Indonesian Physical Review

Volume 5 Issue 2, May 2022

P-ISSN: 2615-1278, E-ISSN: 2614-7904

Comparison of Infrared and Optocoupler Sensors Performance for Lab-Scale RPM Measurement System

Elin Nur Afifah Amatullah Haquarsum, Riska Ekawita, Elfi Yuliza*

Department of Physics, Faculty of Mathematics and Natural Sciences, University of Bengkulu, Indonesia.

E-mail: elfi.yuliza@gmail.com

ARTICLE INFO

Article info:

Received: 25-04-2022

Revised: 13-05-2022

Accepted: 20-05-2022

Keywords:

Generator; digital RPM; infrared sensor; optocoupler sensor; laboratory scale

How To Cite :

Haquarsum, E. N. A. A, Ekawati, R., Yuliza, E. (2022). Comparison of Infrared and Optocoupler Sensors performance for Lab-Scale RPM Measurement System. Indonesian Physical Review, 5(2), 130-136

DOI :

https://doi.org/10.29303/ipr.v5i2.150

ABSTRACT

In utilizing various alternative energy, generators are used to convert alternative energy into electrical energy, for example, biomass, wind, and hydroelectricity. Generally, the measurements made on the generators are rotational speed measurements in the form of revolutions per minute (RPM). In developing lab-scale alternative power sources, the availability of generators with complete quality and specifications is still minimal, including RPM capacity. Therefore, the measurement which can read the RPM accurately, digitally, and automatically is needed. However, the measurement tools available are still manual, not automatic, and prone to parallax errors. Hence, a digital and automatic RPM measurement was developed in this study. Two different sensors were used to develop digital RPM based on a microcontroller. The stages obtained started with electronic system development, calibration, and testing of lab-scale renewable energy systems. The measurement can be read from the infrared and optocoupler sensors on the Archimedes turbine. The measurement results showed that the use of the Optocoupler sensor is more accurate than the infrared sensor. This is based on the data obtained from calibration and testing results on the Archimedes turbine. This RPM measurement is digital and real-time.

Introduction

In the usage of alternative energy sources, a generator is a primary component to convert the energy form into electrical energy. Generators are used in almost all alternative energies for example biomass, wind, and hydroelectricity [1-5]. The use of generators in the development of renewable energies especially on a laboratory scale, revolution velocity (Revolution Per Minutes, RPM) measurement is one of the mechanisms to obtain the performance of the developed system. Therefore, the availability of digital and real-time RPM measuring tools is urgently needed. One of the commonly used tools for measuring RPM is the use of a tachometer. The tachometer is a standard measuring instrument that can read RPMs [6]. However, the use of a tachometer has several disadvantages, namely, measurements are still manual, cannot record and save data automatically, and is prone to parallax error [7]. On the other hand, with the development of various sensors and microcontroller systems, it is possible to conduct the RPM measurement digital instrument and the real-time data saving.

Several sensors that can be used in the development of digital RPM measurements include infrared sensors and optocoupler sensors. The development of a motor speed measurement system based on an infrared sensor system was carried out by Palanisamy (2021) aiming to measure motor speed, especially in hard-to-reach areas [8]. Nurhaliza (2019) also proved that optocoupler sensors can be used to measure motor speed [9]. It is also stated that the optocoupler sensor has better sensitivity than the infrared sensor [10]. However, the performance comparison of these two sensors is still not found. Therefore, to get a comparison of the to perform of these types of sensors, it is necessary to develop a measurement system using both types of sensors. In this study, a microcontroller-based RPM measurement system was developed using an infrared sensor and an optocoupler sensor. Then, numerical comparison of the RPM measurements was also carried out using the two sensors that were developed. As well as measurements of RPM in the Archimedes turbine.

Experimental Method

This study aims to compare the performance of digital RPM developed by utilizing infrared and optocoupler sensors. The comparison of the two performances of these sensors aims to obtain a digital RPM system that is stable, accurate, real-time, and low-cost. To achieve this goal, several stages are carried out as shown in Figure 1.

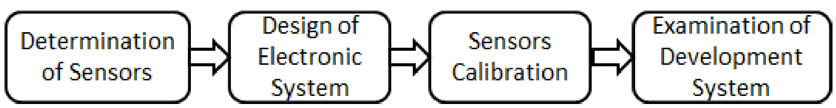

Figure 1. Block diagram of the development system

The first stage of this research is the selection of sensors used in the development of digital RPM systems using infrared sensors and optocoupler sensors. Sensor selection is done to see the level of accuracy that can be read by each sensor and to achieve a more accurate measurement system. The second stage is to design an electronic circuit system for each sensor. Then, calibration is carried out for each system that has been developed and the last one is being tested.

