ISSN (Print) : 2337-9030 ISSN (Online) : 2685-2608

PILLAR OF PHYSICS

Vol. 16 (1), 2022, page. 47-55

DOI : 10.24036/14314171074

IoT-based Wind Speed Measurement System

Alif Yulanda Putri[1], Yulkifli[1*], Syafriani[1], Yenni Darvina[1]

[1] *Department of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar Padang 25131, Indonesia*
*Corresponding author. Email: *yulkifliamir@fmipa.unp.ac.id*

ABSTRACT

Weather is the state of the atmosphere at any time which is expressed by the high and low values of the weather element parameters. Observations of weather elements are carried out so that they can be used as needed in the future. This study aims to determine the performance and design specifications of a wind speed measurement system based on the internet of things with a smartphone display. This measuring instrument is built using a wind speed sensor, namely a wind speed sensor as a speed sensor, Arduino Uno to connect sensor readings to NodeMCU, the NodeMCU ESP8266 microcontroller which is used to access the internet network so that it can be sent to the thingspeak server and data from thingspeak is displayed on an android smartphone using inventory application. The results of measuring, testing, and analyzing wind speed using the Internet of Things and a smartphone display, namely Arduino Uno, process the wind speed detected by the wind speed sensor before sending it to NodeMCU ESP8266. After that, the data is sent to the thingspeak server which will be displayed on the Android phone. Second, the average accuracy of wind speed measurements on the first, second, and third days were 95.96%, 94.83%, 96.16%, and the average accuracy of wind speed measurements on the first, second, and third days were 92.85%, 94.43% and 96%.

Keywords : Instrument; Wind Speed Sensor; Internet of Things; Thingspeak

I. INTRODUCTION

The high or low values of the weather elements' parameters represent the current state of the atmosphere, or weather. Most of the time, weather elements are observed so that they can be used in the future. Numerous organizations require weather data, such as: The general public, as well as the industries of agriculture, plantation, shipping, aviation, the Public Works Service, and tourism, all of which utilize it in accordance with their particular requirements[1]. BMKG provides information services about Indonesia's climate, weather forecasts, and weather data because so many people need them. These services can be found on the official BMKG website. The accuracy, precision, and update speed of the measured data on the BMKG website need to be improved in order to provide quick and accurate information about the weather, which is crucial for critical activities like aviation, shipping, and others. A program based on the interpolation and extrapolation of weather data from various Indonesian locations produced the weather data that are displayed on the BMKG website. As a result, we require a data collection system that is unaffected by geographical constraints. It is absolutely necessary to have accurate and precise information with real-time updates about the current weather conditions at various points in a particular area or area[2].

Wind is one part of the weather that is very important for several things. In meteorology, wind is one of the most important factors in determining the weather and climate of a location. Wind energy is a renewable resource that does not pollute the air like fossil fuel power plants. In addition, it emits no emissions into the atmosphere, which could one day cause more health problems[3]. The first and second measurement units that can be used to determine wind is wind speed. Important information that can be used for purposes such as disaster prevention that will be caused by the wind itself will be obtained by measuring wind speed[4]. Therefore, wind is an energy that is highly recommended for use in the future[5]. Wind speed is the speed of air moving horizontally which is influenced by the barometric gradient of the location of a place, the altitude of a

Submitted: February 1, 2023 Accepted: May 19, 2023 Published: May 31, 2023

place, and the topography of a place. In addition, wind is also a natural resource that has many uses, for example to produce energy, for the purposes of aircraft navigation during takeoff and landing, and for aerospace sports such as paragliding, parasailing, and aeromodelling. To take advantage of the wind, it is necessary to know the wind speed through a measurement. Therefore, to obtain accurate wind speed measurement data, a measuring instrument is needed[6].

