Weather Station Design Using IoT Platform Based On Arduino Mega

Medilla Kusriyanto
Electrical Engineering Department
Industrial Technology Faculty, Indonesia Islamic University
Yogyakarta, Indonesia
medilla@uii.ac.id

Agusti Anggara Putra
Electrical Engineering Department
Industrial Technology Faculty, Indonesia Islamic University
Yogyakarta, Indonesia
anggaraputra9552@gmail.com

***Abstract*— Weather stations are built for the purpose of collecting quantitative data about the weather conditions of a place. Monitoring weather conditions in an environment today is considered to be very important because of the uncertain weather changes every day. This research tries to make weather station which can be accessed through website by using IoT platform. Users can know the weather changes in an area without the need to come to the area. This design uses Arduino Mega 2560 as a microcontroller. The measured weather parameters include temperature and humidity using DHT-22 sensors, rain detection using FC-37 rain sensor, and air pressure using BMP180 sensor. Air pressure measurement results are used to predict the weather. The measurement results of all sensors are stored in SD Card and displayed on TFT LCD 2.2 'and website using ESP8266 wifi module. In this research, the difference of measurement result with PCE-THB 40 module with an average error of 3.74% for temperature, 2.14% for air humidity and 0.32% hPa for air pressure.**

Keywords*— *IoT, ESP8266, Weather Station, Data Logger

I. Introduction

Weather Station is a form of application of science and technology to know and predict the weather conditions at a particular location. The weather station is designed to collect quantitative data about the weather conditions of a region in order to be able to know and predict weather conditions in a region. In Indonesia weather conditions are always announced for a 24-hour period through weather forecasts analyzed by the Meteorology Climatology and Geophysics Agency (BMKG)

Human activities depend on weather factors. Weather is an air condition that lasts for a short period of time so the short-term weather forecasting process should be done as quickly and accurately as possible. Weather conditions in a place is determined by a number of factors including air temperature, humidity, wind direction, wind speed and air pressure. By looking at these factors, the weather can be predicted for weather conditions the next day.

In this research try to develop weather prediction by using IoT platform. With this device, users can know the weather conditions of a place by utilizing the internet network.

In [1], it is mentioned that they have designed, developed and tested a low cost weather monitoring station using raspberry pi, which monitor the weather data, including wind speed, wind direction, air temperature, humidity, atmospheric pressure, rain, and solar radiation. Weather data are sent via Wi-Fi network to a database server as well as it stored in memory card. On the other hand, a web application which presents acquired weather data at remote locations. This system provides real-time data acquisition and transfer of measured parameter like other high cost commercial weather station. It is very low cost, small size, easy use and reliable which can be easily used in various applications.

In [2], it is mentioned that an Automatic Weather Station (AWS) data logger using microcontroller Netduino. It will be useful to each sector which affected by weather. This research implement a telemetry system on Netduino logger in purpose to place it on remote area application, beside the study was developed a switching channel method to expand the number of I/O analog pin on Netduino. This research conclude that processing analog signal on Netduino has an alteration between its real value even not significantly, some treatment has implemented to reduce the error of data output, with using good power resource and moving averaging on each data reads (FAH).

In [3], it is mentioned that weather information is required before performing an activity, especially activities that directly relate to nature such as agricultural activities. Weather parameters are taken from the temperature, wind speed and solar radiation intensity. The system was designed with speed of optokopler as sensors, sensor LM35 as temperature sensor and sensor instensitas LDR as a measure of the sun. all sensors acquired by ATmega8535 microcontroller. The signal from the sensor is then processed and sent to the processor board to be translated into wind speed of the data parameter, temperature, and intensity of the sun. KYL 1020 U used as an intermediary to transmit data from the processor board to the client computer.

