DESIGN OF DATA LOGGER WIND SPEED PARAMETERS USING MICROCONTROLLER BASED ON ARDUINO MEGA 2560

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Abstract

Wind Power Plants (PLTB) in general produce electricity by utilizing wind energy to drive turbines. However, PLTB cannot be utilized optimally because the wind speed is not constant over time. In order to produce PLTB with maximum power from highly fluctuating winds, it is necessary to study wind parameters, so a wind speed parameter data logger system was formed in this Final Project. This final project focuses on designing a data logger to collect and record wind speed parameter data. The data logger in this final project uses Arduino Mega2560 microcontroller, anemometer sensor, BMP180 temperature and pressure sensor, DHT11 humidity sensor, RTC module and SD card module. The results of testing the wind speed parameter data logger system show that the performance of all sensors works well with reference to standard digital tools. Comparison of the output value of the wind speed sensor with a digital measuring instrument has an error of 1.57%. Comparison of the output value of the temperature sensor with a digital measuring instrument has an error of 0.044%. The output value of the pressure and humidity sensors is related to temperature where the higher the temperature, the lower the pressure and humidity, and vice versa. Wind speed parameter data is collected every 1 second and stored in an Excel document (.xlsx). Comparison of the output value of the temperature sensor with a digital measuring instrument has an error of 0.044%. The output value of the pressure and humidity sensors is related to temperature where the higher the temperature, the lower the pressure and humidity, and vice versa. Wind speed parameter data is collected every 1 second and stored in an Excel document (.xlsx). Comparison of the output value of the temperature sensor with a digital measuring instrument has an error of 0.044%. The output value of the pressure and humidity sensors is related to temperature where the higher the temperature, the lower the pressure and humidity, and vice versa. Wind speed parameter data is collected every 1 second and stored in an Excel document (.xlsx).

Keywords: *wind power plant, data logger, arduino mega 2560, anemometer*

1. Introduction

Indonesia is a developing country in Southeast Asia which is experiencing an increase in population every year. In September 2020, the number of 270.20 million people was recorded in Indonesian government agencies. Indonesia with a land area of 1.9 million km2 has a population density of 141 people per km2[1]. Along As time goes by and the population increases in Indonesia, the need for various fields will also increase, one of which is the need for electrical energy.

National electricity consumption continues to increase. This is shown by electricity consumption data for 2015, which was 910 kilowatt hours (kWh)/capita, then in 2020 it increased to 1,084 kilowatt hours (kWh)/capita [2]. To meet the demand for national electricity consumption, the Indonesian government added capacity at the power plant. It was recorded that until mid-2020 the power provided by the national power plants reached 71 Giga Watt (GW). This figure increased by 1.3 GW compared to late 2019 with a power of 69.7 GW [2]. Therefore, to help meet the demand for electricity consumption in Indonesia, we must start running generators with renewable energy sources (EBT) with various developments. Among the existing renewable energy sources, wind power plants (PLTB) can be an alternative to increase electricity capacity in an effort to meet the demand for national electricity consumption. The Wind Power Plant (PLTB) utilizes wind energy to drive the turbine so that the generator blades behind the turbine rotate and can provide electrical energy. It can be said that PLTB cannot be utilized optimally, because in Presidential Decree No. 22 of 2017 the potential for wind energy in Indonesia reaches 60.65 GW. However, until the year 2020 source energy electricity with the utilization of wind energy has only reached 135 MW with details of PLTB Sidrap 75 MW and PLTB in the Janeponto area of 60 MW [3]. This is partly due to the relative wind speed that changes over time, so that the power generated is less than the maximum. To produce maximum power from this highly fluctuating wind, it is necessary to study wind parameters [4].