As is the case with data on the results of natural disasters that occurred in the period 1815-2014 that occurred in Indonesian territory. In addition, tornadoes are the second largest, accounting for 21% of the number of disasters that occur. The tornado is a natural wind disaster that can last up to five minutes and rotates at a speed of more than 63 kilometers per hour. Tornado-related losses can include human casualties, environmental damage, property loss, and psychological effects. To cover these deficiencies, now sensors with various specifications have been developed and can measure various natural phenomena. Specifications are measures (metrics) and values for those measures[7]. The measurement system has an important role in human life, especially to know the value of physical quantity. Measurement is comparing quantities unknown physical value with physical quantities whose value is known. The measurement results are universal that can be expressed in numbers and units or values and units, such as measurements of speed, weight, temperature and others[8].

In previous research, a wind speed measuring device based on the ATMega 328P microcontroller was designed, but this tool can only measure wind speed[9]. In addition, research was also carried out which designed a wind speed measuring device using an optocoupler sensor with a PC display. Making this measuring tool using a sensor is an optocoupler. Optocoupler can be defined as an electronic device which utilizes light as an on-off trigger optocoupler or optical isolator (optoisolator) is an integrated circuit consists of a phototransistor and an LED (light emitting diode) a combination of emitter and detector. Because it uses a PC display, of course data monitoring can only be done in certain places.

To obtain the expected accuracy in measurement results or data, a tool was developed that uses electronic instrumentation to measure wind speed using a digital meter to read measurement results more easily and accurately. In addition, digital measuring tools are easier to use and save time when measuring. So the author tries to do research with the title "IoT-based Wind Speed Measurement System" so that data can be accessed anytime, anywhere and can be controlled.

II. METHOD

System design, hardware design and software design are the three parts of design. The device goes from start to finish in system design. An instrument for measuring wind speed was designed and built. The tool designed and built is a tool to measure wind speed. For more details can be seen in Figure 1.

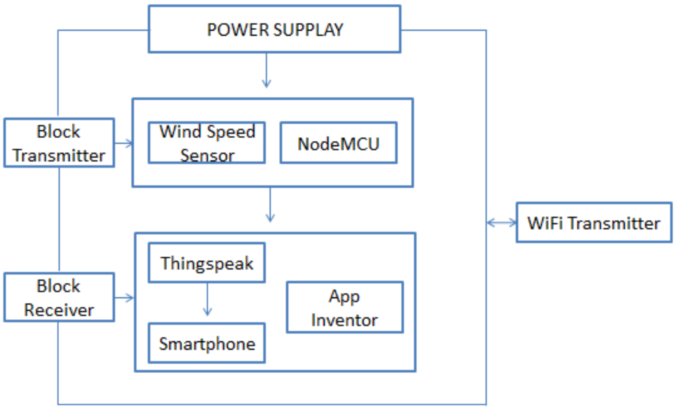

Fig 1. System Block Diagram

Based on figure 1 by following the steps on the diagram for a better understanding system design. Digital measuring tools will be more useful and will save time when measuring[10]. One real-world example is the benefits of wireless or wireless telemetry, which include the fact that it doesn't cost as much as using cables. so that using a wireless system for measuring can be more practical and efficient because the user doesn't have to be right next to the device every time to wait for the necessary data and can also be watched from a distance[11]. Wind speed, as depicted in the block diagram in Figure 1, is a sensor for wind speed. The microcontroller known as the NodeMCU is connected to this sensor. The Arduino programming language is used to program the sensor, which is embedded in the NodeMCU microcontroller. Additionally, this program can connect to existing WiFi.

Once they are connected, the data will be sent to Thingspeak, the used server. Utilizing App Inventor programming, the data is then retrieved and displayed on an Android smartphone. The circuit, microcontroller, and sensor of the measuring instrument are housed in a small box when the wind speed measurement is designed. This measuring instrument was made to work with Android smartphones. The design of this research hardware can be seen in Figure 2.

