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EASY MONITORING AND DATA RECORD SYSTEM OF ELECTRIC CURRENT DETECTED BY ACS712 AFFORDABLE NON-DESTRUCTIVE ELECTRICAL CURRENT SENSOR

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ABSTRACT

*Monitoring and data record system of electric current on the current conducting wire has been developed. Recently, the current measurement was conducted by electronic circuit configuration by adding the shunt resistance in the circuit configuration. Compare to the voltage measurement, the electric current measurement has several obstacle and sometimes dangerous, especially on the AC current measurement. This study offers the automation of electric current measurement using affordable and non-destructive ACS712 Hall effect sensor. Hall effect is the phenomena of charge flow deflection in the metal plate that is placed in the magnetic field. By using this sensor, it is possible to detect the AC and DC current on conducting wires. The output of the sensor voltage will be change based on the magnetic field obtained due to current flows in the wire. Those output voltage are processed in microprocessor of ATMEGA238. Measurement results are saved in *.txt format. LabVIEW is used as the display system interface to simplify the utilization. The measurement is conducted in the Faraday cage. This system can be one of answer for the efficient and stable affordable current measurement with the precision is 0.9954 and average of accuracy percentage is 99.5934%. To reach those precision, the sensor calibration formula in datasheets should be corrected by subtracts the sensor calibration formula with the constant of 0.125.*

Keywords : ACS712, Current Electricity, Hall Effect, Monitoring System

I. INTRODUCTION

Nowadays, an automation system has been widely developed in the world, especially in the industry field. A precise system of DC and AC current sensors are required by the automotive and chemical industry in many applications [1]. This field is begun to operate with human full assistance, then they shift to machine, electro-mechanic, and finally robotic based on artificial intelligence with fully automatic. Any model design of the automation system in the industry field depends on the optimal capability of the developed control system. For example, the performance of the control system in the industry with various motors such as AC, DC, servo or stepper motor. Those would be disturbed if the motor system does not work properly. One of the reasons for the poor motor system is unstable of electric current supply. Therefore, it is needed the constant current supply for applied in the system to improve their performance.

The maximum capability of control system relates to the optimum motor work applied in the system. The velocity, torque, and rotation direction are the important parameter to be arranged. The magnitude of the motor velocity and torque net depending on the number of current flows in the motor system [2]. The velocity and torque stability is corresponding to constant flowing current. Poor stability of current flowing leads to unstable motor rotation velocity and torque adjustment. In the motor control system, the more voltage applied, the more current produced. Too much current in the system affects the disruption system and burn the motor coil. The current flowing should be monitored continually. The use of high-precision instruments and excellent products in industrial fields is essential [3].

Generally, the current measurement in the electrical circuit uses ammeter that is not efficient. This problem appears because the circuit will be loaded by the shunt resistance in the ammeter [4]. The disadvantage of this configuration are the measurement can be interrupted, shunts for large currents are overwhelming. They can dissipate heat and the output is galvanically connected with the measured circuit [1]. Therefore, it is needed to develop the current measurement system that does not disturb the electrical circuit work. In addition to date, the measurement of electric current sometimes dangerous. Therefore, the non-destructive sensor is needed. Many current sensor has been developed nowadays such as fluxgate sensor in PCB technology, X-magnetoresistance current sensor such as anisotropic (AMR), giant (GMR), tunnelling (TMR), colossal (SMR) and other. Each of sensor have advantages and disadvantages.

One of low-cost and efficient current sensor based on a highly sensitive Hall effect sensor is ACS712. ACS712 is affordable high precision sensor module based on Hall effect. The use of ACS712 sensor has been conducted by clamp meter as standard [5, 6]. However the uncertainties is large, around 20% [5] even around 80% [6] for some of their measurements. In those study [5, 6], the environment of the measurement were not carefully taken. There are no magnetic shielding in instrument setup and the measurement was not taken in electromagnetic fields free room. In addition to that, the real time data record is not provided. Therefore, those are not really contactless.