RPM in this system is calculated using equation (1) where the equation is inputted into the coding script of the running program.

$$RPM = \left(\frac{Rev}{Time}\right) * 60000 \quad (1)$$

where (Rev/Time) is the formula for calculating RPM, while 60,000 shows a time of 1 minute (60x1,000ms) [8].

Both sensors have their own working principle. An infrared sensor is an electronic component that in its use between receiver and transmitter uses infrared as a data communication medium [10]. The infrared sensor will detect an object if it is within a sensible distance or hits the light from the sensor [12]. Thus, this infrared sensor can indicate the presence of a nearby object by sending and receiving infrared waves [13]. The light will be reflected on the reflective strip and will be captured by the phototransistor [14]. While the optocoupler sensor is an electronic component that will work based on the triggering of optical light. The optocoupler sensor consists of two parts, namely the receiver and the transmitter [15]. The LED on the sensor acts as a transmitter while the phototransistor works as a receiver [16]. In its application, this optocoupler sensor is commonly used to detect motor speed, pulse calculation, position limits, etc. [17].

Before the examination of this development system, these two sensors were first calibrated. Calibration is performed to achieve the accuracy of the developed system. Calibration of the infrared sensor and optocoupler is conducted using a motor as a rotation generator and the place of the object for an RPM reading. The illustration of reading an object on the infrared sensor and the optocoupler sensor is shown in Figure 2.

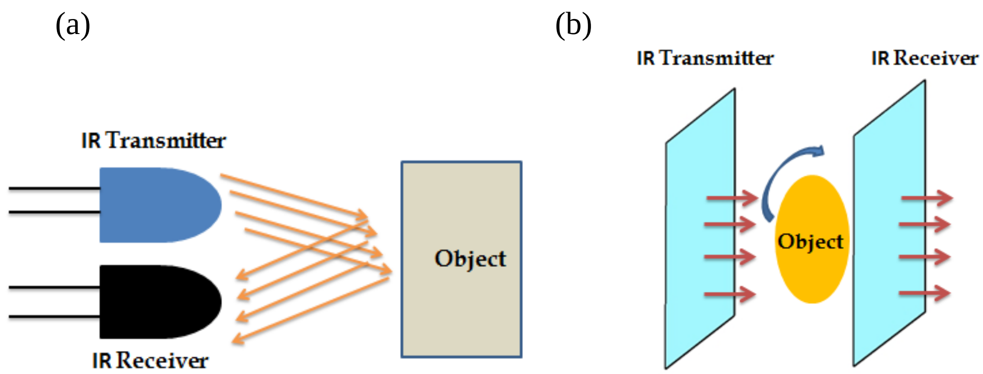

Figure 2. Illustration for measurement system (a) Infrared Sensor, (b) Optocoupler sensor

On the infrared sensor, the RPM measurement will be read if an object is detected by the IR transmitter, then the object reading will be received by the IR receiver. Meanwhile, on the optocoupler sensor, the RPM measurement will be read if the LED on the sensor lights up as a sign of an object passing through the gap in the sensor. The IR transmitter will capture the reading from the object and then transmit it to the IR receiver. Once the infrared sensor and the optocoupler sensor have been calibrated, the test phase continues. To calculate the error resulting from measurement sensors, using the equation (2).

$$error\ \% = \frac{value\ obtained - value\ real}{value\ real} \tag{2}$$

Tests for RPM measurement were carried out on the Archimedes turbine, where RPM measurement is done to find out how many rotations are produced by the rotor on the generator. Infrared sensors and optocoupler sensors are placed at the end of the rotor on the generator.

Result and Discussion

In this work, the RPM measurement was developed using infrared sensors and optocoupler sensors. Before being used to measure RPM on an Archimedean turbine system, the calibration was performed by using a tachometer. The calibration results for each sensor shown in Figure 3.

