Original Research Article

Design and Manufacture of Rainfall Measuring Instrument Based on ATmega329P Microcontroler Using Hall Effect Sensor

ABSTRACT

Aims: To produce low-cost measuring instruments with high accuracy, which are expected to be used as a reference in developing rainfall observation instrumentsto reduce observation costs.
Study design: Design of Rainfall measuring instruments based on ATmega328P Microcontroller using hall effect sensor.
Place and Duration of Study: Departementof Physics, Udayana University, and Indonesian Agency of Meteorology, Climatology, and Geophysics (BMKG), Region-III Badung, from June 2022 toAugust 2022.
Methodology: Calibration is done by pouring the volume of water measured using a standard milliliter glass into the tipping bucket as a set point, then calculating the number of tippings based on the area of the funnel and the volume of water poured out. The difference in the number of tipping results of calibration of rainfall measuring instruments using hall effect sensors against reference devices is used for error calculations.
Result: Rainfall measuring instruments based on the ATmega328P microcontroller using hall effect sensors have been produced. Measurement accuracy was obtained 97.97% with uncertainty (U95) of 0.06 mm/min. The accuracy value indicates that the resulting tool has a good level of accuracy compared to standard tools.
Conclusion: has been designed and manufactured a low-cost rainfall measuring instrument with high accuracy and precision, which has been calibrated with BMKG standard tools.

Keywords: rainfall; ATmega328P;Hall Effect Sensor; telemetry.

1. INTRODUCTION

Rain is an important factor in all aspects of life, not necessarily the arrival of rain at this time is very influential on industrial activities, especially in the agricultural sector [1]. Technological developments demand that all aspects contribute to its use, except for the determination of rainfall [2]. The instrument for measuring rainfall that falls to the ground surface per unit area is called a rainfall gauge. Several types of rain measuring instruments that have been developed include weighing, capacitance, tipping bucket, optics, and others [3]. Rainfall intensity measuring devices have a very important role in monitoring the productivity of an area. Based on the description above, researchers are interested in conducting research to produce rainfall measuring instruments based on ATmega328P microcontrollers using low-cost hall effect sensors with high accuracy, which is expected to facilitate the measurement of rainfall intensity and can be used as a reference in developing rainfall observation instruments.

1.1 Arduino Uno R3 ATmega328P

Arduino is one of the microcontrollers that are widely used today because of the ease of use of Arduino and its program language compared to the minimum microcontroller system [4]. Arduino Uno is one version of the existing Arduino. The Arduino Uno is equipped with ATmega328P as a microcontroller, 14 digital pins and 6 analog input pins but the use of programming languages is still the same as other Arduino [5]

1.2 Hall Effect Sensor

Hall effect sensor is a device that can be activated by an external magnetic field. The input of this sensor is the magnetic density around the sensor, if the magnetic density exceeds a predetermined threshold, then the sensor will detect and produce output [6]. The basic principle of the hall effect sensor is to convert the current flowing through the conductor around the magnetic field into a voltage proportional to the amount of current passing through the conductor. If there is no magnetic field on the sensor, the distribution of current flowing on the sensor does not cause voltage [7].

2. METHODOLOGY

2.1Design of System

The design used is shown in Figure 1. This design uses a hall effect sensor as input. Microcontroller Arduino Uno R3 ATmega328P as the center of processing input and output sensor reading data. HC-05 module as a medium for transmitting data via Bluetooth connection. While the output in this design there are two, namely display media on OLED and applications on Android.

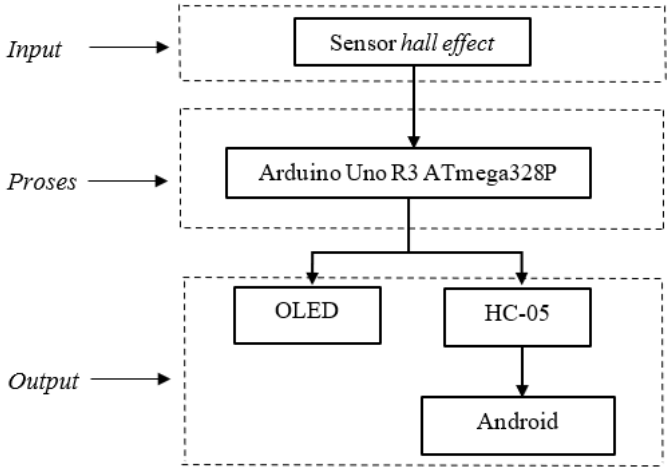

Figure1. Block diagram of design tool.

2.2 Calibration Methods

Calibration is the application of observation equipment by comparing the designation of the measuring instrument with known and traceable standard values [8]. Data collection for calibration is carried out by observing the output data of rainfall measuring instruments and BMKG standard tools. The calibrated parameter is the intensity of precipitation.