In [4], it is mentioned that climate observing has critical influence on mankind. Gathering of the various data of fleeting elements of the climate variations is extremely noteworthy. The essential point of their research is to build up an installed framework to outline a climate observing framework which empowers the checking of climate parameters. This type of frame work includes various sensors involving temperature, Humidity, wind speed, wind bearing information can be signed into cloud so that any one (validated individual) from wherever can watch the particular information. If there should be an occurrence of any catastrophes like flame, substantial

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downpour, overwhelming wind, temperature or moistness might be wild, in these cases the moment data can be passed on all through the world utilizing cloud to the verified people, regardless of the fact that his equipment is wrecked in crisis.

In [5], it is mentioned that developed wireless sensors to send weather parameter data. In this research, a cheap, simple system can be developed to form a weather station system. The microcontroller is used to process data from sensors in the form of temperature, air pressure, humidity and wind speed data to be sent wirelessly using 433 Mhz radio frequency with an optimal delivery distance of 150m.

II. PROPOCED DESIGN OF THE WHEATER STATION

A. Wheather System

The main part of the weather forecast system is shown in Fig 1. this system consists of arudino mega 2560 microcontroller as data processing center, DHT 22 temperature sensor, rain detection sensor, BMP 180 air pressure sensor, DS3231 RTC, 3.5 "touch screen LCD, esp 8266 as information sending media to IoT platform and SD data storage Card.

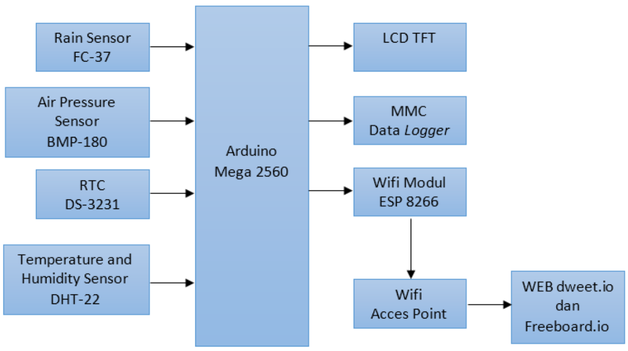


Fig. 1. Wheather System Block Diagram

B. Rain Sensor

This module is used to find out if there is rain. The module works by measuring the humidity obtained from drops of water collected on the sensor board. The amount of water drops makes the parallel resistance found on the sensor board have a change in value. If the drops of water collected on the ground increase, the resistance value which is converted to the voltage form will be lower and if the drops of water collected are small, the voltage value changes to high. When the sensor board is dry (there is no water point), this module outputs a 5 volt analog voltage.

C. Air Pressure Sensor

BMP180 is a pressure sensor made by Bosch company. The air pressure sensor measures the absolute pressure around the sensor and varies according to weather and altitude (Altitude). Depending on how to use data, the BMP180 can be used to monitor weather changes, height measurements, or other tasks that require accurate pressure readings.

BMP180 has a sampling rate of up to 128 samples per second and the design is connected directly to the microcontroller with I2C communication. The BMP180 consists of a piezo-resistive sensor, an analog to digital converter and a control unit with E2PROM and I2C interfaces.

D. DHT 22 Air and Humidity Sensor

DHT22 is a digital sensor that is used to measure the temperature and humidity of the surrounding air. DHT22 uses capacitive humidity sensors and thermistors to measure the ambient temperature connected to 8-bit single-chip computers and converted into digital signals on the data pin.

To measure humidity, DHT22 uses two electrodes by holding the substrate moisture between the electrodes. Changes in humidity are obtained from changes in the conductivity of the substrate or resistance between changes in these electrodes. The change in the resistance value is measured and processed by the IC which makes it ready to be read by the microcontroller.

To measure temperature, this sensor uses an NTC or thermistor temperature sensor. A thermistor is actually a variable resistor whose resistance changes according to temperature changes. This sensor is made from semiconductive materials such as ceramics or polymers to give a large change in the value of resistance from small changes in temperature

E. Wireless Modul ESP8266

ESP8266 is a WiFi module with high performance that can stand alone because it has GPIO and can also be connected to a microcontroller. This WiFi module is a SoC (System on Chip) with an integrated TCP / IP protocol stack that allows the microcontroller to access WiFi networks with simple connectivity (SPI / SDIO or I2C interface / UART). This module is programmed using AT-Command commands if using Serial communication.