In the present work, we developed the system of electric current sensor of ACS712 and ATMEGA328 as the microcontroller. Meanwhile, LabVIEW is used as the system interface to simplify the utilization and also connected to the PC for the efficient large data storage. The measurement is conducted in the Faraday cage. The correction on the sensor calibration is also study to optimize the sensor precision.

II. METHOD

A. Fundamental Theory

Hall effect is the phenomena of charge flow deflection in the metal plate that is placed in the magnetic field. The charge flow detection causes the voltage difference between plate side called hall potential [7]. Hall effect sensor is the sensor that is designed by using hall effect principle to detect the magnetic object. The hall effect sensor works besides of Lorentz force [8] as shown in Fig. 1. If the magnetic field B is placed perpendicular with the metal plate (conductor or semiconductor), this field will give deflection force F in the plate as expressed by $il \; x \; B$, where the force is found to be the right side. The charge will obtain Lorentz force as given by $F = q\,(v \times B)$. This causes the charge deflection in the perpendicular direction with charge velocity direction and magnetic field direction. So that, difference voltage will occur in the plate side which is parallel to the current direction. All the hall effect equipment is activated by a magnetic field [9]. In the current sensor application, hall effect detects the magnetic field that is generated by electric current flow. Sensor ACS712 type is the current sensor that works besides of hall effect. It is operated with linear hall effect and low resistance.

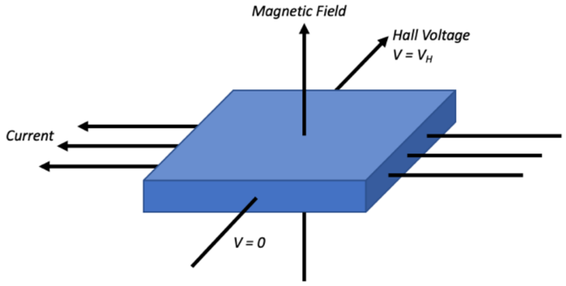


Fig. 1. Hall phenomena in the metal plate due to the presence of the magnetic field [7]

B. Experimental Method

Fig. 2 shows the block diagram of the sensor system where the system consists of ACS712 as the detector, ATMEGA238 as microcontroller and PC for measurement display where LabVIEW is used for a software interface. The measurement is conducted in the Faraday cage. Faraday cage or Faraday room or Faraday shield is an enclosure used to block the electromagnetic fields. It developed by continuous covering of conductive material. This room is available in our Laboratory, Institut Teknologi Bandung. By conducting the measurement in this cage, our system is free from unwanted magnetic fields signal that can be affected to the Hall effect sensor readout. In other words, we have ultra-low noise in our measurements.

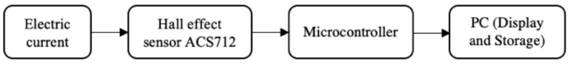


Fig. 2. Sensor system block diagram

Real-time monitoring of current measurement is displayed in the PC using LabVIEW. Figure 3 shows the flowchart of the LabView program which developed in the present work.

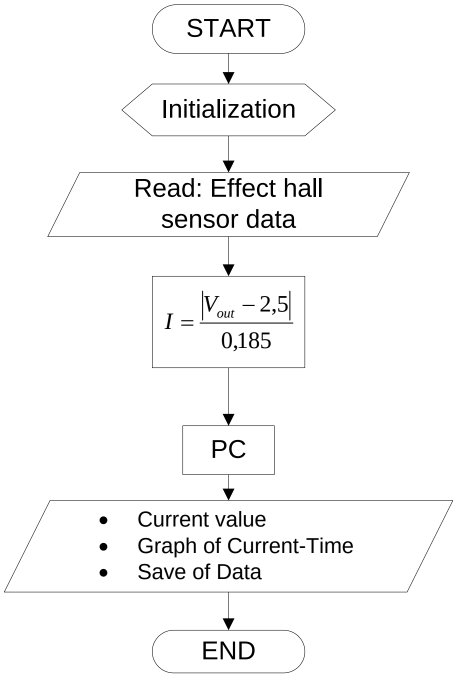


Fig. 3 Flowchart of labVIEW program

Calibration function is obtained from the sensor datasheet module as given by

$$I = \left(\frac{|V_{ou} - 2,5|}{0,185} \right). \tag{1}$$

The measured data in this works is the percentage of error, accuracy, and precision of the system. The percentage of error is calculated by following Eq. (2) [10].