3. RESULT AND DISCUSSION

3.1 Result

Research on the design and manufacture of rainfall measuring instruments based on ATmega328P microcontroller using hall effect sensors, was carried out at the Electronics and Instrumentation Laboratory of the Physics Study Program, Udayana University and the Meteorology, Climatology and Geophysics Calibration Laboratory, Wilaya-III Badung, from June 2022 to August 2022. The design results of the rainfall measuring instrument based on ATMega328P microcontrollerusing a hall effect sensor are shown in Figure 2 and the schematic design is shown in Figure 3

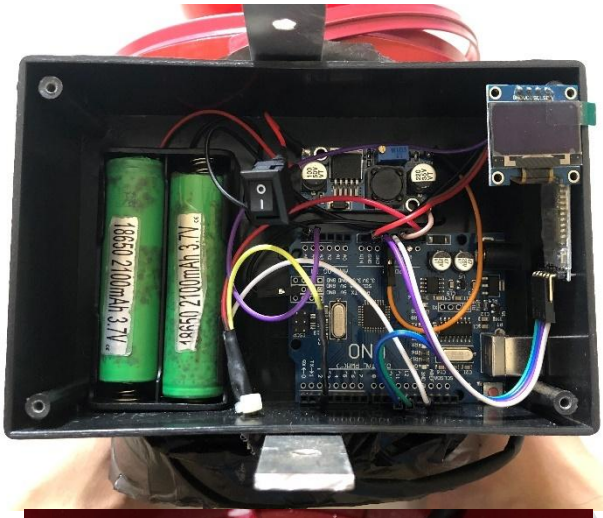

Figure2. Result of design tool.

