Journal of Technomaterial Physics Vol. 4, No. 2, 2022 | 97-106

JoTP

Journal of Technomaterials Physics

IoT-Based Automatic Home Light Monitoring System Using Wemos D1 Mini

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Abstract. This research aims to design an IoT-based home light monitoring system using Wemos D1 Mini. This tool is designed to control the current and voltage contained in house lights automatically. The sensor used to measure the current in the house lights is the ACS712 sensor, and the sensor used to measure the voltage in the house lights is the ZMPT101B sensor. The simulation of the house lights on this tool uses three LED lights, where each lamp is located on the terrace of the house, living room, and kitchen with different light power variations. In addition, the Blynk application on smartphones can be used to turn lights off and on and monitor currents and voltages. The test results show that this tool can control three regulated room lights and monitor the current and voltage in the three lights online using the Blynk application.

Keywords: LED lights, Blynk, Wemos D1 Mini, ZMPT101B, ACS712

Received 7 January 2022 | Revised [15 August 2022] | Accepted [29 August 2022]

1 Introduction

The Internet of Things (IoT) was first introduced by Kevin Ashton in 1999. IoT is generally defined as connecting intelligent objects and enabling them to interact with other objects, environments, or other intelligent computing devices via the internet. IoT technology is connected to various data acquisition terminals via the internet and other communication networks [1]. Information about the property is obtained in real-time, converted into a data format suitable for transmission over the network, and sent to the data center [2]. The data is then processed by intelligent processors that use cloud computing and other intelligent computing technologies that can process large amounts of data to achieve IoT goals [3].

Along with the development of the times, Indonesian people began to switch to the use of LED lights [4] [5]. In this regard, technological developments provide convenience and security in everyday life, especially in the internet field [6]. Furthermore, technological developments in the internet make it easier for us to connect wirelessly [7]. This can be used, for example, in

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Journal Homepage: https://talenta.usu.ac.id/JoTP

monitoring current and voltage in household appliances, such as lamps in households. Furthermore, by utilizing the internet, we can communicate and share data [8].

One application that can utilize the Internet of Things for remote hardware control, sensor data display, data storage, visualization, and other operations is Blynk [9]. Blynk is an open-source application that can be downloaded on iOS or Android [10].

Based on this, this study aims to design a home light monitoring system (current and voltage) based on IoT by utilizing the Blynk application. The controller used is Wemos D1 Mini, while the sensors used are the ACS712 current sensor and ZMPT101B voltage sensor.

2 Research Methodology

The home light monitoring system in this study uses three LED lights to simulate household lights, where each lamp is located on the house's terrace, living room, and kitchen with different lighting power. The controller used is Wemos D1 Mini, while the sensors used are the ACS712 current sensor and ZMPT101B voltage sensor. Figure 1 shows a block diagram of the IoT-Based Automatic Home Light Monitoring Tool Using Wemos D1 Mini. Figure 2 shows the entire set of the home light monitoring system. Figure 3 shows a flowchart of it.