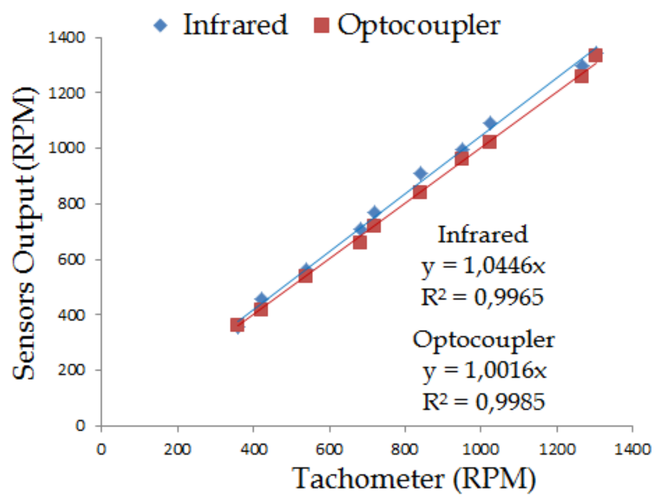

Figure 3. Calibration results of Infrared and Optocoupler Sensors

According to Figure 3, the tachometer is on the x-axis and both sensors are on the y-axis. Based on the linear graph, the equation is $y = 1{,}0446x$ for the infrared sensor with ra egression of 0.9965 and $y = 1{,}0016x$ for the optocoupler sensor with regression of 0.99885. Based on the calibration results, shows that the graph of the optocoupler sensor tends to be more linear compared to the graph of the infrared sensor. This is also evidenced by the measurement error results in each sensor calibration. The calculation error on the infrared sensor is 0.0624% while the error on the optocoupler sensor is 0.0025%. From the results of the error calculations that have been done, it shows that the error on the optocoupler sensor is smaller compared to the infrared sensor. Based on the graph and the error measurement results, the performance of the optocoupler sensor is better than the infrared sensor. For further, the two sensors were tested on the Archimedes turbine.

The performance of the developed system on Archimedes turbine is depict in Figure 4.

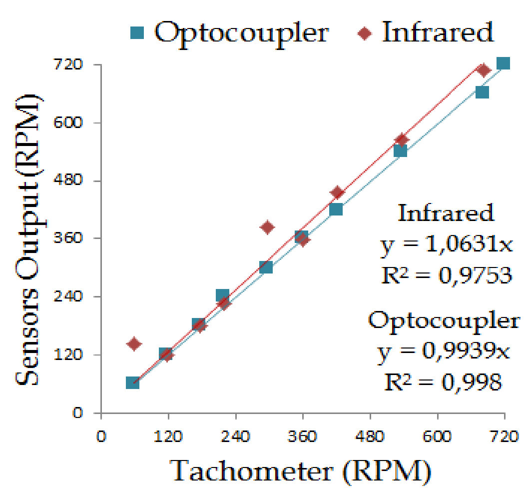

Figure 4. RPM Measurement Results on the Archimedes Turbine

From Figure 4, it can be seen that the RPM reading on the optocoupler sensor is more stable and accurate than the RPM reading on the infrared sensor. Figure 4 also shows that the RPM measurement results on the optocoupler sensor are more linear compared to the graph on the infrared sensor where the measurement results tend to be spread out and non-linear. Due to the optocoupler sensor, the reading of the RPM value will only occur if objects are passing through the gap in the optocoupler sensor. Meanwhile, the infrared sensor may encounter a measurement error when the RPM reading is caused by another object picked up by the IR emitter on the infrared sensor. According to Figure 4, the equation for the infrared sensor is $y = 1{,}0631x$ with a regression of 0.9753 and the optocoupler sensor is $y = 0{,}9939x$ with a regression of 0.998. Where on the x-axis is the tachometer as a standard reading and the y-axis is the both of sensors. In the data collection process for measuring RPM in the Archimedes turbine, that is by placing an infrared sensor and an optocoupler sensor on the generator rotor which has been given an object for sensor reading. Based on calibration and RPM measurement results using an Archimedes turbine, it was found that the RPM reading on the optocoupler sensor was better than the infrared sensor. Indeed, the RPM measurement is performed in a disclosed area. While infrared sensors are not suitable for measurements in the disclosed area [18].

Conclusion

In this work, a digital and real-time prototype of an RPM measurement system based on infrared and optocoupler sensors system and microcontroller was developed. Furthermore, the performance comparison of both digital RPM systems has also been tested. Several steps were conducted for obtaining the performance of the RPM measurement system. According to the calibration and examination of the Archimedes turbine, it can be concluded that the optocoupler sensor has better accuracy and alternative laboratory-scale.

Acknowledgment

This work was financially supported by the University of Bengkulu, Indonesia through “Penelitian Unggulan FMIPA UNIB” and “PKM Jurusan Fisika FMIPA UNIB” in fiscal year 2021.