F. Weather Forecast Algorithm

This algorithm uses the words "Modern Altimeter and Barometer using the MPL115A system" written by John B. Young. This algorithm uses the barometric sensor measurement pressure to estimate the weather. This method uses a simple approach to see an increase or decrease in pressure. In general, the increase in pressure over time is the tendency to approach the weather will be bright. While the pressure drop indicates the weather will rain or cloudy.

A more complex approach to measuring pressure and seeing how gradients change over time and stored on a variable in measurement. This method can take less than 12 hours to see the pattern of pressure changes. Table 1. shows the changes in pressure and weather conditions predicted. Pressure changes are measured within one hour. It takes at least 3 hours to conclude how the pressure changes.

TABLE I. PRESSURE AND PREDICTED WHEATHER

Analysis	Output
$dP/dt > 0.25$ kPa/h	Increased pressure fast, unstable.
0.05 kPa/h $< dP/dt < 0.25$ kPa/h	Increased pressure slowly, stable or good weather
-0.05 kPa/h $< dP/dt < 0.05$ kPa/h	Stable weather conditions
-0.25 kPa/h $< dP/dt < -0.05$ kPa/h	Pressure drop slowly, light rain / stable
$dP/dt < -0.25$ kPa/h	Fast pressure drop, storm or unstable

G. PCE-THB 40 Modul

PCE-THB 40 is a digital thermometer-hygrometer-barometer with data recording functionality. This compact yet robust data logger detects ambient temperature, relative humidity and atmospheric or barometric pressure. Measurement values are displayed in real time on the large LCD screen and saved to the included SD card. Data can also be transferred via an optional USB data cable complete with PC-compatible software (SOFT-LUT-US) for live visualization. Measurement quota can be freely adjusted, with data captured every 5, 10, 30, 60, 120, 300 or 600 seconds, or automatically when there is an alteration of ±1º, ±1% RH or ±1 hPa.

III. RESULT AND DISCUSSION

Testing is done to get the data produced by the tool while working. This test is done by comparing weather parameters obtained from weather station with PCE-THB 40 module measurements and data provided on the BMKG website. The weather parameters measured are temperature, humidity and air pressure.

A. Temperature Test Result

The test is carried out by comparing the measurement data of DHT22 temperature sensor with PCE-THB 40 Module measurement data every half hour

TABLE II. TEMPERATURE TEST RESULT

Time	Weather station Temperature (°C)	PCE-THB 40 Temperature (°C)	error (%)
9:30:00	35	36	2.86
10:00:00	45	47	4.44
10:30:00	47	48	2.13
11:00:00	43	42	2.33
11:30:00	43	45	4.65
12:00:00	37	39	5.41
12:30:00	44	44	0.00
13:00:00	34	35	2.94
13:30:00	38	38	0.00
14:00:00	32	33	3.13
14:30:00	34	37	8.82
15:00:00	32	34	6.25
15:30:00	32	34	6.25
16:00:00	32	33	3.13
		Mean of error (°C)	3.74

From the measurement results of the DHT22 sensor, the highest temperature is 47 ° C at 10.30 and the lowest is 32 ° C at 3:00 p.m. In table 1 it is seen that the air temperature data is fluctuating, where the air temperature increases at 9.30-11.30 and decreases at 12:30-16.00. This can be caused by the duration of sun exposure and the difference in the angle of arrival of sunlight. The smallest angle of the sun comes in the morning and evening, while the biggest angle is during the day. Data fluctuations are caused by sunny and cloudy weather conditions.