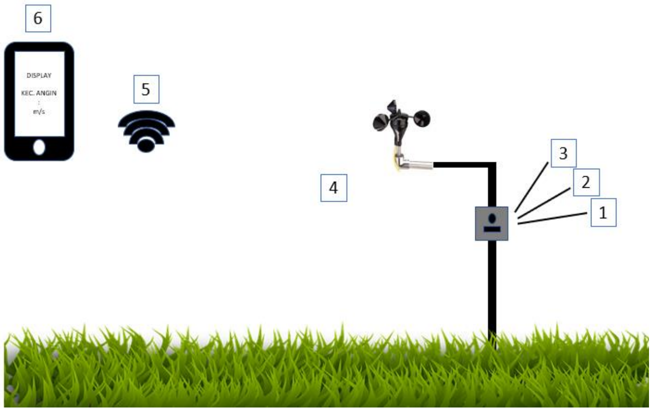

Fig 2. Hardware design

Information: 1. Gauge builder circuit box
2. Button for On/Off
3. Button for Reset
4. Wind Speed Sensor
5. Wifi is used to send signals so that the Android smartphone and microcontroller can connect to the internet.
6. Smartphone to display measurement data

Based on figure 2 we can see the function of the components of the research tool. Hardware performance is closely linked to software. Instructions and programming tools are run by this software. The form of software design of the tool can be seen in Figure 3.

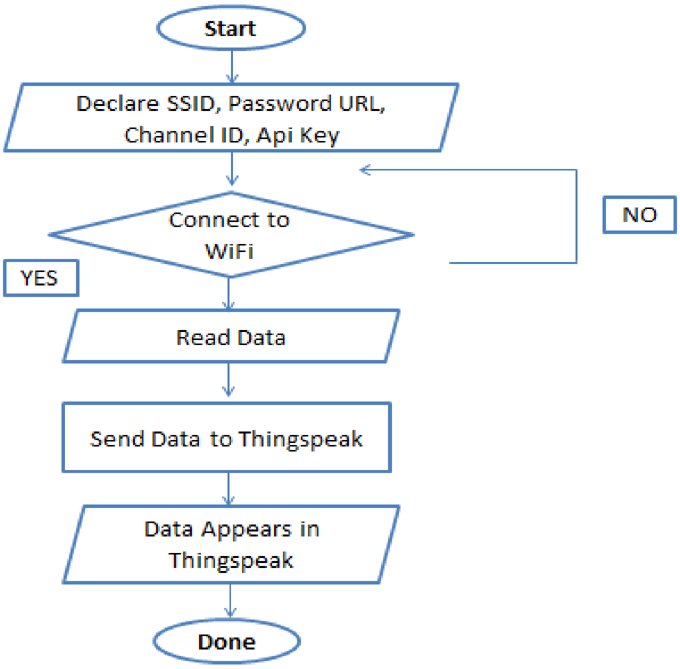

Fig 3. Software Design

Figure 3 can be explained the flow of the software. Before designing software in the Arduino IDE, the first step is to install the NodeMCU ESP8266 board. How to Install the ESP8266 Board from NodeMCU: Type the URL into the Additional Boards Manager URLs column on the file tab, then click preferences, http://arduino.esp8266.com/stable/package_esp8266com_index.json. 24, go to the tools tab, select boards, then boards manager. Enter "ESP8266" into the boards manager search field. Install the ESP8266 board and wait for it to be installed. The first step is to connect the NodeMCU board to the existing WiFi transmitter. Before connecting, the brand new wireless transmitter announces the SSID and password first. The procedure will start over until the board is connected. The board can read sensor data and send it to the internet, specifically Thingspeak, if it is connected to the WiFi transmitter. In Thingspeak, data is presented graphically in real time.

