensor module, (4) ADC module, (5) wireless module, (6) USB ASP module, (7) RS232 module, (8) LCD modules.

## 3. Technical data collection

After manufacture simulator completed, then test tools needed for data retrieval. Test tool is done by providing load on the transformer, to adjust the load in order to obtain the maximum current value or the peak load, and the measured temperature value. Comparative parameter required in testing this tool is AVO Meter and Thermocouple [11].

Results of test tools covering the current measured by the ACS712 current sensor is then compared with the AVO Meter and the temperature measured by a temperature sensor, later compared with thermocouple. Next will be obtained graph circuiting and temperature and then performed the analysis of the test results. Expenses that are used in order to obtain the value of the variable flow and temperature are variable resistor with specification 50 Ohm / 3A and 20 Ohm / 5A.

## 4. Technical analysis of data

Data analysis techniques used for the analysis of test results tool is the least squares method. This technique is one of the regression technique that can be used to test the linearity of a relationship. Least squares method is used based on two assumptions. The first is that there is actually a linear relationship between the measured response  $Y$  and the standard analysis of concentration  $X$ , and a second assumption that any deviation of the individual points from the straight line arises from an error of measurement [6,12,13]. The formula used in this technique are as follows:

4.1. *a* and *b* of the equation  $Y = a + bX$

$$a = \frac{(\sum Y)(\sum X^2) - (\sum X)(\sum XY)}{n \cdot \sum X^2 - (\sum X)^2} \quad (1)$$

$$b = \frac{n(\sum XY) - (\sum X)(\sum Y)}{n \cdot \sum X^2 - (\sum X)^2} \quad (2)$$

*X* = Variabel Independen

*Y* = variabel Dependen

4.2. Regression test

*H0*: non-significant regression line to predict changes in the variable *Y* to each of the *X* variable price.

*H1*: significant regression line to predict changes in the variable *Y* to each of the *X* variable price.

**Calculate:**

$$JK_{(T)} = JK_{(a)} + JK_{(b|a)} + JK_{(res)}$$

$$JK_T = \sum y^2 = \sum y^2 - \frac{(\sum Y)^2}{n} \quad (3)$$

$$JK_a = \frac{(\sum Y)^2}{n} \quad (4)$$

$$JK_{(b|a)} = b \cdot \sum (x - \bar{x})(y - \bar{y}) \quad (5)$$

**Calculate: *KT***

$$KT_a = \frac{JK_a}{db_a} \quad (6)$$

$$KT_{(b|a)} = JK_{reg} = \frac{JK_{(b|a)}}{db_{(b|a)}} \quad (7)$$

$$KT_{res} = \frac{JK_{res}}{db_{res}} \quad (8)$$

$$F_{count} = \frac{KT_{(b|a)}}{KT_{(res)}} \quad (9)$$

Price *F* arithmetic compared with *F* table with a significance level of 5% and 1% to decide whether accept *H1* or *H0*.

4.3. Coefficient of determination

$$R^2 = \frac{JK_{reg}}{\sum Y^2} \quad (10)$$

4.4. Bias

Bias is the difference that occurs between the measurement results and the actual results due to systematic errors. Systematic errors in measurements lead to biased results [6]. Bias is formulated as follows:

$$bias = \mu_B - \mu_A \quad (11)$$

4.5. Relative error

Accuracy is a relative term in sense that what is an accurate or inaccurate method very much depends on the need of the scientist and the difficulty of the analytical problem. Accuracy is expressed in terms of either absolute error or relative error [6]. Relative error is defined as follows:

$$E_r = \frac{\bar{x} - \bar{x}_t}{\bar{x}_t} \times 100\% \quad (12)$$

**Information:**

*X* = Average measurement results

*X<sub>t</sub>* = Average real value

## 5. Research results

Results of this research includes the results of making simulators, test results, and the results of the data analysis. The results of the simulator are as follows:

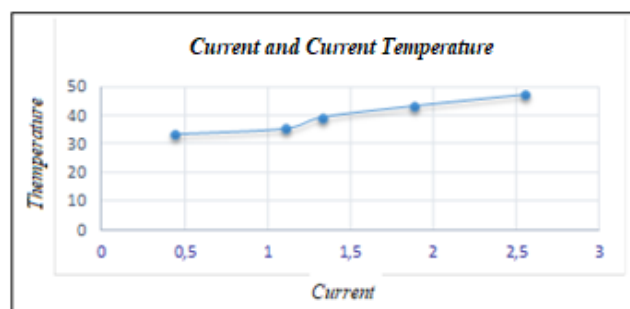
**Figure 7.**

Results Simulator

Manufacture

## 6. Test results tool

Based on the testing tool obtained graph of current and temperature relationship as follows:

**Figure 8.** Current and Current Temperature**Table1.** Test Results of Current and Temperature

Current		Temperature °C	
Current Sensor	Ampere	Temperature Sensor	Thermocouple
0.44	0.55	33.33	33
1.11	1.09	35.29	34
1.33	1.52	39.22	39
1.89	1.92	43.14	41
2.56	2.44	47.06	46
1.466	1.504	39.608	38.6

From the results of testing the device obtained the following values:

- Regression line significance test  
Coefficient value  $a = 29.531562$

Coefficient value  $b = 6.867789$

$JKT = 126.21668$

$JKa = 7843.96832$

$JKb | a = 121.4311629$



$$\begin{aligned}
 JK_{res} &= 4.785459 \\
 KT_a &= 7843.96832 \\
 KT_b | a &= 121.4311629 \\
 KT_{res} &= 1.595153 \\
 F_{(count)} &= 76.125088 \\
 F_{5\% \text{ and } 1\%} &= 10.13 \text{ and } 34.12
 \end{aligned}$$

Based on the value of  $F_t$  5% and 1%, then the value of  $F_{(count)}$  fell on the area reject  $H_0$  and accept  $H_1$ , it can be said that a significant regression line to predict changes in the response variable  $Y$  based on each value of  $X$ .

b. Coefficient of Determination

From the calculation coefficient of determination obtained value = 0.962. From this determination coefficient calculation, it could be concluded that the effect of variable  $x$  to  $y$  is reached 96.2%, or it can be said that the current variable influence to variable temperatures of 96.2%.

c. Bias

From the calculation of the bias current to the bias current value obtained by -0.0038 and bias current temperature of 1,008.

d. Relative Error

Relative error of calculation values obtained for the relative error current of 2.52% and current temperature at 1.21%.

## 7. Conclusion

Based on the research that has been done, then got some conclusions that can be taken about the simulator WSN has been made, the conclusion is as follows:

- To test the significance of the regression line, based on the calculated result, the value of  $F_{(count)} = 76.125088$  with  $\alpha = 0.05$  and  $\alpha = 0.01$  and the df of the numerator 1 and df denominator 3 obtained  $F_{(table)} 5\% = 10.13$  and  $F_{(table)} 1\% = 34.12$ , so that  $F_{(count)}$  fell on the area accept  $H_1$  and reject  $H_0$ , it can be concluded that significant regression line to predict changes in the variable  $Y$  (temperature) to each of the  $X$  variable price (Current).
- Based on the results of significance test of the regression line was concluded that the regression line significantly to forecast changes in a variable  $Y$  against each price variable  $X$ , then the magnitude of the effect of variable  $X$  (Current) to  $Y$  (temperature) is shown on the coefficient of determination which is based on the results of calculating earned value 0.962. It can be concluded that the influence of variable  $X$  (Current) to variable  $Y$  (temperature) reached 96.2%.
- Based on the results of the test tool and the comparison parameters obtained bias between the measurement results with the actual value. For there is a flow variable bias of -0038 and temperature variables are biased by 1.008.
- Based on the results of the test tool and comparator parameters obtained the price of Relative Error which shows the proximity of the price measurement results with the real value. For current variable there is  $E_r = 2.52\%$  and temperature variable equal to  $E_r = 1,21\%$ .

## References

- [1] Kalita and Hemanta K Wireless Sensor Network Security Analysis *International Journal of Next-Generation Networks (IJNGN)* **1** 1
- [2] Li, Shuang An Interference-Aware Routing Algorithm for Multimedia Streaming Over Wireless Sensor Networks *International Journal of Multimedia and Its Applications (IJMA)* **2** 1
- [3] Sohraby K 2007 *Wireless Sensor Networks: Tenhnology, Protocols, and Applications* New Jersey: John Wiley & Sons, Inc.
- [4] Harter P Van and Setiawan E 1985 *Instalasi Listrik Arus Kuat 2* Bandung: Binacipta



- [5] Romadona and Madayun S A Analisa Penyelesaian Gangguan Trafo Distribusi Dengan Menggunakan Metode (Root Cause Problem Solving) *Jurnal Tugas Akhir* 1
- [6] Holler 2007 *Principles of Instruments Analysis* USA-Canada: Nelson Education Ltd.
- [7] Rappaport and Theodore S 2002 *Wireless Communication* USA: Prentice-Hall
- [8] Akyldiz L F Wireless Sensor Networks: A Survey *Journal of Computer Networks* 38
- [9] Newby and Timothy J 2010 *Instrucutional Technology for Teaching and Learning* USA: Prentice-Hall, Inc.
- [10] Oxford Dictionary of English 2010 UK: Oxford University Press
- [11] Hasan Iqbal 2006 *Analisis Data Penelitian dengan Statistik* Jakarta: Sinar Grafika Offset
- [12] Riduwan 2012 *Dasar-Dasar Statistika* Bandung: Alfabeta
- [13] Sugiono 2013 *Metode Penelitian Pendidikan (Pendekatan Kuantitatif, Kualitatif dan R&D)* Bandung:Alfabet