In overcoming this, a Wind Power Plant (PLTB) is needed to have a tool that includes a data logger system (data recorder). This data logger functions to collect and record data from sensors needed for the study of wind parameters [5]. The study of wind parameters is needed to map wind energy potential such as wind speed and direction, air temperature, humidity and air pressure in an area [6]. To determine wind potential, an appropriate measuring instrument is needed [7]. It is important to read wind parameters and determine the choice of a place that has wind energy capabilities according to the minimum operating standards of the turbine with the aim that the Wind Power Plant (PLTB) can produce the greatest output power.

In this Final Project, the design of a wind speed measuring instrument based on Arduino Mega 2560, anemometer (wind speed sensor), DHT11 (humidity sensor), BMP180 (air pressure and temperature sensor), RTC module, micro SD card module, and LCD. The tool that has been created is intended to collect, display, and record wind speed, air temperature, humidity, and air pressure data in real time and the recorded data will be stored on an SD card via a micro SD module [8].

2. Method

2.1. Input Power Design

The input power used is a DC 7 V – 12 V Arduino Mega 2560 input voltage source using a DC jack connected from a laptop [9]. The Arduino Mega 2560 input voltage is used to supply the sensors used in the study with the breakdown of a voltage of 5 V to activate the anemometer sensor, a voltage of 3 V for the BMP180 temperature and pressure sensor, a voltage of 5 V for the DHT11 humidity sensor, a voltage of 5 V for the RTC module, voltage 5 V for LCD 16x4 and voltage 5 V for SD card storage module.

2.2. Control Circuit Design

The design of the control circuit in this final project research uses an Arduino Mega 2560 type microcontroller. The choice of this type of microcontroller is based on the ability of the microcontroller to process sensor data which is quite good, the memory capacity of the microcontroller is in accordance with the large number of source code programs for the Final Project, and the microcontroller has many pins.

Table-1 Arduino Mega 2560 features

Component	**Specification**
microcontroller chips	ATmega2560
operating voltage	5 Volts
Input voltage (via DC jack a recommended)	7 Volts – 12 Volts
Digital I/O pins	54 pieces, 6 of which are equipped with PWM output
Analog input pins	16 pieces
Flash memory	256KB (8KB used for *bootloader*)
SRAM	8KB
EEPROM	4KB
Clockspeed	16Mhz

2.3. Sensor Circuit Design

The series of sensors used in this study were 5 sensors including anemometer sensor, DHT11 humidity sensor, BMP 180 pressure and temperature sensor, RTC module, SD card module, and 16x4 LCD module. The circuit design of each sensor is explained as follows.

2.3.1 Sensors SpeedWind(Anemometer)

The wind speed measuring instrument in making the final project uses the anemometer wind speed sensor output from Depoinovasi. The anemometer sensor produced by Depoinovasi uses an optocoupler sensor module and a propeller uses a cup type or bowl type. Wind speed measurements work using an optocoupler module by distinguishing the dark and bright gaps created by the rotation of the encoder circle shaft on this anemometer sensor.

Figure-1 Optocoupler sensor construction using a rotary disk encoder

The optocoupler anemometer sensor output from Depoinovasi has the following specifications and features:

Table-2 Anemometer sensor specifications and features

Component	Specification
sensor module	*Optocoupler sensor* with a rotary disk encoder
operating voltage	DC 5 Volts
Optical sensor	Use sensors optics typegap
output(output)	PWM (Pulse width *modulation)*
Wheel diameter	17.5cm
Number of encoder slits	18 gaps
Radio(ballast distance outer with shaft)	8cm

The result of the anemometer sensor is a PWM (Pulse Width Modulation) signal, then this PWM sign is processed by the Arduino ATmega 2560 via PIN D2 or 2 digital, by programming in the form of an external interrupt and a timer interrupt.

2.3.2 DHT11 Humidity Sensor

Humidity sensor in final project designusing a humidity sensor type DHT11. The DHT11 sensor uses 3 input pins, namely VCC, GND (Ground), and Data. A digital data signal containing humidity information for the surrounding environment will be sent from the DHT11 humidity sensor to the Arduino Mega 2560 microcontroller via digital pin 5[10].

