International Journal of Multidisciplinary Research and Development
www.allsubjectjournal.com
ISSN Online: 2349-4182 ISSN Print: 2349-5979
Received: 18-02-2023, Accepted: 07-03-2023, Published: 22-03-2023
Volume 10, Issue 3, 2023, Page No. 41-43

The real-time measurement equipment for rainfall based on water discharge using a flow meter sensor

Jatmiko Endro Suseno*, Siti Masyitoh, Agus Setyawan
Department of Physics, Faculty of Science dan Mathematics, Universitas Diponegoro, Semarang, Indonesia

Abstract
This rainfall monitoring system uses a rainfall sensor made from flow meter YF-S201, using microcontroller Wemos D1 which is based on ESP8266. The purpose of this study of the rainfall measurement system is to create a real-time rainfall information system that can be used locally in the wanted area, and by using the Internet of Things (IoT) so that it can monitor the weather from a distance and real-time by displaying rainfall data through Blynk application on the smartphone. This study began with designing, manufacturing, and programming system. Then testing rainfall sensor. The results of the test are the relative error value of the rainfall sensor is 0.31 mm to 20.16 mm and the RMSE value is 0.59.

Keywords: water discharge, flow meter YF-S201, rainfall, internet of things (IoT), Blynk

Introduction
In this digital era, it is common to monitor the weather, which has close links with agriculture, aviation, shipping, and natural disasters. Many physical parameters can affect weather such as temperature, humidity, air pressure, wind speed, and precipitation. Several studies on rainfall measuring systems have been carried out. Research conducted by Simanjuntak in 2019, used the MD-0127 rain sensor. On the MD-0127 rain sensor, rainwater will experience electrolysis when it rains and falls on the sensor panel. However, this sensor can only detect rain or not, and cannot determine the amount or amount of rain that falls [1]. Another study by Hanan *et al* in 2019, namely monitoring rainfall using HC-SR04. In this study, the measurement of rainfall was carried out by pouring water into a measuring cylinder. When there is no water in the tube the precipitation is 0 mm. When the tube is filled with water as high as 1 cm the detected rainfall is 0.43 mm. After measuring the data, the servo will spill water in the tube. The weakness of this study is that when the water in the tube is full, the servo will spill water in the tube and the calculation starts from the beginning, so the measurement of rainfall values is limited [2].

In this research, a rainfall sensor monitoring system was created from the YF-S201 water flow meter using Internet of Things (IoT) technology. By using the Blynk application, you will get a personal weather monitoring system that is easy to make and can be used in the desired area, can provide rainfall data information, and can be accessed from anywhere and at any time.

Rainfall
Rainfall is a determinant of the amount or amount of rainwater that falls on an area. The definition of 1 millimeter (mm) rainfall is the amount of rainfall that falls on a surface with an area of 1 m^2 in an area assuming that nothing absorbs or evaporates [3]. According to the Meteorology, Climatolo, gy and Geophysics Agency, there are 5 categories of rain intensity based on the amount of rainfall that falls every 1 hour shown in Table 1.

Table 1: Rainfall category [3]

Rainfall category	Rainfall (mm/h)
Very light	0.1-1.0
Light	1.1-5.0
Medium	5.1-10.0
Heavy	10.1-20.0
Very heavy	>20.0

Water flow meter YF-S201
The water flow meter YF-S201 is made up of a plastic valve, a waterwheel, and a hall-effect sensor. This flow meter has good accuracy because the hall-effect sensor pulse frequency is directly proportional to the volume or amount of water that passes through the sensor's surface so that the flow meter can be used for measurements that require great accuracy and precision [4].
The working principle of the YF-S201 water flow meter is that when water flows through the water wheel, the wheel will rotate according to the speed of the water flowing through the wheel. This continuous rotational movement creates a magnetic field effect which will be detected by the hall-effect sensor and read by the microcontroller [5].

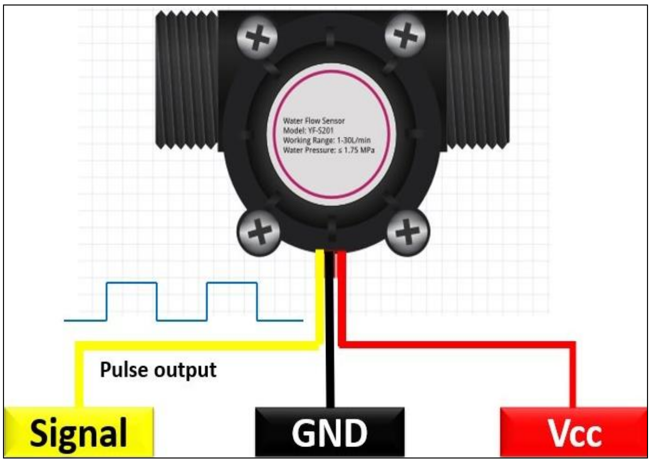

Fig 1: Flow Meter sensor [6]