From the measurement data using PCE-THB 40 module, the temperature values range from 33-48˚C. On the results of temperature measurement comparison using DHT22 sensor and PCE-THB 40 module, the biggest temperature error is 3 ° C at 14.30 and the average error is 1.35˚C, where the accuracy of the DHT22 temperature sensor is ± 0.5 ° C.

B. Testing of Air Humidity Sensor

The test was carried out by comparing the data of DHT22 humidity sensor measurement with 40 PCE-THB Module measurement data every half hour. The test result shown in table 3.

From the results of testing the DHT22 sensor, the highest air humidity was 61% at 4:00 p.m. and the lowest was 24% at 10:00. From table 3 it can be seen the fluctuating air humidity data, where the humidity increases at 11:30 until 16:00 and moves down at 09.30-10.30. This is because warm air can hold more water vapor than cold air, so that the large air humidity is inversely proportional to the air temperature. While fluctuating data is caused by cloudy weather conditions.

TABLE III. HUMIDITY TEST RESULT

Time	weather station humidity (%)	PCE-THB 40 module Humidity (%)	error (%)
9:30:00	43	44	1
10:00:00	24	24	0
10:30:00	25	22	3
11:00:00	32	31	1
11:30:00	25	26	1
12:00:00	38	36	2
12:30:00	32	27	5
13:00:00	49	47	2
13:30:00	44	43	1
14:00:00	59	58	1
14:30:00	49	46	3
15:00:00	57	54	3
15:30:00	59	55	4
16:00:00	61	58	3
		Mean of error (%)	2.14

From the measurement data using the PCE-THB 40 module, the measurement of air humidity is 22-58%. In the comparison of air humidity measurement using DHT22 sensor and PCE-THB 40 module, the biggest air humidity error is 5% at 12.30 and the average error is 2.14%, where the accuracy of the DHT22 temperature sensor is ± 5%.

C. Testing of Air Pressure Sensor

The test is done by comparing the data on the measurement results of BMP180 Pressure sensor with 40 PCE-THB Module measurement data every half hour. The test result shown in table 4.

TABLE IV. AIR PRESSURE TEST RESULT

Time	weather station air pressure (hPa)	PCE-THB 40 air pressure (hPa)	error (%)
9:30:00	975.9	973	0.30
10:00:00	975.9	972.8	0.32
10:30:00	975.6	972.8	0.29
11:00:00	975.5	972.4	0.32
11:30:00	974.8	971.7	0.32
12:00:00	974.1	971.3	0.29
12:30:00	973.7	971	0.28
13:00:00	973.6	970.4	0.33
13:30:00	972.7	969.8	0.30
14:00:00	972.6	969.7	0.30
14:30:00	972.4	969.4	0.31
15:00:00	972.3	969.2	0.32
15:30:00	972.1	969.1	0.31
16:00:00	973.8	969.2	0.47
	Mean of error (hPa)		0.32

From the data, the air pressure moves down gradually from 09:30 to 15:30, then moves up from 15.30-16.00. From the results of the BMP180 sensor measurement, the highest air pressure is 975.9 hPa at 09:30 and the lowest is 972.1 hPa at 15.30, where a rapid decrease in air pressure can indicate weather changes.

From the measurement data using the PCE-THB 40 module, the air pressure measurement was 969.1 - 973 hPa. At the comparison of air pressure measurement using BMP180 sensor and PCE-THB 40 module, the biggest air pressure error is 3.1 hPa at 12.30 and the average error is 3.08 hPa, where the accuracy of the BMP180 pressure sensor is -4.0 and + 2.0 hPa.

D. Test of data delivery on the IoT platform website

The test is done by looking at the status of sending data to the website dweet.io on the data logger. From the results of observations on the status of the data logger, data transmission can be done as long as the Wifi ESP8266 module is connected properly to the microcontroller and connected to the internet network. The test result shown in Fig 2.

