Design Of Portable Automatic Weather Station Based On Raspberry PI

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ABSTRACT

Observation of the weather elements is very necessary for the welfare of mankind, the weather elements that are observed will be used as material to predict the weather in the future. Weather data can also be used to reduce the risk of adverse effects caused by the weather itself. To measure the weather with an automated monitoring system that is cheaper and of good quality, AWS was created. The AWS design using Raspberry Pi was made as a use of Raspberry Pi mini computer technology for the purposes of the Meteorology, Climatology and Geophysics Agency (BMKG). humidity, Rain Counter, wind direction, wind speed, air pressure, altitude, and GPS. Display data can be monitored via the web in the form of an Analog Gauge.

Keywords : *Portable, Raspberry Pi, Automatic Weather Station*
Paper type Research paper

INTRODUCTION

Automatic Weather Station (AWS) is a piece of equipment designed to automatically acquire and collect weather data; such as temperature, pressure, humidity, solar radiation, rainfall, and wind. The existence of AWS can make it easier to observe the weather. The weather data obtained are used to reduce the risk of bad consequences caused by the weather itself. Agencies that need weather data include: agriculture, fisheries, transportation, tourism and also the general public [1]. The AWS observation system has long been developed in developed countries [2]. The relatively high price of AWS devices makes it difficult for some people to obtain them.

The Meteorology, Climatology and Geophysics Agency (BMKG) has installed a number of AWS equipment; whether installed in an integrated manner (Jabodetabek area); as well as stand-alone (not integrated). Currently, more than 70 AWS devices have been installed at BMG observation stations with various brands, such as Cimel, Vaisala, Jinyang, RM Joung and so on[3]. This is relatively difficult in maintenance, because it requires a number of people who master the equipment with different brands.

Previous research on AWS has been carried out by utilizing a microcontroller and several sensors as a data acquisition tool with supporting storage facilities and communication tools so that an AWS prototype is made using the AVR-Atm microcontroller [4].

Furthermore, in different studies, air pressure, humidity, wind direction and speed, solar energy, and the amount of rainfall with alternate displays using an LCD and Global Positioning System (GPS) elevation are connected via RS-323 communication [5].

From this research, it can be concluded that the AWS that was created in the previous study can be developed in a display way using the web and designed to be portable.

The presence of web technology that allows access to data between devices (devices) and is able to display and store images is an alternative as an AWS monitoring tool. On the web, applications can be developed that can access data such as through a Raspberry Pi device. When AWS can be scanned digitally, the data can be immediately loaded and stored on the smartphone so that it can be viewed again for observation or research at any time.

Based on the description above, the title "Design of Automatic Weather Station Based on Raspberry Pi" is taken which is a development from previous research. Regarding the use of the Raspberry Pi minicomputer as an AWS with 6 sensors as a data acquisition tool, it measures several weather parameters such as air pressure, temperature humidity, wind direction, wind speed, rain counter, and GPS data that can be displayed in web form.

METHOD

A. Materials

1. Raspberry Pi

Fig 1. Raspberry Pi

Raspberry Pi is one of the single board computers (SBC) which is quite popular even though there are several other SBCs such as BeagleBone, Intel, Galileo, PandaBoard, CubieBoard, and others. Raspberry Pi is usually abbreviated as raspi or RPI. Raspberry Pi was first released in February 2012 which was developed by the non-profit Raspberry Pi Foundation, which was fronted by a number of developers and computer experts from Camridge University, England. Initially, RPI was created for the computer learning process for school students, along with the development of technology from RPI itself, now RPI can be used for various applications such as home automation applications, web servers based on html, php, and mysql, file servers, DNS servers, download servers, and others. To support these applications, RPI2 is equipped with several facilities such as GPIO, serial, I2C, LAN port, HDMI port, and others [6].