$$\text{percentage of error} = \frac{Y_n - X_n}{Y_n} \; x \; 100\% \tag{2}$$

where Y_n is the true value and X_n is the value that is read in the developed system. The measurement accuracy of the system is determined by Eq. (3) called relative accuracy [10].

$$A = 1 - \left|\frac{Y_n - X_n}{Y_n}\right| \tag{3}$$

The resulting measurement is stated as $X \pm \Delta X$, then average value, standard deviation, absolute error, and relative error can be examined. Average value can be expressed as Eq. (4).

$$\bar{X} = \frac{1}{n}\sum_{n=1}^{n} X_n \tag{4}$$

Where Xn is the value of n data and n is the total number of measurement. To calculate the standard deviation (ΔX) can be used Eq. (5).

$$\Delta X = \frac{1}{n}\sqrt{\frac{n\sum X_i^2 - (\sum X_i)^2}{n-1}} \tag{5}$$

Relative error (KR) of the system can be calculated by following Eq. (6), and system precision can be given by Eq. (7).

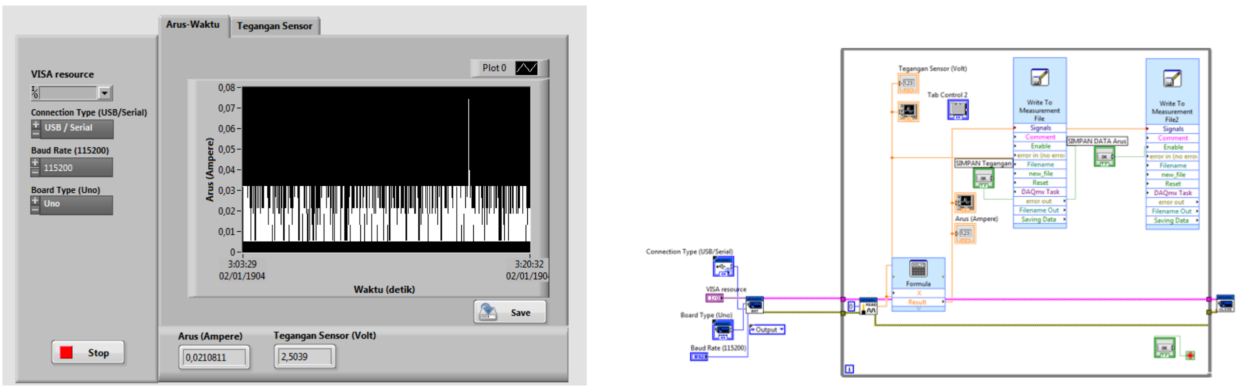
$$KR = \frac{\Delta X}{\bar{X}}\ x\ 100\% \tag{6}$$

$$\text{Precision} = 1 - \left|\frac{X_n - \bar{X}_n}{\bar{X}_n}\right| \tag{7}$$

Where Xn is the value of n measurement and $\bar{X}_n$ is the average value of the total number of n measurement.

III. RESULTS AND DISCUSSION

The graphics of electrical current measured and output voltage of the sensor are shown in real time. Additionally, the measured data is saved on PC in *.txt format. The front panel and diagram block of LabVIEW program for the electrical current monitoring could be shown in Fig. 6 (a) and Fig. 6 (b) respectively. The LabVIEW is one of system interface between microcontroller and PC. Serial Port in Fig. 6 is used as connection specific code of microcontroller with PC [11]. Both graphics and value of electric current and voltage measured are shown in PC Display. Those are recorded automatically within the change of sensor output voltage measured.