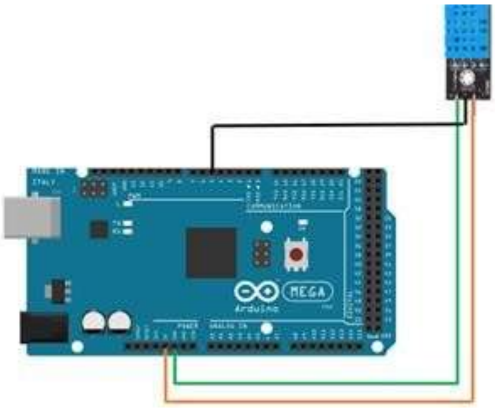

Figure-2 Schematic of the DHT11 circuit

2.3.3 BMP180 Pressure and Temperature Sensor

The pressure and temperature sensors used in the design of this tool are of the BMP180 type. The choice of the BMP180 sensor in making this final project is due to the reason that the BMP180 sensor is a barometric pressure sensor (digital barometric pressure sensor) as well as a temperature sensor which has a high level of accuracy in reading data. The BMP180 sensor is equipped with 4 pins namely VCC, GND, SDA (Data), and SCL (Clock)[11]. The communication technology used by the BMP180 sensor is I2C (inter integrated circuit) serial communication where this technology is a two-way serial interaction standard.

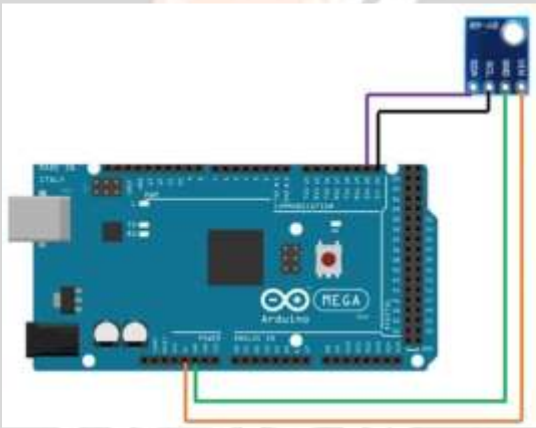

Figure-3 Schematic of the BMP180 circuit

2.3.4 RTC (Real Time Clock) Module

In designing this final project, the timing design is to determine the real time that will be used on the Arduino Mega 2560 in processing data in scheduling using the DS3231 RTC module. The reason for choosing the DS3231 RTC module to be used as a time parameter is because this module provides accurate time information starting from the date, hour, minute, and second [12]. The electronic circuit of the DS3231 RTC module is described in Table 3.

Table-3 DS3231 RTC pin connections

RTC DS3231	Arduino Mega 2560 pins
GND	GND
VCC	5V
SDA	Pin 20 (SDA Pins)
SCL	Pin 21 (SCL Pins)

The schematic for the DS3231 RTC module circuit with Arduino Mega 2560 pins can be seen in Figure 4.

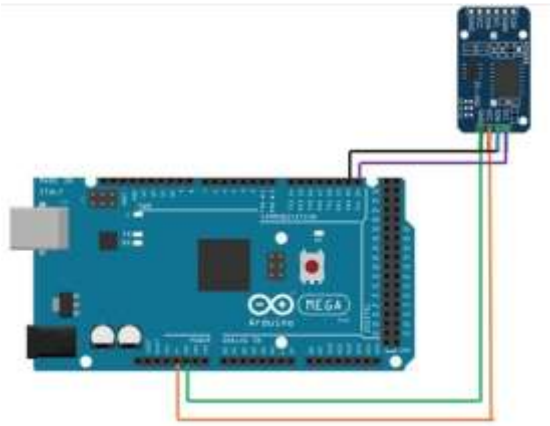

Figure-4 Schematic of the RTC module circuit

2.3.5 MicroSD Card Module

The SD card module used in the design of this final project has the goal of recording the output data of all sensors which have previously been processed in the Arduino Mega 2560 microcontroller. The SD card module circuit with Arduino Mega 2560 is a communication circuit for writing and reading Arduino data with the SD card module. . This communication uses SPI communication which must pass through the SPI pin on the Arduino Mega 2560. The pins used to connect the SD card module, can be seen in Table 4 as follows[13] :