2. BMP 280

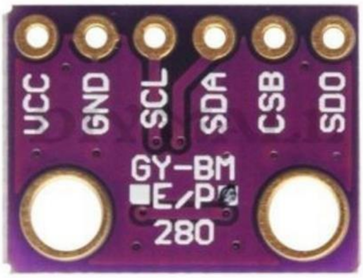

Fig 2. BMP280

BMP280 digital pressure sensor / barometric sensor / temperature sensor is a sensor module that functions as an altitude meter (Altitude meter) by utilizing the difference in air pressure (Barometric Sensor), this sensor module can also function as a temperature sensor. The BMP280 sensor detects the height of an object by utilizing air pressure when it is above the air in a certain area. So the higher a place, the less amount of air above it and the lower the air pressure [7].

3. DHT 11

Fig 3. DHT 11

DHT 11 is a sensor that can measure 2 environmental parameters at once, namely temperature and humidity. In this sensor there is an NTC type thermistor (negative temperature coefficient) for measuring temperature, a resistant type humidity sensor and an 8-bit microcontroller that processes the two sensors and sends the results to the output pins in a single-wire bi-directional format (single cable. two-way direction). DHT11 sensor is a sensor with digital signal calibration which is able to provide temperature and humidity information [8].

4. Wind Direction Sensor

Fig 4. Wind Direction Sensor

The wind direction sensor is a sensor that is very sensitive to the rotation and direction of the sensor, because this sensor uses a magnetic field as a reference for its detection. The data has been obtained for 8 cardinal points.

5. Wind Speed Sensor

Fig 5. Wind Speed Sensor

Anemometer is a device used to measure wind speed and to measure direction, an anemometer is one of the instruments often used by weather centers such as the Meteorology, Climatology and Geophysics Agency (BMKG). The word anemometer comes from the Greek anemos which means wind, wind is air that moves in all directions, wind moves from one place to another. This anemometer was first introduced by Leon Battista Alberti from Italy in 1450[9].

6. Rain Counter

Fig 6. Rain Counter

Rain Counter is a sensor that can detect raindrops on the sensor pcb. Returns a digital value or an analog value. Works on voltage 3.3 V to 5 V making it suitable for microcontrollers or Raspberry Pi. The rain sensor is a switching device that is driven by rainfall (rain).

7. GPS

Fig 7. GPS

GPS (Global Positioning System) is a module to detect signals from navigation satellites. By using this module, you can create a navigation system and can be used as location tracking. A GPS module with a large ceramic antenna like this one is suitable for outdoor and indoor applications (1 floor or covered with one roof layer). In addition to a larger antenna, it is also active with an amplifier circuit so that it is easier to get GPS satellite signals [10].

B. Method

The research method in designing the AWS prototype can be explained as follows:

1. Study of literature
   Searching various written sources, whether in the form of books, archives, magazines, articles and journals, or documents that are relevant to the problem being studied.
2. Creating a microprocessor program
   Coding the AWS sensor to be investigated so that it can be connected to the microcontroller (Raspberry Pi).
3. Prototype design
   Designing AWS sensor placements such as stanchions, panel boxes and cable arrangement.
4. Testing Design results hasil
   AWS testing is conducted in a variety of environments. for example home, campus, and so on. AWS has air pressure parameters using the BMP 280 sensor, DHT 11 humidity, wind direction sensor, wind speed, rain counter, GPS. The results are displayed in the form of coordinate values using the NODE-RED software on the Raspberry Pi.

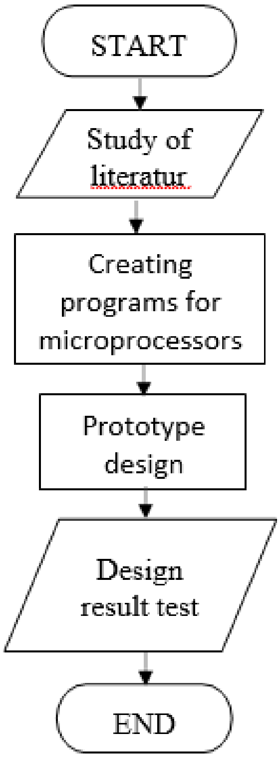

Fig 8. Block Diagram of Research Stages

C. Block Diagram Tool

It takes several electronic components and supporting devices in the design of this hardware or hardware so that the system can work and run properly according to its function. So a block diagram of the tool is made as follows to make it easier:

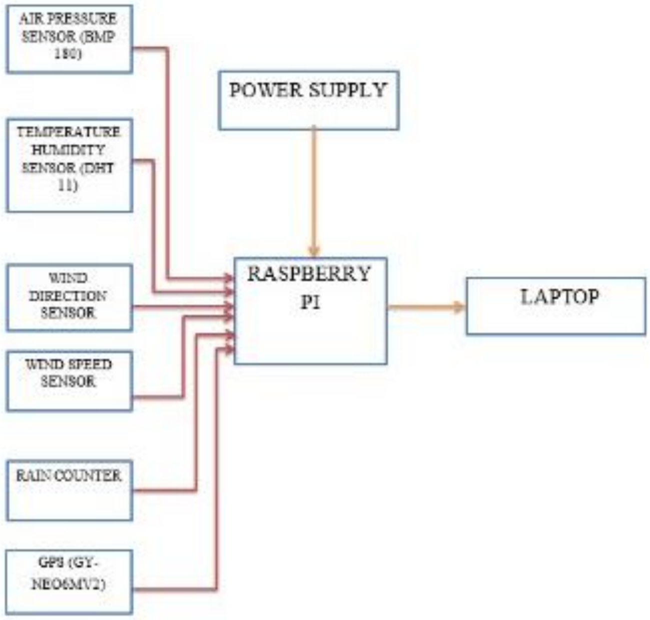

Fig 9. Block Diagram Tool

Sensors air pressure sensors, humidity temperature, wind direction, wind speed, rain counter, GPS are installed and connected to the input of the microcontroller (Raspberry Pi) in an integrated manner. The microcontoller output is connected to the laptop. Microcontroller programming is done after the input and output hardware is installed. Then the circuit system test is carried out.

The structure of AWS consists of several stages. The first sensor is Air Pressure, Humidity, Temperature, Wind direction, Wind speed, Rain counter, GPS which functions as input for the generated data. Then the microprocessor which consists of raspberries. The data generated by the input will be received by the process and then converted according to the value of the calibration of the tools then the data will be stored on a micro SD which functions as a hard disk (main data store).

D. Flowchart Software

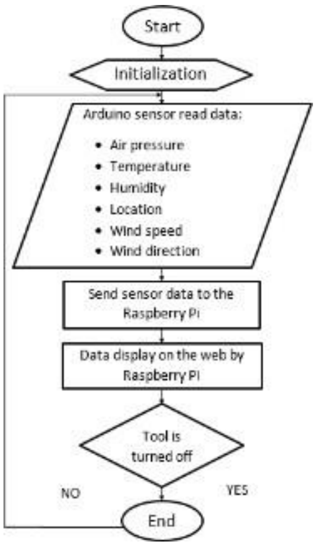

Fig 10. Flowchart Software

E. Hardware Design

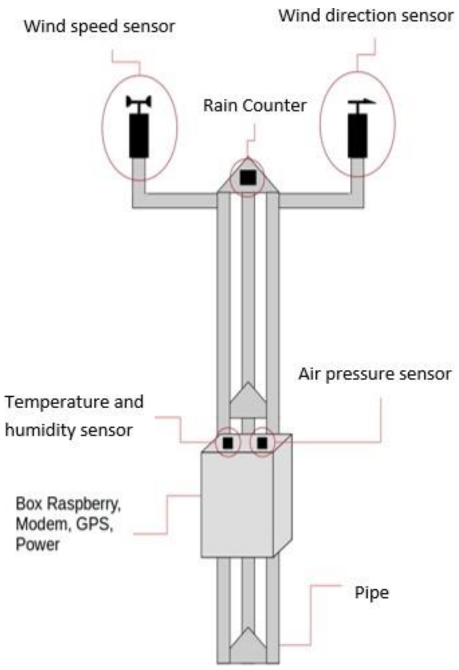

Fig 11. Design of a Portable Automatic Weather Station (AWS).