(a) **(b)**

Fig. 6. (a). Front panel labVIEW display and (b). Diagram block labVIEW software

In the measurement and analysis, data were taken 10 times by comparing the measured value and power supply readout. The power supply that used is variable power supply where the electrical current and voltage could be vary by 5 digit of decimal. Voltage supply that used is 5 Volt by varying the electric current from 1 A to 3 A.

From data that measured by calibration formula in the sensor data sheet as shown in Eq. (1), data listed in Table 1 are obtained. From those data, the average value of the precision is 0.9957 and average standard deviation is 0.0042 and average relative error percentage is 0.2458%. Additionally, the average value of accuracy measurement is 93.60102% with the average error percentage is 6.39898%.

From the measured data obtained, the trends of results are consistent in repetition measurements. However, the results will be close to the calibration data if the equation of sensor calibration is subtracted by constant of 0.125. Therefore, the calibration formula should be change to be:

$$I = \left(\frac{|V_{out} - 2{,}5|}{0{,}185} \right) - 0{,}125 \qquad (8)$$

Table 1 shows the results of the measurement 1 using equation (1) and measurement 2 using the equation (8). From those measurement data, the average precision is 0.9954, average of standard deviation is 0.0042 and relative error percentage is 0.26796%. Additionally, the average of accuracy percentage is 99.5934% and the average of error percentage of the measurement is 0.4064%. Based on that results, the system has good both accuracy and precision. Those are the things can be optimized due to the use of magnetic shielding to isolate the current Hall sensors from the influence of the unwanted measured currents [12] and the correction in calibration formula.

Tabel 1. The Comparison of Measurement 1 and 2

Power Supply (Amp)	Average Measurement 1 (Amp)	Average Measurement 2 (Amp)
1	1,12	1,00
1,2	1,32	1,20
1,4	1,52	1,40
1,6	1,72	1,60
1,8	1,93	1,81
2	2,13	2,01
2,2	2,33	2,21
2,4	2,53	2,40
2,6	2,72	2,60
2,8	2,93	2,81
3	3,13	3,01

From the measured data, the graphs of correlation between electric current from power supply as the input and the output voltage read on sensor as shown in Fig. 7. As the electric detected become bigger, the output voltage of the sensor will be bigger as well.

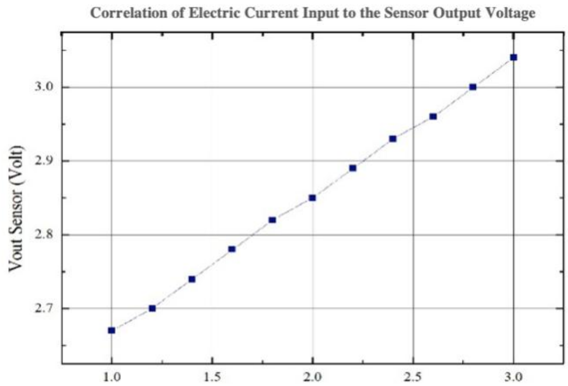


Fig. 7. Graphic of the correlation between electric current input and output voltage of the sensor.

From the measurement results, the response time of the sensor also can be obtained. The response time is the time that takes for the sensor have a respond to the input signal from the initial state to 90% of the final state. The response time graphic is shown in Fig. 8. The response time is taken by giving a sudden stimulus when the sensor is in equilibrium until the sensor shows the maximum voltage value and reaches equilibrium again. The difference in time of equilibrium after and before stimulation is calculated as the sensor response time.

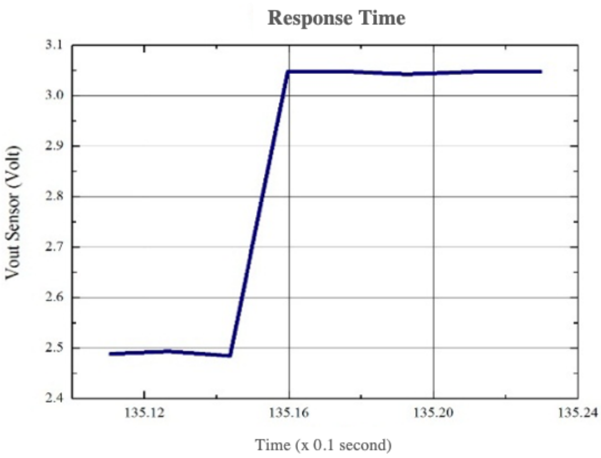


Fig. 8. Response time of the sensor

This system has response time 0.018 seconds that obtained from 90% of (135.16-135.14). The response time of this system is pretty fast.