Table-4 SD card module pin connection

SD Card Module	Arduino Mega pins
GND	GND
VCC	5V
MISO	pins 50
MOTION	Pins 51
SCK	Pins 52
CS	Pins 53

The schematic of the SD card module circuit with Arduino Mega 2560 pins can be seen in Figure 5.

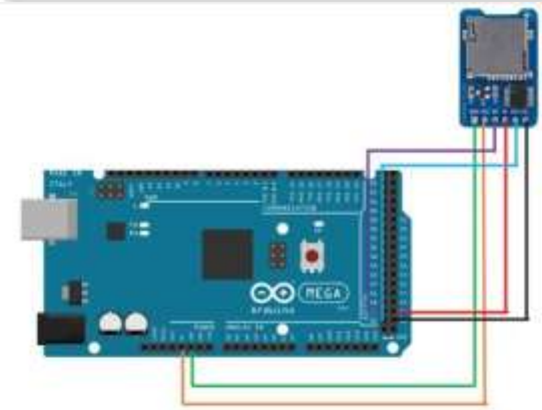

Figure-5 Schematic of the SD card module circuit

3. Results and Analysis

3.1. TestingWind Speed Sensor

Wind speed sensor testing is carried out to determine the error value resulting from a comparison of the wind speed value read by the sensor with a standard digital measuring instrument. Testing of the wind speed

sensor is carried out by using a fan with various speeds as a source of wind to rotate the sensor vane. Testing of the wind speed sensor and standard measuring instruments is carried out simultaneously and at a fixed distance from the fan.
Wind speed sensor testing is done using RPM (Rotations Per Minute).

3.2 Temperature Sensor Testing

Testing the temperature sensor in this final project research uses the temperature reading facility from the BMP180 sensor module, the author prefers the BMP180 sensor over DHT 11 as a temperature reader because this module has a high level of precision and has quite good sensor durability. Testing of this temperature sensor is carried out at room temperature by comparing the output temperature of the sensor with a standard digital measuring instrument
Temperature sensor testing aims to test the temperature sensor in real time, then analyze the error comparison of the temperature output value read by the sensor with a standard digital measuring instrument. Comparison of the test values read by the temperature sensor with standard digital measuring instruments shown in Table 6.

Table-6 Data on temperature sensor test results

Time	ScoreTemperature (BMP180 Sensor) (°C)	ScoreTemperature (Standard Instrument) (°C)	*Error* (%)
22:03:05	29.54	29.53	0.034
22:03:07	29.55	29.54	0.034
22:03:09	29.53	29.54	0.034
22:03:11	29.54	29.55	0.034
22:03:13	29.55	29.56	0.034
22:03:15	29.55	29,52	0.102
22:03:17	29.54	29.53	0.034
Average Error Value			0.044

Based on Table 6 testing the temperature sensor using the BMP180, seven test data were taken and it had a fairly small average error of 0.044%.
Comparison of the ambient temperature value read by the sensor with a standard measuring instrument in real time is shown in Figure 9.

Figure-9 Comparison graph of the temperature value read by the sensor with a standard thermometer

Figure 9 shows a comparison graph of the ambient temperature value that is read by the sensor with a standard thermometer measuring instrument from the test results using the time data when the test was carried out. From the graph above, it can be seen that the comparison between the temperature value read by the sensor and a standard thermometer does not have a large enough difference.