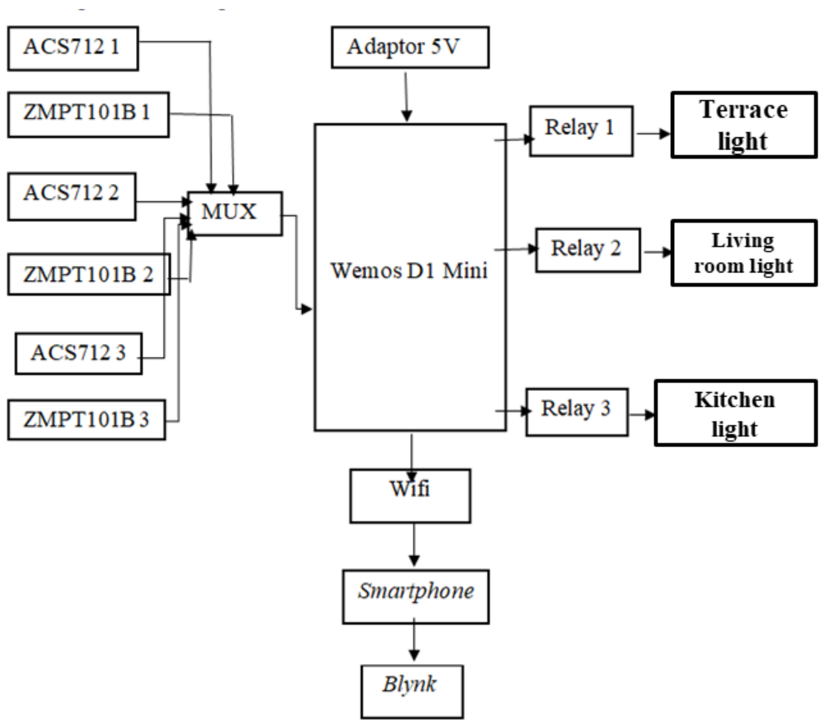

Figure 1. Block diagram of the home light monitoring system

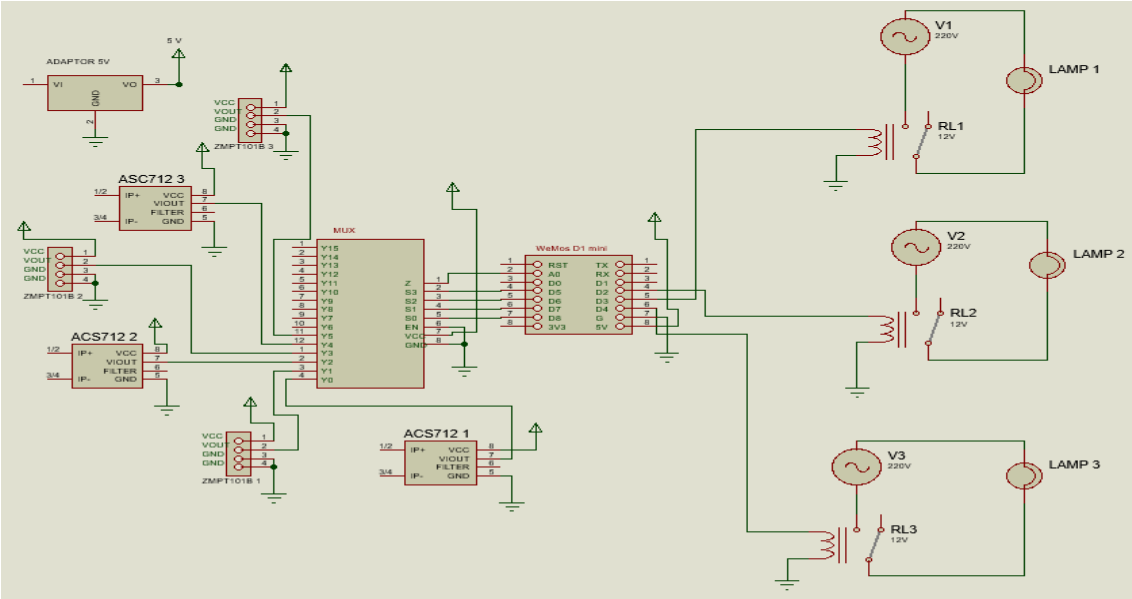

Figure 2. The overall circuit of the home light monitoring system

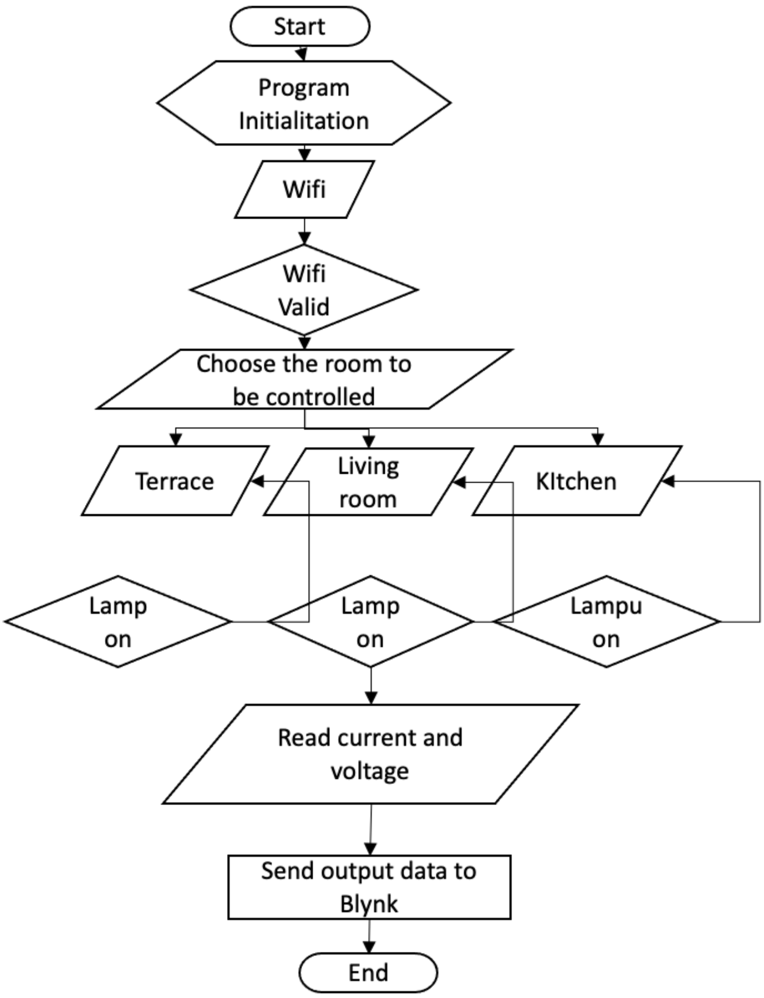

Figure 3. Flowchart of the home light monitoring system

The application testing *Blynk* was done to control the lights, in this case, the terrace lights, living room, and kitchen.