III. RESULTS AND DISCUSSION

Data from research on wind speed measurements based on the Internet of Things to be displayed on an Android smartphone by getting some data. Sensors convert raw physical data from real-time scenarios into an easy-to-understand machine format that can be easily transferred between different data formats[12]. Internet connections and physical objects are connected in the Internet of Things paradigm. Providing reliable sensing capabilities, these objects should be ubiquitous and ubiquitous. In addition, these devices support collaboration capabilities, enable unique address management, and offer ubiquitous applications. There is ample evidence that more and more Internet of Things systems are being used for various routine daily tasks[13]. The Internet of Things can also automatically and in real time identify, find, track and monitor objects and generate events related to them in their applications[14]. The relationship between the various quantities measured by wind speed instruments can be explained using these data. A graphical representation of the data obtained can be used to represent it.

The parts that go into making a measuring instrument and how they work together to make a measuring instrument are called performance specifications. This measuring instrument is designed to observe the wind speed. Measurement data can be saved so that they can be viewed again at any time if needed. The electronic circuit for the system builder has been designed to be useful as a measuring instrument. The wind speed sensor is used to measure wind speed. It has three cups that are connected by an arm that is attached to the drive shaft. The rotor rotates in a fixed direction when the wind blows because all of the cups face the same circular direction. For the purpose of keeping records, the rotating cup system is connected to a signal generator, either mechanically or electronically. The wind speed sensor can be seen in Figure 4.

Fig 4. Wind Speed Sensor

In Figure 4 the wind speed sensor consists of three cups that are connected by an arm that is attached to the drive shaft. The rotor rotates in a fixed direction when the wind blows because all of the cups face the same circular direction. Because it is a digital output, the sensor can be calibrated and the ADC need not be programmed into the microcontroller. A space known as a circuit box is used to house electronic circuits. The series box is made of acrylic and measures 9x9x6 cm in size and has a thickness of 0.3 cm. The results of the measuring instrument design can be seen in Figure 5.

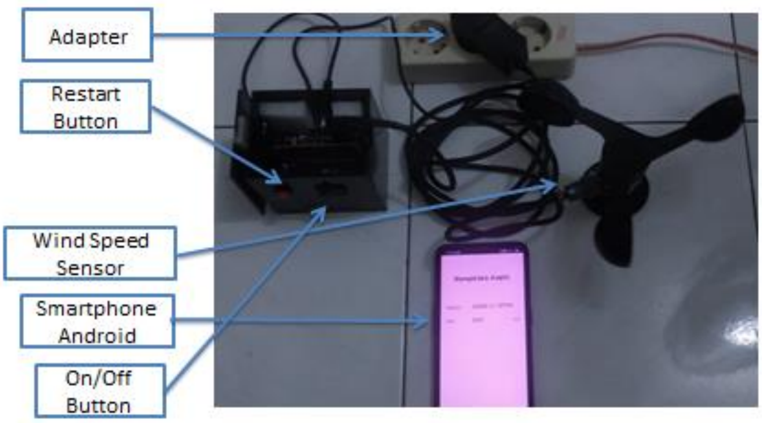

Fig 5. Wind Speed Measurement Tool

Figure 5 shows the results of designing a wind speed measuring device. In general, this measuring instrument consists of a circuit box that functions as a circuit holder with a sensor located close to the circuit box. The input system and transmitter are two of the components that make up this measuring instrument, which is made up of a series of boxes. There is a reset button and an on/off switch on the inputs. A wind speed sensor, an Arduino Uno microcontroller, and a NodeMCU are the components of the transmitter. If the measuring instrument is connected to a voltage source, the on/off button can be used to turn it on and off. An essential component is the on/off switch in a circuit. A series must also be present in the measuring instrument for the reset button circuit. When the measuring instrument fails to function normally or makes a mistake, the circuit for the reset button will come in very handy. The measuring instrument can be brought back to its original state by pressing the reset button. The measuring suite builder comes equipped with an adapter. The microcontroller is very sensitive, so the adapter is used. If the current entering the microcontroller is unstable, the microcontroller won't work properly and will get hot.