DISCUSSION

From the initial design, the NODE-RED program scheme was made on the Raspberry Pi which can be accessed via the web with the IP address 192.168.43.36:1880. The program scheme for NODE- RED is shown in Figure 5.

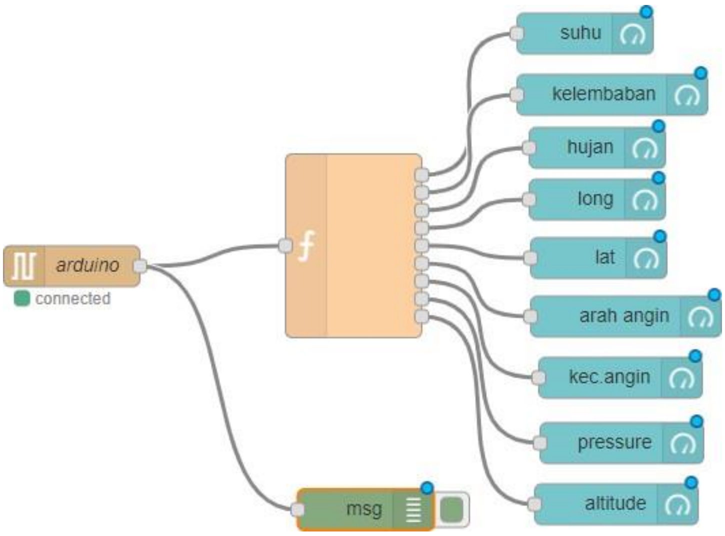

Fig 12. Schematic of the Node-Red Program

After the NODE-RED program scheme was created, data were taken from 3 different locations. The results of the sensor data display can be seen on the NODE-RED dashboard at test location 1 which is shown in Figure 13.

Fig 13. Display dashboard data at Test Location.1

While the weather data using the android application for location 1 is shown in Figure 14.

Fig 14. Display of Test Location 1 Weather Data on the Android Application

For the test results at test location 2 can be seen in Figure 15.

Fig 15. Data Dashboard Display at Test Location 2

While the weather data using the android application for location 2 is shown in Figure 16.

Fig 16. Display of Test Location 2 Weather Data on Android Applications

The test results at test location 3 can be seen in Figure 17.

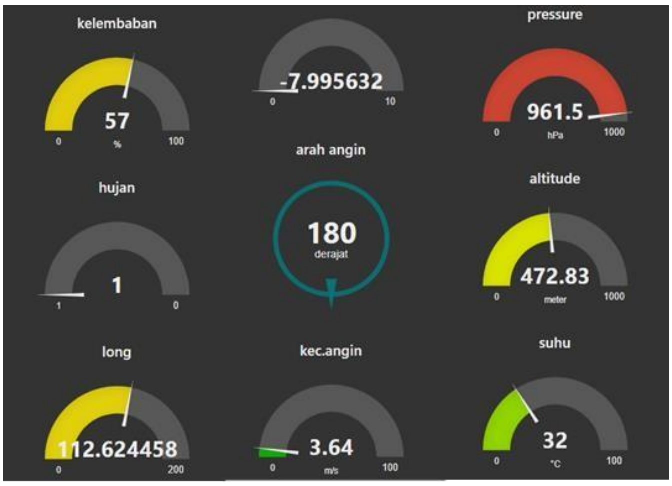

Fig 17. Data Dashboard Display at Test Location 3

While the weather data using the android application for location 3 is shown in Figure 18

