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Design of Air Pressure and Height Measuring Equipment based on Arduino Nano Using BME280 Sensor

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Abstract

This research has succeeded in designing air pressure and altitude measuring instruments based on Arduino nano using a BME280 sensor. The design of this tool uses the BME280 sensor as an input for the parameter values of air pressure and altitude. The measurement results are displayed on the organic light emitting diode (OLED), which has been processed by the Arduino Nano. Sending measurement results uses the HC-05 module. Calibrate air pressure parameters at the Center for Meteorology, Climatology and Geophysics Region III Denpasar uses the Vaisala PTB 330 digital barometer in the media pressure chamber while calibrating the altitude parameter using Google Earth for reference. The results of the calibration of the two parameters indicate that the design of the measuring instrument has a good level of accuracy, for air pressure of 99.99% and altitude of 99.98%. In addition, the test of the suitability of the OLED output data and the application shows that the data communication has been successful and is in accordance with the match level of 100%.

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1 Introduction

Air pressure is one of the weather parameters. The air pressure parameter is related to altitude. The higher the altitude, the lower the air pressure (Fernandez & Tirtayasa, 2017). One of the weather parameter information systems that have long been developed by several developed countries is the Automatic Weather Station (AWS). This system, besides being relatively expensive, is also difficult to apply. In Indonesia the AWS system is only used by certain agencies, especially government agencies, so we need a simple system that is cheaper and easier to apply, but has good accuracy to determine the parameters of air pressure and altitude of a place (Hanifan, 2019). Weather parameter information can be accessed easily through websites such as Weather Underground, World Weather Information Service, and Accuweather to Weather Forecast from the Meteorology, Climatology, and Geophysics Agency (BMKG). This information service is information on weather parameters globally, nationally or in a wide area. Along with technological developments in the fields of electronics and telecommunications, the measurement of air pressure and altitude parameters can be carried out independently and within local area coverage (Saptadi & Kiswanto, 2020).

One of the technologies for measuring air pressure and altitude parameters is the BME280 sensor. The BME280 sensor has been used in the research conducted by Utama et al. This study was conducted to compare the level of accuracy of the BME280 sensor with DHT sensors with a reference to the hygrometer measuring instrument. In measuring the error rate of each sensor, it shows that the DHT11 sensor has an average error rate of 38.84%, the DHT22 sensor is 8.96%, and the BME280 sensor is 3.78%. This shows that the BME280 sensor has the highest level of accuracy compared to the other three sensors (Utama et al., 2019). Research on measuring air pressure and altitude parameters using the BME280 sensor has been carried out by Saptadi & Kiswanto (2020). The data of these parameters is compared with the data on The Weather Channel website. From the data processing of sixty data, the average margin of error for air pressure is 0.2%, and altitude is 3.86%. based on Arduino Nano using the BME280 sensor. This tool uses the BME280 sensor as input for air pressure and altitude parameters. Arduino Nano is a microcontroller for processing input. HC-05 module as data sender via Bluetooth network (Sadewo et al., 2017; Putra et al., 2019; Putra, 2020; Eritt et al., 2010).

2 Materials and Methods

The schematic of the Arduino Nano-based air pressure and altitude measuring device using the BME280 sensor can be seen in Figure 1. In the design of this tool, the Arduino Nano microcontroller is used as the center for processing input and output of sensor reading data. For input data from the BME280 sensor module, while the output of this tool there are two systems, namely OLED display media and applications on Android smartphones. HC-05 module as data sender via Bluetooth connection.

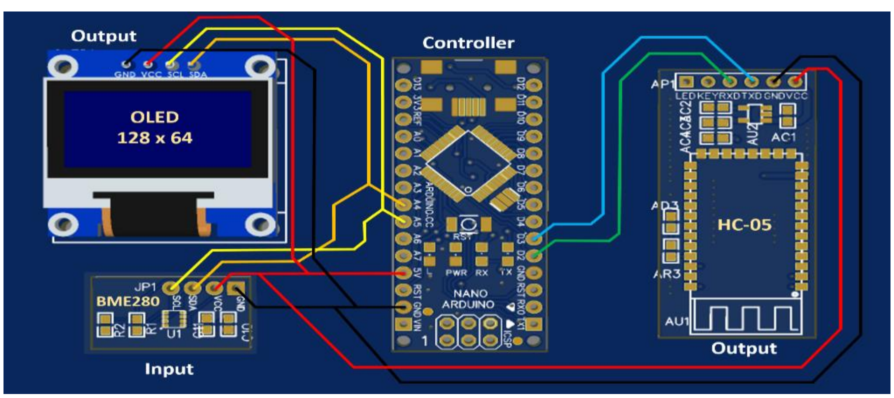

Figure 1. Schematic design of air pressure and altitude measuring instruments

The BME280 sensor will read and forward the digital data signal. The data will be processed by the Arduino Nano microcontroller and obtained data in the form of air pressure and altitude displayed on a 128 x 64 pixel OLED and sent to the Android smartphone application via a Bluetooth connection. Sending data via Bluetooth using the HC-05 module (Chanchangi et al., 2021; Yang et al., 2019; Kalia & Ansari, 2020; Archana et al., 2016).