The Android smartphone can receive sensor data from the microcontroller, which acts as the measuring instrument's brain. The microcontroller that is being used is the NodeMCU ESP8266, but the data from the sensors are first sent to Arduino Uno before going to Nodemcu. The NodeMCU ESP8266 is a microcontroller that connects to the internet via a wifi module. There are nine digital pins and one analog pin on the NodeMCU ESP8266. This microcontroller is programmed with the Arduino IDE so that it can connect to a local wifi transmitter (WLAN). The processor chip has 16 GPIO lines, some of which communicate with flash memory and other SoC components. There are still approximately 11 GPIO pins available for use in GPIO applications. In most cases, receiver and transmitter communicate with a host PC from which compiled object code is downloaded by making use of two of the 11 GPIO pins. A USB cable is used to transfer data from the host to the board after this module has been charged[15]. The obtained data will then be sent to the thingspeak server by the Nodemcu ESP8266. Installation of measuring instruments at BMKG can be seen in Figure 6.

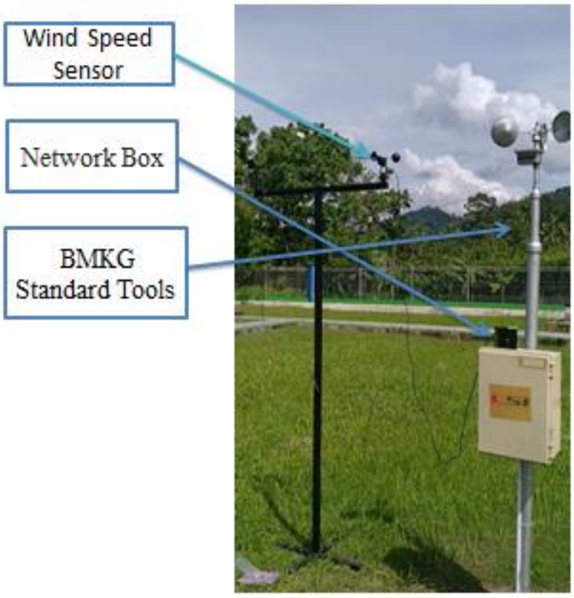

Fig 6. Installation of measuring instruments in the BMKG.

In Figure 6 it can be seen that the measuring instrument is installed adjacent to the standard anemometer at the BMKG Sicincin. Data retrieval is carried out for 3 days, the data is directly processed by the program on the MCU Node microcontroller which is connected to Wifi and sent directly to Thingspeak in real-time. The display can be seen in Figure 7.

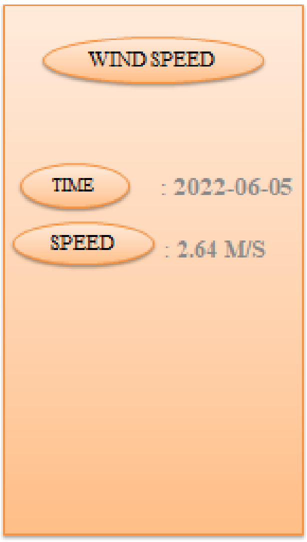

Fig 7. Measuring Instrument Interface on a Smartphone

In Figure 7, you can see the display of the Thingspeak data sent by the IoT by the measuring instrument running in real-time. The android smartphone functions as a data viewer, as an output and a receiver for measuring instruments. An interface for android smartphones whose data is retrieved from the Thingspeak server will be created using app inventor. The wind speed sensor, which uses the capacitive principle to sense the wind, serves as the foundation for the wind speed measuring instrument that is based on the internet of things and has an android smartphone display. Since it has been calibrated and has a digital output, the wind speed sensor can communicate with the microcontroller without the need for an ADC. The data read by the sensor is processed by this measuring instrument using arduino uno, and it is then sent to the NodeMCU, ESP8266 microcontroller. This microcontroller has the advantage of being a wifi module so that it can receive signals from WLAN (Wifi transmitter) and can access the internet network. Measurement results are displayed on an android smartphone so that they can be seen anywhere and anytime and are equipped with memory so that data can be stored. This measuring instrument has a very small size and the power supply comes from PLN using an adapter.