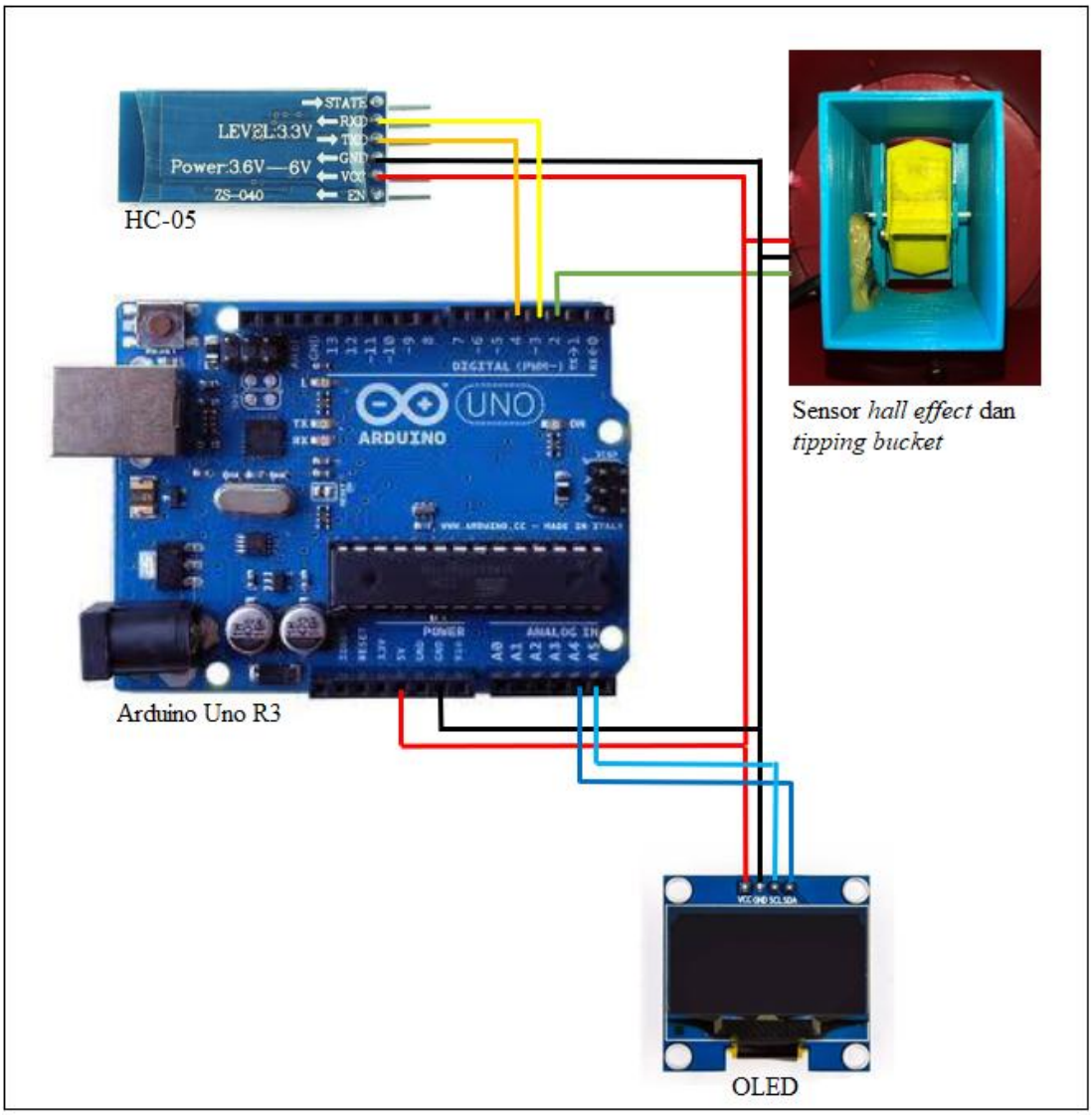

Figure3. Schematic design.

3.2 DISCUSSION

3.2.1 Calibration of Rainfall Parameters

Calibration of rainfall parameters is carried out to test the rainfall measurement value of the design tool with Tipping Bucker Rain Gauge Calibrator. The set point range used in the calibration process is between the nozzle rate 25-300mm/hour. The rainfall parameter calibration result data is shown in Table 1

Table1.Calibration Data of Rainfall Parameter

Set Poin (mm/hour)	Reference Tool (mm)	Design Tool(mm)	Correction (mm)	Error* (%)	Deviation Standard
25	21.67	21.93	0.27	1.23	0.23

50	21.47	21.67	0.20	0.93	0.20
100	21.27	21.20	-0.07	0.31	0.12
200	20.67	20.07	-0.60	2.90	0.35
300	19.87	19.00	-0.87	4.36	0.23

The data in Table 1 shows that the error value of the temperature measurement obtained is less than 5%. This value still meets the tolerance for the classification of rainfall measurement error values set by WMO, which is a maximum of 5% [11]. The standard deviation value obtained shows a small value, this shows that the design tool has a good level of precision for rainfall parameters. The calibration data in Table 1 are plotted into a linear test graph as shown in Figure 4.

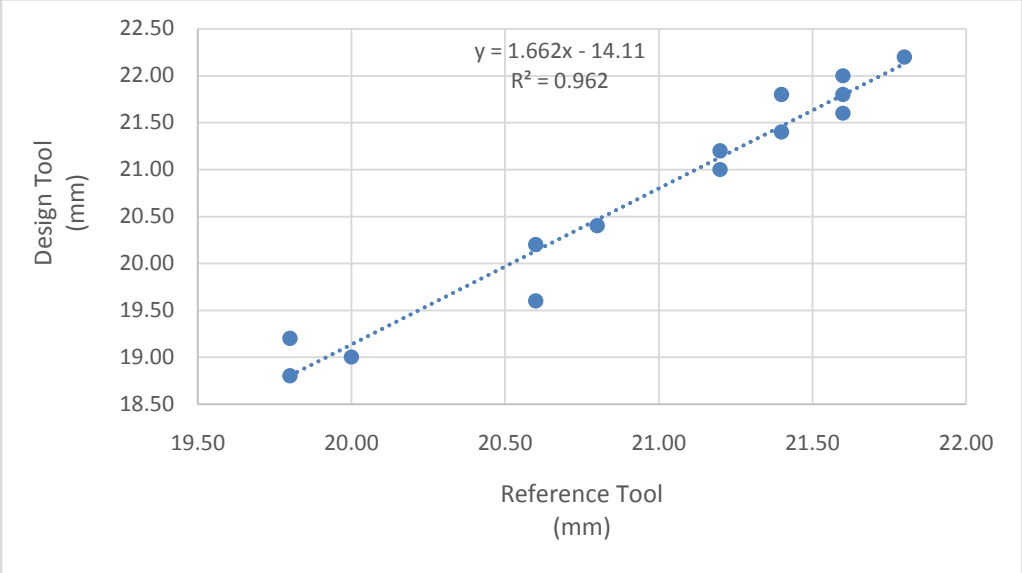

Figure4. Graph of rainfall parameter calibration.

Based on the plotted data, a linear equation was obtained with a regression coefficient (gradient) of 1.6624 and a regression constant of -14.116 so that an equation close to y = x could be obtained. This shows that the measurement results between design tools and standard tools are close to the same. In addition, the value of the coefficient of determination (R^2) of 0.9627 was obtained. This value can be interpreted as the accuracy of the measurement results of design tools against standard tools is 96.27%.

4. CONCLUSION

The conclusions obtained are:

1. The design of Rainfall measuring instrument based on the ATmega328P microcontroller using a hall effect sensor has been produced.
2. The resulting tool design has been calibrated with BMKG standard tools. Calibration is carried out by comparing the measurement results of the design tool with the BMKG tool so that the accuracy of the tool is obtained through the calculation of the coefficient of determination. The resulting tool has a good level of accuracy and precision for the measurement of rainfall parameters.

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