3 Results and Discussions

The results of the design of the air pressure and altitude measuring instrument can be seen in Figure 2. The main part of the hardware of this tool is the Arduino Nano microcontroller. The microcontroller is the center for processing input data from the BME280 sensor (Astawan et al., 2019; Widiana et al., 2019; Safitri et al., 2019). The processed data will be displayed on the OLED OLED. Before the design tool is implemented, the first step that must be done in a tool design is to calibrate it

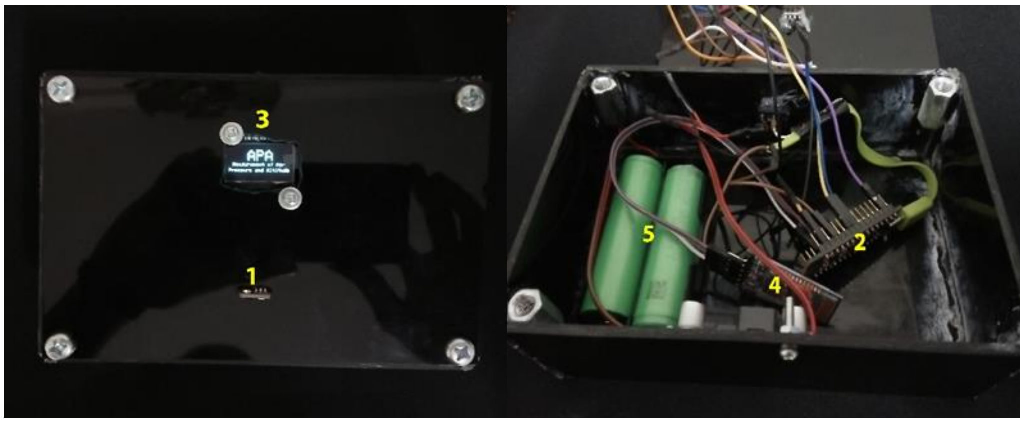

Figure 2. The results of the design of the Arduino Nano-based air pressure and altitude measuring instrument

Air pressure calibration aims to test the design of measuring instruments with a standard digital barometer. The calibration of the air pressure parameters was carried out by comparing the design of the measuring instrument with the Vaisala PTB 330 in the media pressure chamber. Calibration data is shown in Table 1

Table 1
Air pressure parameter calibration data

Measurement to-	Reference Tool Air Pressure (hPa)	Tool Design Air Pressure (hPa)
1	800,30	800,85
2	800,30	800,82
3	800,30	800,81
4	800,30	800,83
5	800,30	800,76
6	800,29	800,78
7	800,29	800,82
8	800,29	800,77
9	800,29	800,82
10	800,29	800,78

Based on the calibration data of the air pressure parameters in Table 1, the average correction between the standard tool and the tool design is 0.50. From the calibration data, a linear regression graph is made which aims to determine the level of suitability of the designed tool with the reference tool as shown in Figure 3.

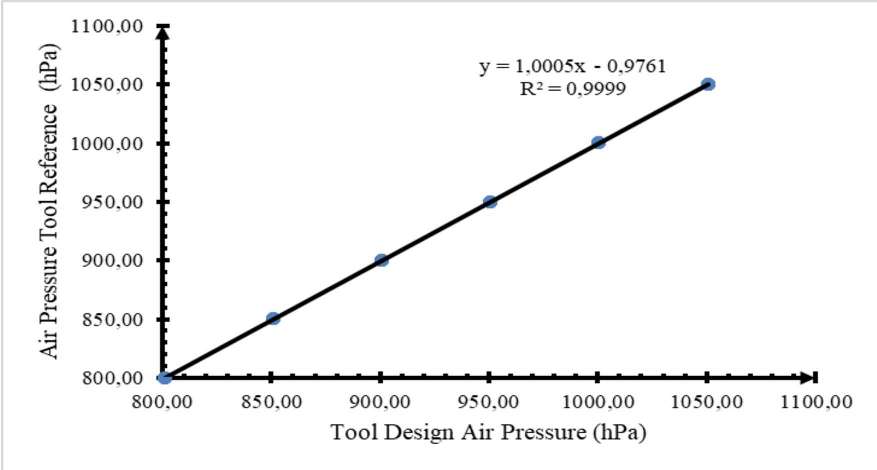

Figure 3. Graph of calibration of air pressure parameters

Calculation of the coefficient of determination (R2) in Figure 3, obtained by 0.9999, this value can be interpreted that the level of accuracy of tool design with standard tools is 99.99%. Altitude calibration aims to test the design of measuring instruments with altitude reference data on Google Earth. This calibration was carried out in the South Kuta area. The range of altitude values used in the calibration process is between 0.10-120 masl. Calibration data for 0.10 masl is shown in Table 2