Design specifications or also known as product specifications describe product characteristics, system building materials, system sizes, system dimensions, and tolerances. Design specifications are more focused on system accuracy and precision. To find out the data stored on the measuring instrument, measurements are carried out and save the measurement data. The characterization of wind speed sensors was done to see how wind speed affected the duration of weather data collection and time spent collecting it. Measurements are taken to determine the wind speed sensor's characteristics. In the mean time, in view of the perception of sensor yield, it is displayed in Table 1.

Table 1. Wind Speed Sensor Testing

Time (s)	**Wind Speed Data (m/s)**
10.00	4,16
10.01	2,57
10.02	2,19
10.03	1,47
10.04	2,26
10.05	1,89
10.06	1,74
10.07	0,38
10.08	0,68
10.09	1,66
14.00	3,40
14.01	2,83
14.02	2,57
14.03	3,32
14.04	4,38
14.05	2,83
14.06	1,74
14.07	3,97
14.08	2,87
14.09	3,10

Based on measurements taken during the first level test and the second level test, the wind speed had a range of 10.00 to 14.00 mph. However, there have been times when this has fluctuated due to the frequently shifting weather.

Measurements were carried out for three days from 4 to 6 June 2022. Based on analysis of measurement data on 4 June 2022 from 11.00 WIB to 16.00 WIB. The results of the measuring instrument are compared with AWOS, a comparison chart of the measuring instrument with AWOS can be seen in Figure 8.

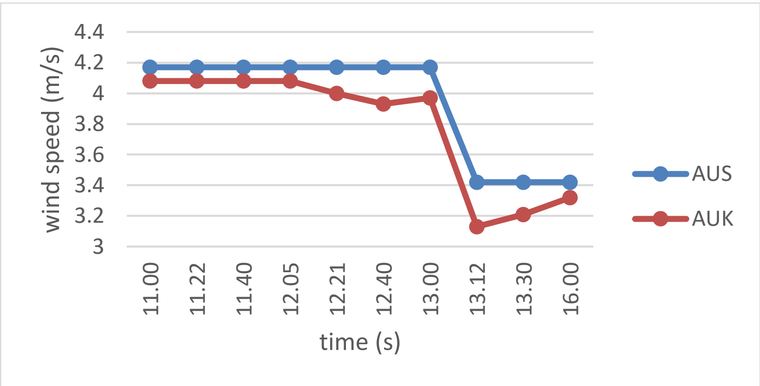

Fig 8. Comparison of measuring wind speed with standard tools on June 4, 2022 at 11.00 WIB to 16.00 WIB

Based on the graph in Figure 8, at certain minutes there are deviations in the results of the measuring instrument compared to the AWOS tool in the BMKG. This is due to changes in weather ranging from sunny, cloudy, and rainy. However, wind speed measurement with standard tools is not too far away. There is a decrease and increase in wind speed data caused by weather changes. The measurement results on June 5 2022 at 11.00 WIB to 16.00 WIB obtained a comparative chart of measuring instruments with AWOS as shown in Figure 9.

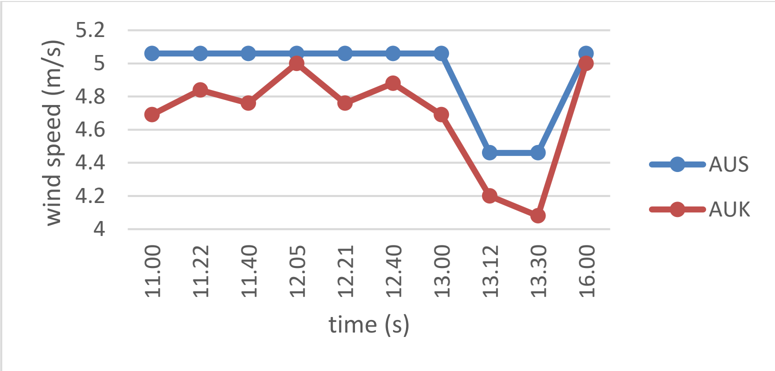

Fig 9. Comparison of wind speed measurements with standard tools on June 5 2022 at 11.00 WIB to 16.00 WIB