3.3 Air Pressure Sensor Testing

Air pressure sensor testing aims to test the performance of the air pressure sensor in real time, then analyze the relationship between the output value of air pressure and the temperature read by the sensor and analyze the magnitude of the sensor error value. by comparing the average output valueair pressure read by the sensor with a calculated value using the formula. Data collection for the air pressure sensor test was carried out at Marina Beach, Semarang, Central Java, Thursday, September 23, 2021 in the afternoon. The test results data read by the air pressure sensor are shown in Table 7.

Table-7 Data from air pressure sensor testing results at Marina Beach

Time	Temperature (°C)	Air Pressure (mbar)
16:41:44	30,44	1009,67
16:41:46	30,42	1009.73
16:41:48	30,43	1009,69
16:41:50	30,41	1009.76
16:41:52	30,43	1009,69
16:41:55	30.45	1009.66
16:41:57	30,48	1009,61
16:41:59	30,56	1009,6
16:42:01	30,61	1009.56
16:42:03	30,66	1009.54
16:42:05	30,7	1009.52
16:42:07	30,76	1009,51
16:42:10	30.79	1009,51
16:42:12	30,82	1009,48
16:42:14	30.85	1009,42
Average Air Pressure (mbar)		1009,60

From the calculation of air pressure using the formula, the air pressure value is 1009.42 mbar. From the comparison of the average air pressure from Table 7 with calculations using the air pressure formula, an error value of 0.0178% is obtained, from these results it can be seen that the air pressure sensor using the BMP180 can work well and has a high level of precision.

The relationship between the output value of air pressure and the temperature read by the sensor in real time is shown in Figure 10 below.

Figure-10 Graph of the relationship between air pressure and temperature

From Figure 10 it can be seen that high air pressure occurs when the air temperature conditions are low and vice versa, low air pressure occurs when the air temperature conditions are high. So it can be concluded that air pressure is inversely proportional to ambient temperature.

3.4 Testing sensor HumidityAir

Testing the air humidity sensor in this final project research, the author uses the DHT11 sensor module. This test aims to test the performance of the air pressure sensor in real time, then analyze the relationship between the output value of air humidity read by the sensor and the ambient temperature where the test is carried out. Data collection for the air humidity sensor test was carried out at Marina Beach, Semarang, Central Java, Saturday, September 25 2021 in the morning. The test results data read by the air humidity sensor are shown in Table 8.

Table-8 Data on the results of testing the air humidity sensor

Time	Temperature (°C)	Humidity (%)
10:09:33	31.85	64.00 %
10:09:36	31.85	64.00 %
10:09:38	31.85	64.00 %
10:09:40	31.88	64.00 %
10:09:42	31.90	64.00 %
10:09:44	31.92	64.00 %
10:09:46	31.94	64.00 %
10:09:48	31.97	63.00 %
10:09:51	31.99	63.00 %
10:09:53	32.03	63.00 %
10:09:55	32.03	62.00 %
10:09:57	32.03	62.00 %
10:09:59	32.03	62.00 %
10:10:01	32.04	62.00 %
10:10:03	32.06	62.00 %

Average Humidity	63.13%

Based on Table 8 testing of the air humidity sensor using the BMP180, fifteen test data were taken. From these data it is known that the average air humidity at Marina Beach, Semarang in the morning is 63.13%. In testing the BMP180 sensor, the highest humidity value was 64% and the lowest humidity was 62%. From Table 4.5 it can be seen that air humidity has decreased when the temperature value or temperature is higher.
The relationship between the output value of air humidity that is read by the sensor and the ambient temperature is shown in graphical form in Figure 11 below.

From the graph in Figure 11 above it can be seen that the value of air humidity decreases when the air temperature conditions are higher and high air humidity occurs when the air temperature conditions are low. So it can be concluded that the relationship between air humidity and ambient temperature is inversely proportional.