Table 2
Altitude parameter calibration data

Coordinate (°) / Location	Measurement To -	Reference Tool Height (mdpl)	Reference Tool Height (mdpl)
-8.752138, 115.162971 / Hidden Beach, Kelan	1	0,10	0,31
	2	0,10	0,14
	3	0,10	0,34
	4	0,10	0,15
	5	0,10	0,52
	6	0,10	0,33
	7	0,10	0,21
	8	0,10	0,10
	9	0,10	0,22
	10	0,10	0,00

Based on the calibration data of the entire height parameter, the average correction between the reference data and the design of the tool is 0.48. This value is used as the reference standard. From the calibration data, it is plotted in the graph in Figure 4. The calculation of the coefficient of determination (R2) is 0.9998, this value can be interpreted that the level of accuracy of the tool design with reference is 99.98%.

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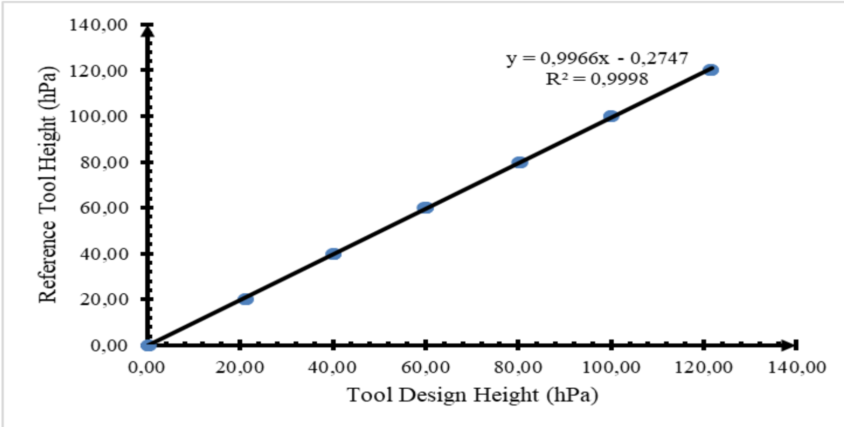

Figure 4. Graph of altitude parameter calibration

After the calibration process, the application of the design of the Android smartphone-based air pressure and altitude measuring instrument was carried out in two places, namely Jimbaran Beach and Jl. Raya Uluwatu Pecatu. Measurements of air pressure and altitude of each place are carried out at three coordinate points. At each coordinate point, ten data were collected. The application data are shown in Tables 3 and 4

Table 3
Data on the application of measuring instrument designs on Jimbaran Beach

Coordinate (°)	Measurement To -	Air pressure (hPa)	Height (mdpl)
-8.781541, 115.163412	1	1011,54	2,83
	2	1011,51	3,05
	3	1011,52	3,04
	4	1011,52	2,98
	5	1011,54	2,84
	6	1011,53	2,95
	7	1011,57	2,58
	8	1011,54	2,82
	9	1011,53	2,94
	10	1011,52	3,03

Table 4
Application data of measuring instrument design on Jl. Raya Uluwatu Pecatu

Coordinate (°)	Measurement To -	Air pressure (hPa)	Height (mdpl)
-8.828969, 115.137475	1	987,53	204,88
	2	987,60	204,25
	3	987,58	204,48
	4	987,57	204,43
	5	987,57	204,78
	6	987,57	204,53
	7	987,52	204,95
	8	987,53	204,89
	9	987,52	204,94
	10	987,53	204,84

The application of this tool design is carried out at six-coordinate points (Mulyanto et al., 2017; Arsyad et al., 2020; Singh et al., 2012; Bento, 2018). Where the three coordinate points are on Jimbaran Beach and the other three points are on Jl. Raya Uluwatu Pecatu. Based on the application data for measuring air pressure and altitude, the average air pressure on Jimbaran Beach is 1011.28 hPa with an average altitude of 5.03 masl. While on Jl. Raya Uluwatu Pecatu obtained an average air pressure of 987.33 hPa with an average altitude of 206.61 masl. This shows that the air pressure and altitude values between the two places are different (Chiang et al., 2009; Petković et al., 2015; Sakr et al., 2011; Maharjan et al., 2018).

4 Conclusion

Based on the results and discussion, the following conclusions are obtained:

1. The Arduino nano-based air pressure and altitude measuring instrument have been successfully designed using the BME280 sensor displayed on the OLED.
2. The workings of the air pressure and altitude measuring instrument in this study use the BME280 sensor as input data to be processed by the Arduino Nano. Sensor reading data will be displayed on OLED.
3. The results of air pressure calibration have an accuracy rate of 99.99%, while for altitude it has an accuracy rate of 99.98%.

Conflict of interest statement
The authors declared that they have no competing interests.

Statement of authorship
The authors have a responsibility for the conception and design of the study. The authors have approved the final article.

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