Rainfall conversion calculation

The amount of rainfall is obtained from the discharge of rainwater that falls on an area per unit of time which is formulated in the dynamic's fluid theory [7] about water discharge as shown in Eq. 1.

$$Q=\Delta V/\Delta t = \Delta (A.\ h)/ \Delta t \quad (1)$$

Where
Q: water discharge (m^3/s)
A: funnel area (m^2)
V: water Volume (m^3)
h: water height (m)
t: time (s)

The final conversion can be done by comparing rainwater discharge and experimental equipment which is solved using Bernouly's fluid continuity formula [7] as shown in Eq 2.

$$Q_1 = Q_2$$
$$\Delta(A_1.h_1)/ \Delta t_1=\Delta(A_2.h_2)/\Delta t_2$$
$$A_1\Delta h_1/\Delta t_1= A_2\,\Delta h_2/\Delta t_2 \quad (2)$$

Where
Q_1: rain discharge
A_1: rain funnel area (m^2)
h_1: rainwater height (mm)
t_1: rain experiment time (s)
Q_2: equipment discharge
A_2: equipment glass funnel area (m^2)
h_2: equipment glass height (mm)
t_1: equipment experiment time (s)

The conversion from rainwater discharge to rainfall refers to the definition of rainfall value, namely, rainfall is the height of the tube with a funnel area of $1m^2$. Therefore, if funnel area (A_1) is $1m^2$ and $\Delta t_1=\Delta t_2$ then rainfall height (Δh_1) can be calculated using eq. (3).

$$\Delta h_1 = A_2\,\Delta h_2 \quad (3)$$

Methods

Rainfall measurement tool based on flow rate uses a flow meter sensor, which works in a simple, practical, accurate and efficient manner. The workings of the rainfall measurement tool are by calculating the discharge of rainwater that enters the gauge using a flow meter sensor. The flow meter output is in the form of a count voltage per unit time whose value is proportional to the water discharge. By using the conversion formula, it can convert the rainwater flow rate into a rainfall value. The working step of the tool, namely the measuring funnel facing upward is connected to the hose through the flow meter sensor, the discharge value is obtained, namely the count per unit time, then the sensor output will be read and processed by a digital electronic circuit to become a rainfall value, which will then display the rainfall value to the LCD viewer. and Wi-Fi networks.

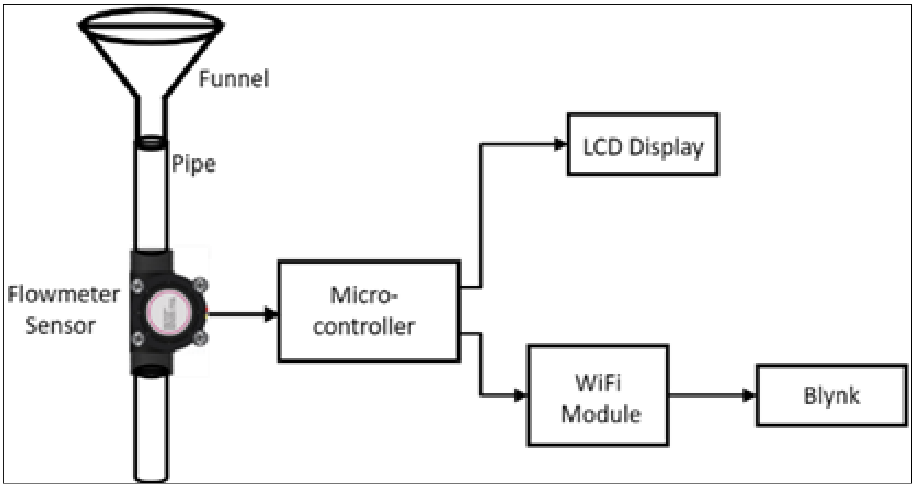

Fig 2: System block diagram

The way this tool works is that when the sensor receives water flow from rainfall, the flow meter YF-S201 output in the form of water flow velocity in units of milliliters/second will be converted to rainfall units, namely millimeters (mm).

Result and discussion

Measuring the water level in the equipment glass

Measurement of the height of the water in the measuring cup is done by measuring the volume of water in the measuring cup with a diameter of 20 cm which is flowed with water with a discharge of 10.56 cm^3/s, 21.12 cm^3/s, 31.68 cm^3/s, 42.24 cm^3 /s, 52.80 cm^3/s for 30 seconds with 3 repetitions for each discharge value. The following results of measuring the water level in the measuring cup are shown in Table 2.

Table 2: Results of measuring the water level (in mm) in an equipment glass

Rainwater discharge (cm^3/s)	Water Volume (cm^3)	Water height (mm)
10,56	308,33	9,81
21,12	668,33	21,26
31,68	855	27,20
42,24	1241,67	39,51
52,80	1388,33	44,17

Table 2 shows the water level in the equipment glass at each discharge value, respectively 9.81 mm, 21.26 mm, 27.20 mm, 39.51 mm and 44.17 mm.