Based on the graph in Figure 9, at certain minutes there are deviations in the results of the measuring instrument compared to the AWOS tool in the BMKG. This is due to changes in weather ranging from sunny, cloudy, and rainy. However, wind speed measurement with standard tools is not too far away. There is a decrease and increase in wind speed data caused by weather changes. The measurement results on June 6 2022 at 11.00 WIB to 16.00 WIB obtained a comparative chart of measuring instruments with AWOS as shown in Figure 10.

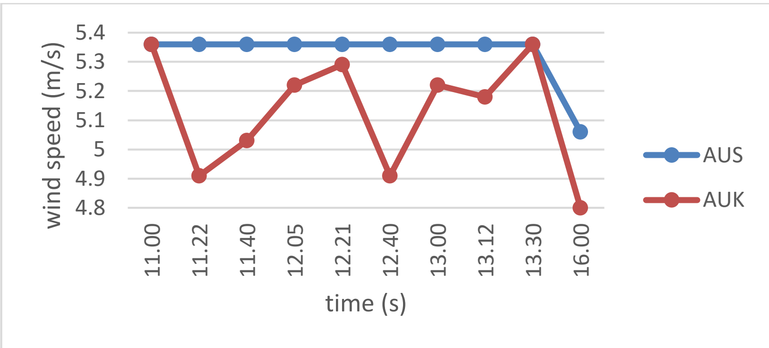

Fig 10. Comparison of wind speed measurements with standard tools on June 6 2022 at 11.00 WIB to 16.00 WIB

Based on the graph in Figure 10, there are also deviations from the results of the wind speed measuring instrument with standard tools, but the deviations are quite a lot, but not too bad. At the time of measurement, the weather conditions tended to change from sunny, cloudy and rainy so that the wind speed decreased to increased as before.

IV. CONCLUSION

Several conclusions can be drawn from the results of measuring, testing, and analyzing wind speed and direction using the Internet of Things and a smartphone display. A measuring tool box with the electronic circuit of the measuring instrument is installed in the results of the wind speed tool's performance specification. A wind speed sensor, a Nodemcu ESP8266 microcontroller, an Arduino Uno, an on/off button, and a reset button make up the measuring tool builder circuit. The Android phone shows the results of the measurements of wind speed. The arduino uno processes the wind speed detected by the wind speed sensor before transmitting it to the ESP8266 NodeMCU. After that, the data is sent to the ThingSpeak server, where it will be displayed on the

Android phone. Second, the average accuracy of wind speed measurements on the first, second, and third days is 95.96%, 94.83%, 96.16%, and the average accuracy of wind speed measurements on the first, second, and third days is 92.85%, 94.43% and 96%.

ACKNOWLEDGMENT

I express my deepest gratitude to the BMKG Sicincin Climatology Station for helping to obtain data from the AWOS tool (automatic weather observation station).

REFERENCES

[1] M. Suradam, R. Reinaldo, E. Andri, and I. Sugihartono, "Perancangan Sistem Telemetri Akuisisi Data Cuaca Dengan XBee Pro-S2," no. 1600 m, pp. 102–106, 2013.

[2] B. S. Rafdito Harisuryo, Sumardi, "Sistem Pengukuran Data Suhu dan Tekanan Udara Dengan Telemetri Berbasis Frekuensi Radio," *Transient*, vol. 4, no. 3, p. 9, 2015.