3.5 Testing System

3.5.1 Testing sensors

In this test, all sensors used in the Final Project research were combined into a single unit and produced output values in one part. These sensors include anemometer sensor, BMP180 sensor, DHT11 sensor, RTC module, and SD card storage module.
Overall sensor test data collection was carried out at Marina Beach, Semarang, Central Java on Saturday, September 25 2021 in the morning. From the sensor test as a whole, the data is obtained as follows:

Table-9 Overall sensor test results data

Time	V Wind	Tem pera ture (°C)	Pressure (mbar)	Humidity
10:18:51	3.96	31,27	1011.61	62.00%
10:18:54	5.09	31,29	1011.71	62.00%
10:18:56	5.09	31,26	1011.72	62.00%
10:18:58	5.09	31,23	1011,62	62.00%
10:19:00	4.52	31,21	1011.65	62.00%
10:19:02	3.96	31,19	1011.73	62.00%
10:19:04	4.52	31.15	1011,62	62.00%
10:19:06	4.52	31,14	1011.53	62.00%
10:19:09	3.96	31,12	1011.59	63.00%
10:19:11	4.52	31,13	1011.53	63.00%
10:19:13	4.52	31.09	1011.65	63.00%
10:19:15	5.09	31.05	1011.65	63.00%
10:19:17	4.52	31.03	1011.66	63.00%
10:19:19	3.39	30.99	1011.63	63.00%
10:19:21	3.96	30.99	1011.64	64.00%
10:19:24	4.52	30.97	1011.55	64.00%
10:19:26	4.52	30.99	1011.58	64.00%
10:19:28	3.39	30.97	1011.56	64.00%
10:19:30	3.96	30.96	1011.64	64.00%
10:19:32	3.96	30.99	1011.67	64.00%
Speed Average Wind				4.35m/s

From Table 9 the overall sensor testing can run as expected by the author in this Final Project research, all sensors run well

3.5.2 Storage System Testing

The data logger storage system in this study uses an SD card module as the main component of data recording. To anticipate data loss, the authors use alternative storage namely using the data streamer available in Microsoft Excel software.

The data from the data logger test results for the wind speed parameter which is stored using the SD card module is shown in Figure 12, and for the storage system using the Microsoft Excel data streamer is shown in Figure 13.

Figure-13 The storage system uses an SD card module

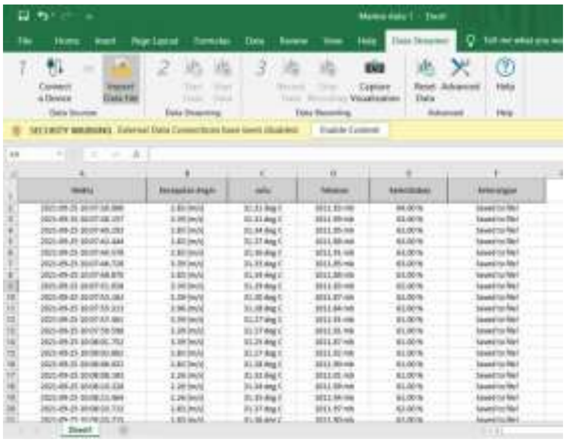

Figure-13 Storage system using *data streamer*Excel

4. Conclusion

Based on the test results on all sensors used in the study, it shows that all sensors work well to be used as wind speed parameter data loggers. The wind speed sensor using a slit type anemometer sensor has been successfully realized and produces a comparative value between the wind speed read by the sensor and a standard anemometer measuring instrument that does not have a large enough difference.

Air temperature sensor using the BMP180 sensor module has worked well, comparison between the temperature value read by the sensor and a standard thermometer measuring device does not have a large enough difference.
The results of testing the air pressure sensor are inversely proportional to the ambient temperature, that is, when the ambient temperature is low, the resulting air pressure is high and when the temperature in an environment is high, the resulting air pressure is low.
The output value of air humidity is inversely proportional to the ambient temperature, when the ambient temperature is high, the air humidity in that place decreases, and vice versa.
Testing of the system as a whole was successfully realized, the wind speed parameters influenced each other. Rising and falling air temperature and humidity cause variations in air pressure, high air pressure meets low air pressure causing variations in wind.

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