Fig 18. Display of Test Location 3 Weather Data on Android Applications

From Figure 13 and Figure 14 it can be seen that the conditions of the test location 1 when testing the sensor are:

a. Air humidity is 47%. While the android weather application is 63%
b. The rain sensor is "1" which means it is not raining. On android weather app also shows sunny.
c. The wind direction sensor shows the direction 315 ° which means the wind direction is towards the Northwest.
d. The wind speed is 3.75 m/s. While the android weather application is 4 m / s.
e. Air pressure aimed at 958.96 hPa. While the android weather application is 1013 hPa.
f. The altitude is 493.9 meters above sea level.
g. The temperature is 26 ℃. On the android weather application that is 31℃.
h. GPS shows the position is at:
   - Latitude : -7.970849
   - Longitude : 112.706153

From the test results at test location 1, a comparison data chart for the parameters of air humidity, rain counter, air pressure, temperature is obtained as shown in Table 1

TABLE 1. COMPARISON OF TEST LOCATION DATA 1

Sensor	**Data AWS**	**Data Android**	**Error (%)**
Air Humidity	47%	63%	25%
Rain Counter	1	1	0
Air Pressure	958.96 hPa	1013 hPa	5%
Temperature	26℃	31℃	16%
Wind speed	3.75 m/s	4 m/s	6.25%

From Figure 15 and Figure 16 it can be seen that the conditions of the test location 2 when testing the sensor are:

a. Air humidity is 74%. While the android weather application is 70%
b. The rain sensor is "1" which means it is not raining. On android weather app also shows sunny.
c. The wind direction sensor shows the direction of 135 ° which means the wind direction is towards the Southeast.
d. The wind speed is 1.14 m / s. While the android weather application is 1 m/s.
e. Air pressure is aiming at 963.14 hPa. While the android weather application is 1012 hPa.
f. The altitude is 442.35 meters above sea level.
g. The temperature is 22℃. The android weather application is 19 ℃.
h. GPS shows the position is at:
    - Latitude : -7.97738
    - Longitude: 112.665718

From the test results at test location 2, the comparative data graph is shown in Table 2.

TABLE 2. COMPARISON OF TEST LOCATION DATA 2

Sensor	Data AWS	Data Android	Error (%)
Air Humidity	74%	70%	5%
Rain Counter	1	1	0
Air Pressure	963.14 hPa	1012 hPa	4.8%
Temperature	22℃	19℃	15.7%
Wind speed	1.14 m/s	1 m/s	14%

From Figure 17 and Figure 18 it can be seen that the conditions of the test location 3 when testing the sensor are:

a. Air humidity is 57%. While the android weather application is 54%.
b. The rain sensor is "1" which means it is not raining. On android weather app shows a sunny day.
c. The wind direction sensor shows the direction 180 ° which means the wind direction is towards the South.
d. The wind speed is 3.64 m/s. While the android weather application is 4 m / s.
e. Air pressure aimed at 961.5 hPa. While the android weather application is 1012 hPa.
f. The altitude is 472.83 meters above sea level.
g. The temperature is 32 ℃. On the android weather application that is 31℃.
h. GPS shows the position is at:
    - Latitude: -7.995632
    - Longitude : 112.624458

From the test results at test location 3, a comparison data graph is obtained which is shown in Table 3

TABLE 3. COMPARISON OF TEST LOCATION DATA 3

Sensor	Data AWS	Data Android	Error (%)
Air Humidity	57%	54%	5.5%
Rain Counter	1	1	0
Air Pressure	961.5 hPa	1012 hPa	4.9%
Temperature	32℃	31℃	3.2%
Wind Speed	3.64 m/s	4 m/s	9%

There are differences in air humidity data, rain counters, air pressure, temperature. This is because the comparative data using the android application is sourced from weather station data without knowing its exact location.

CONCLUSION

Based on the results of tests that have been carried out at 3 different locations, it can be concluded that:

1. The highest humidity is found at test location 1 with a value of 74%. While the highest temperature is at test location 2 with a value of 22 ℃.
2. The higher the test location, the greater the wind speed.
3. The AWS system prototype can detect rainy or light weather conditions.

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