[3] A. Khosravi, R. N. N. Koury, L. Machado, and J. J. G. Pabon, "Prediction of wind speed and wind direction using artificial neural network, support vector regression and adaptive neuro-fuzzy inference system," *Sustain. Energy Technol. Assessments*, vol. 25, no. December 2017, pp. 146–160, 2018, doi: 10.1016/j.seta.2018.01.001.

[4] N. Yanti, Y. Yulkifli, and Z. Kamus, "Pembuatan Alat Ukur Kelajuan Angin Menggunakan Sensor Optocoupler Dengan Display Pc," *Sainstek J. Sains dan Teknol.*, vol. 7, no. 2, p. 95, 2016, doi: 10.31958/js.v7i2.131.

[5] T. N. Robby, M. Ramdhani, and C. Ekaputri, "Alat Ukur Kecepatan Angin, Arah Angin, dan Ketinggian," vol. 4, no. 2, pp. 1457–1466, 2017.

[6] E. Safrianti and H. Surya, "Perancangan Alat Ukur Kecepatan Dan Arah Angin," *J. Rekayasa Elektr.*, vol. 9, no. 1, pp. 30–35, 2010.

[7] Y. Pramono and W. Syafriadi, "Monitoring Data Kecepatan dan Arah Angin Secara Real Time Melalui Web," vol. 0, no. 02, pp. 221–226, 2016.

[8] O. Derek, D. Elia, K. Allo, and N. M. Tulung, "Rancang Bangun Alat Monitoring Kecepatan Angin Dengan Koneksi Wireless Menggunakan Arduino Uno," vol. 5, no. 4, pp. 1–7, 2016.

[9] M. L. Mahar, A. Rafi, and A. Tahtawi, "Perancangan dan Realisasi Anemometer Digital untuk Aplikasi Sistem Peringatan Dini," vol. 2, no. 2, pp. 91–96, 2017.

[10] Yulkifli, Z. Afandi, and Yohandri, "Development of Gravity Acceleration Measurement Using Simple Harmonic Motion Pendulum Method Based on Digital Technology and Photogate Sensor," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 335, no. 1, 2018, doi: 10.1088/1757-899X/335/1/012064.

[11] Y. Yulkifli, Y. Yohandri, and Z. Affandi, "Pembuatan Sistem Pengiriman Data Menggunakan Te lemetri Wireless untuk Detektor Getaran Mesin Dengan Sensor Fluxgate," Setrum Sist. KendaliTenaga elektronika -telekomunikasi-komputer, vol. 5, no. 2, p. 57, 2016, doi: 10.

[12] G. Marques, N. Miranda, A. K. Bhoi, B. Garcia-zapirain, S. Hamrioui, and I. de la T. Díez, "Internet of things and enhanced living environments: Measuring and mapping air quality using cyber-physical systems and mobile computing technologies," *Sensors (Switzerland)*, vol. 20, no. 3, pp. 1–20, 2020, doi: 10.3390/s20030720.

[13] M. F. Dvali and M. D. Belonin, "Prospects for deep and ultradeep oil and gas deposits in u.s.s.r.," *Int. Geol. Rev.*, vol. 8, no. 6, pp. 665–675, 1966, doi: 10.1080/00206816609474324.

[14] Q. Zhou and J. Zhang, "Internet of things and geography review and prospect," *Proc. - 2011 Int. Conf. Multimed. Signal Process. C. 2011*, vol. 2, pp. 47–51, 2011, doi: 10.1109/CMSP.2011.101.

[15] D. Parida, A. Behera, J. K. Naik, S. Pattanaik, and R. S. Nanda, "Real-time environment monitoring system using ESP8266 and thingspeak on internet of things platform," *2019 Int. Conf. Intell. Comput. Control Syst. ICCS 2019*, no. Iciccs, pp. 225–229, 2019, doi: 10.1109/ICCS45141.2019.9065451.