IV. CONCLUSION

Based on the results explained, the conclusion of this study can be described as below:

1) System has very good accuracy and precision where the average of precision is 0.9954 with average of standard deviation is 0.0042 and average of relative error percentage is 0.26796%. Additionally, the average of accuracy percentage is 99.5934% with error percentage of the measurement is 0.4064%.
2) The sensor output voltage has linier correlation to the electric current detected. The sensor calibration formula is:

$$I = \left(\frac{|V_{out} - 2{,}5|}{0{,}185} \right) - 0{,}125$$

3) The system has high response with the time response to respond the input sign is only 0.018 second.
4) For the high precision results of the sensor, the calibration sensor should be carefully taken. Measurement should be taken in faraday cage or other magnetic shielding to isolate the current Hall sensors from the influence of the unwanted measured currents.

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REFERENCES

[1] P. Ripka. "Electric current sensors: a review". 2010. *Measurement Science and Technology.* Vol. 21.
[2] T. E. Kissel. *Industrial Electronics*. Prentice-Hall.Inc. 2000.
[3] M. B. Sari, R Wirawan, A. Waris, H. J. Kim, and M. Djamal. "Simulation of Void Detection System using Gamma-Ray Compton Scattering Technique." *Journal of Engineering and Technological Science*. Vol. 51, No. 3, 2019.
[4] J. Wahyudi, G A Pauzi and Warsito. "Design and Characterization of the use of UGN3503 Hall Effect Sensor to Measure the Electric Current in Leybold P6271 Wire Non-Destructivelly". *Jurnal Teori dan Aplikasi Fisika.* Vol. 01. No. 02. 2013.
[5] T. P. Satya, F. Puspasari, H. Prisyanti, and E. R. M. Saragih. "Design and Analysis of Electric Current Measurement System using ACS712 sensor based on Arduino Uno with Clampmeter Standard." *Jurnal SIMETRIS*, Vol. 11 No. 1. 2020.
[6] T. Ratnasari and A. Senen. 'Design of AC and DC Electric Current Measurement Prototype based on Arduino Microcontroller with the electric current sensor of ACS-712 30 Ampere." *Jurnal Sutet* Vol. 7 No.2. 2017.
[7] B. Indarto, B. S. Muntini, D. Darminto. "Development of Magnetometer Hall-Effect Tranduser." *Jurnal Fisika dan Aplikasinya.* Vol.05. No.02. 2009.
[8] M-A. Paun, J-M. Sallese, and M. Kayal. "Hall Effect Sensors Design. Integration and Behaviour Analysis." *Journal of Sensor and Actuator Networks*, ISSN 2224-2708. 2013.
[9] Gilmore. *Microprocessors: Principles and Applications.* McGraw-Hill. 1995.
[10] M. B. Sari, Yulkifli, and Z. Kamus. "Measurement System of Intensity and Duration of Sunlight Realtime PC based on LDR and Stepper Motor". *J. Oto. Ktrl. Inst (J. Auto. Ctrl. Inst).* Vol 7 (1), 2015.
[11] L. Yuliantini, I. Amri, and M. Djamal. "Development of Simple Near Infrared Spectroscopy for Measurement System of Suspended Sediment Concentration". *Risalah Fisika* Vol. 1 No. 1. 2017.
[12] H. G. Kim, G.B. Kang and D. J. Nam Coreless "Hall current sensor for automotive inverters decoupling cross-coupled field". *J. Power Electron*. Vol. 9. 2009.