References

[1] Handayani, N. A., & Ariyanti, D. (2012). Potency of solar energy applications in Indonesia. *International Journal of Renewable Energy Development*, *1*(2), 33–38. https://doi.org/10.14710/ijred.1.2.33-38

[2] Yuliza, E., Lizalidiawati, L., & Ekawita, R. (2021). The Effect of Tilt Angle and Orientation of Solar Surface on Solar Rooftop Miniature System in Bengkulu University. *International Journal of Energy and Environmental Engineering*, *12*(3), 589–598. https://doi.org/10.1007/s40095-021-00390-4

[3] Gogoi, P., Handique, M., Purkayastha, S., & Newar, K. (2018). Potential of Archimedes Screw Turbine in Rural India Electrification: A Review. *ADBU Journal of Electrical and Electronics Engineering (AJEEE)*, *2*(1), 30–35.

[4] Sudibyo, H., Pikra, G., & Fudholi, A. (2021). The Potential of Hydro Renewable Energy

Technology to Electricity Remote Villages in Papua and Maluku Islands, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *927*(1). https://doi.org/10.1088/1755-1315/927/1/012002

[5] Chinnammai, S. (2014). A Study on Energy Crisis and Social Benefit of Solar Energy. *International Journal of Environmental Science and Development*, *5*(4), 404–411. https://doi.org/10.7763/ijesd.2014.v5.518

[6] Darmana, T., & Sya'ban, W. (2015). Rancang Bangun Alat Ukur Kecepatan Putaran Motor. *Jurnal Energi & Kelistrikan*, *7*(1), 71–76.

[7] Tamba, D. S. (2021). Tacometer (Kecepatan Putaran) Berbasis AT Mega 328P. *Jurnal Pembangunan Wilayah & Kota*, *1*(3), 82–91.

[8] Palanisamy, R., Vidyasagar, S., Kalyanasundaram, V., & Sridhar, R. (2021). ContactlessDigital Tachometer Using Microcontroller. *International Journal of Electrical and Computer Engineering (IJECE)*, *11*(1), 293–299. https://doi.org/10.11591/ijece.v11i1.pp293-299

[9] Nurhalija, Yakob, M., & Putra, R. A. (2019). Pemanfaatan Lm393 Ir Sensor Module Sebagai Pengukur Kecepatan Rotasi Berbasis Mikrokontroler. *Jurnal Hadron*, *1*(1), 12–15. https://www.ejurnalunsam.id/index.php/jh/article/view/1579

[10] Yusniati. (2018). Penggunaan Sensor Infrared Switching pada Motor DC Satu Phasa. *Journal of Electrical Technology*, *3*(2), 90–96.

[11] Coates, E. (2017). Opto Coupled Devices. *In Semiconductors module* (pp. 1–19). www.learnabout-electronics.org

[12] Jufriyanto, Zulkarnain, M., Irvawansyah, & Mustafa, S. (2020). Rancang Bangun Media Pembelajaran Penyortiran Benda Berbasis Mikrokontroler. *Journal of Electrical Engineering*, *1*(1), 32–40.

[13] Ginta, P. W., & Milati, R. F. (2011). Robot Pendeteksi Dan Penghitung Jalan Berlobang Menggunakan Sensor Infra Merah Berbasis Mikrokontroler AT89S51. *Jurnal Media Infotama*, *7*(1).

[14] Mishra, P., Pradhan, S., Sethiya, S., & Chaudhary, V. (2017). Contactless Tachometer With Auto Cut Off. *International Research Journal of Engineering and Technology (IRJET)*, *4*(4), 369–371.

[15] Yanti, N., Yulkifli, Y., & Kamus, Z. (2016). Pembuatan Alat Ukur Kelajuan Angin Menggunakan Sensor Optocoupler Dengan Display Pc. *Sainstek : Jurnal Sains Dan Teknologi*, *7*(2), 95. https://doi.org/10.31958/js.v7i2.131

[16] Siswoko, Muhamad Mujahidin ST, M., Iqbal, D. I. A. M., & Moh. (2011). Pengukur Kecepatan Angin Berbasis Rasberry PI. *Jurnal Teknik Elektro Universitas Maritim Raja Ali*

Haji, 1–9.

[17] Electronics, R. (2017). Lm393 Motor Speed Measuring Sensor Module For Arduino. *Data Sheet*, 4–5.

[18] Technolabs, S. (2013). IR Proximity Sensor. *Datasheet,* 1-5.