Determination of rainfall value

Based on Table 2, the average water level (mm) in the measuring cup is obtained at each discharge value. Then the water level is converted to a rainfall value according to Eq. 3, so the rainfall value is shown in Table 3.

Table 3: Rainfall conversion value

Rainwater discharge (cm^3/s)	Water height (mm)	Rainfall (mm)
10,56	9,81	0,31
21,12	21,26	0,67
31,68	27,20	0,86
42,24	39,51	1,24
52,80	44,17	1,39

Testing of the rainfall sensor against the reference rainfall is carried out so that the error rate of the rainfall sensor can be determined. In this test, water discharge is used according to the value of rain intensity in various categories of rain intensity.

Following are the results of a comparison of the RMSE error rate of the rainfall sensor in each category of rain intensity shown in Figure 3.

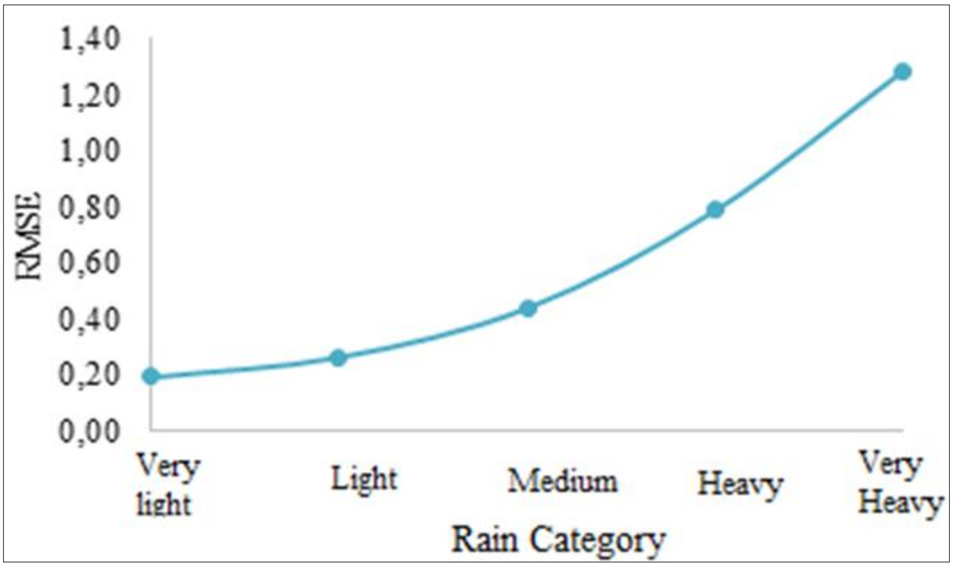

Fig 3: The RMSE value of the rainfall sensor in each rain category

In Figure 3, it is found that the RMSE error rate for measuring the rainfall sensor in each category of rain intensity increases, namely in the very light intensity category rainfall of 0.19, in the light rain category rainfall of 0.26, in the moderate category rainfall of 0.44, in the category of heavy rain intensity of 0.79, and in the category of very heavy rain intensity of 1.28, This is due to a mechanical error from the sensor which is not precise in taking measurements in the high rain intensity category.

Conclusion

Based on the research that has been done, it can be concluded that the test on rainfall sensor with a range of rainfall can be calculated, namely 0.31 mm during very light rain to 20.16 mm during very heavy rain with an RMSE error rate of 0.59.

References

1. Yogesh S, Sreedhar TM, Bharathy GT. Rain Detection System Using Arduino and Rain Sensor, 2nd International Conference on Emerging Trends in Materials, Computing and Communication Technologies International Journal of Scientific Research inScience, Engineering and Technology,2021:9(8):64-68.
2. Hanan Gunawan AAN, Sumadiyasa M. Water Level Detection System Based on Ultrasonic Sensors HC-SR04 and ESP8266-12 Modules with Telegram and Buzzer Communication Media, 2021, 305-309.
3. Kurniawan A. Evaluation of Rainfall Measurements Between Surface Measurement Results (AWS, HELLMAN, OBS) and Estimation Results (Satellite Image=GSMaP) at the Mlati Climatology Station 2018, Jurnal Geografi, Edukasi, dan Lingkungan,2020:49(1):1-7. (Indonesian)
4. Lalnunthari J, dan Thanga H H. Dependence of Hall Effect Flow Sensor Frequency on The Attached Inlet And Outlet Pipe Size, IEEE International Conference on Consumer Electronics-Asia, 2017, 56-60.
5. Kumar M. Measuring water Flow Rate and Volume using Arduino and Flow Sensor, Circuit Digest, 2022, 17.
6. Water Flow Sensor YF-S201 Arduino Interface (theorycircuit.com)
7. Thorne KS, Blandford RD. Modern Classical Physics: Optics, Fluids, Plasmas, Elasticity, Relativity, and Statistical Physics, Princeton University Press, 2017.