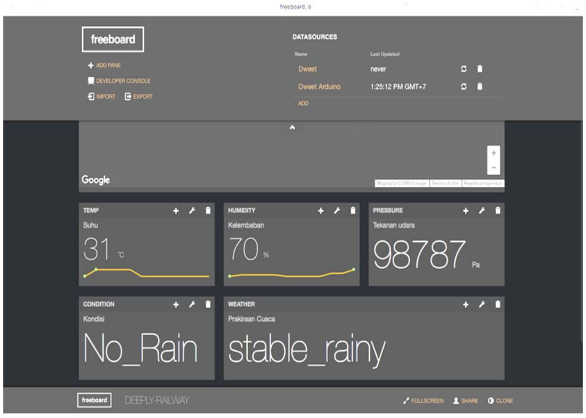


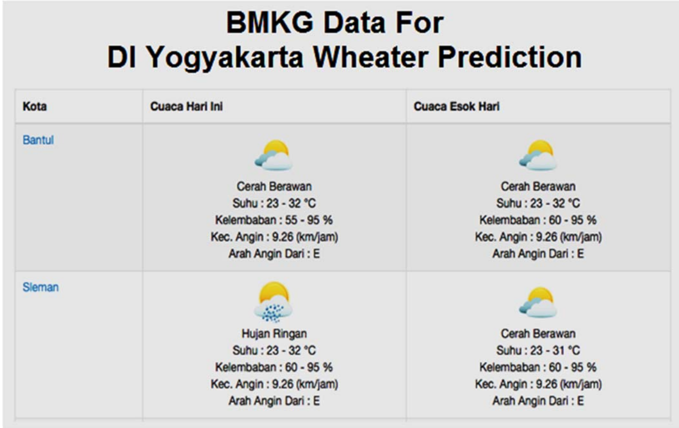
Fig. 2. Dasboard IoT Platform

E. Testing Weather Forecast Algorithms

The test is done by comparing the data from the weather forecast algorithm with weather forecast data available on the BMKG website, then compared to the actual weather conditions. From table 4, there is a decrease in air pressure which indicates that weather conditions will change.

Stored data shows the results of the weather forecast are "stable rainy" at 09.30-15.30 and "stable" at 15.42-16.00. Stable rainy indicates that the area will be light rain. From the data compared with the BMKG weather forecast results, the results are valid or in accordance with the weather forecast data obtained. The test result shown in Fig 3. The BMKG data for yogyakarta wheater prediction shown in Fig 4.

Fig. 3. Wheather Status



BMKG Data For
DI Yogyakarta Wheater Prediction

Kota	Cuaca Hari Ini	Cuaca Esok Hari
Bantul	Cerah Berawan Suhu : 23 - 32 °C Kelembaban : 55 - 95 % Kec. Angin : 9.26 (km/jam) Arah Angin Dari : E	Cerah Berawan Suhu : 23 - 32 °C Kelembaban : 60 - 95 % Kec. Angin : 9.26 (km/jam) Arah Angin Dari : E
Sleman	Hujan Ringan Suhu : 23 - 32 °C Kelembaban : 60 - 95 % Kec. Angin : 9.26 (km/jam) Arah Angin Dari : E	Cerah Berawan Suhu : 23 - 31 °C Kelembaban : 60 - 95 % Kec. Angin : 9.26 (km/jam) Arah Angin Dari : E

Fig. 4. BMKG Data for Yogyakarta Wheater Prediction

IV. CONCLUSION

From the results of the study it can be concluded that weather stations have been made using DHT22 temperature and humidity sensors, BMP180 air pressure, FC37 rain detection, which can connect to the internet and have a data logger. All menu views in the mini weather station are in accordance with the program created. At temperature test using DHT22 sensor and PCE-THB 40 module there is difference of measurement that is biggest error 3˚C and mean of error is 1.35˚C. In air humidity test using DHT22 sensor and PCE-THB 40 module there is difference of measurement that is biggest error 5% and mean of error is 2,14%.

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