Figure 4. Display of the home light monitoring system on Blynk

Calibration is done to determine the value of uncertainty. The first step is to find the standard deviation value by using equation 1

$$\%D = \sqrt{\frac{\sum(x-\overline{x})^2}{n-1}} \quad (1)$$

The second step is to use equation 2 to calculate the uncertainty value of the measurement results (UA1).

$$\text{UA 1} = \frac{\delta}{\sqrt{x}} \quad (2)$$

In the third step, the uncertainty value of the regression approach (UA2) is calculated. The procedure for finding the uncertainty value of the regression approach (UA2) first uses the regression equation (Y_{reg}), as in equation 3.

$$Y_{reg} = +bx \quad (3)$$

$$b = \frac{n\sum xy - \sum x \sum y}{n\sum x^2 - (\sum x)^2} \quad (4)$$

$$a = \bar{y} - b\bar{x} \quad (5)$$

After calculating the value of the regression equation (Y_{reg}), calculate the squared value of the residual amount (SSR). The formula for calculating SSR is as in Equation 6.

$$SSR = \sum(\mathrm{R})^2 \quad (6)$$

After obtaining the value of the residual sum of squares (SSR), the uncertainty value of the regression approach (UA2) was calculated [11].

$$\text{UA}_2 = \sqrt{\frac{\text{SSR}}{\text{n}-2}} \quad (7)$$

3 Result and Discussion

3.1 ACS712 Sensor Testing

The ACS712 is a precision current sensor for measuring alternating current or direct current for current measurement in industrial, automotive, commercial, and communications systems. This sensor generates a magnetic field that flows through a copper wire containing a current reading, detected by the Hall effect IC, and converted into a proportional voltage. The current sensor used in this study is the ACS7125A sensor type with a sensitivity of 185 mV. First, the ACS712 sensor test is run to verify that the sensor is functioning properly. This test was conducted by collecting multiple data at 04.00 WIB and 16.00 WIB. The results obtained from the tests carried out are shown in Table 1.

Table 1. ACS712 Sensor Testing with Current Comparison in Theory

No	Lamp Power	Time	I_{Theory}	$I_{Practice}$ (X)	Difference (Y)	$(x-\overline{x})^2$
1	24 Watt	04.00 WIB	0.10	0.24	-0.14	0.02
		16.00 WIB	0.10	-0.18	0.28	0.06
2	18 Watt	04.00 WIB	0.08	0.13	-0.05	0.003
		16.00 WIB	0.08	0.16	-0.08	0.007
3	11 Watt	04.00 WIB	0.05	0.05	0	0.0004
		16.0 WIB	0.05	0.03	0.02	0.001
Average Value			0.07	0.07	0.005	0.01
			0.46	0.43	0.03	0.10

Table 2. Calculation of Standard Deviation Measurement of ACS712 Sensor

XY	X^2	Y_{reg}	R	R^2
-0.03	0.05	-0.08	-0.145	0.02
-0.05	0.03	0.29	0.027	0.07
-0.006	0.01	-0.05	-0.055	0.003
-0.01	0.02	-0.002	-0.085	0.007
0	0.002	0.10	-0.005	0.000002
0.0006	0.0009	0.10	0.015	0.0002
$\sum xy = -0{,}102$	$\sum X2 = 0{,}022$	$\sum Yreg = 0{,}37$	R = 0	R2 = $^{0.107}$

Based on Tables 1 and 2, the standard deviation value = $\sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$= $\sqrt{\frac{0,10}{5}}$= 0.02. The value of uncertainty UA_{1} = $\frac{\delta}{\sqrt{n}}$= $\frac{0,02}{\sqrt{6}}$= 0.008. Value of variable = b = $\frac{n\sum xy - \sum x\sum y}{n\sum x^2-(\sum x)^2}$= $\frac{-0,62}{0,63}$= -0.9 9 . Variable value = a = $\bar{y}$- b $\bar{x}$= 0.07 – (-0.99)(0, 07) = 0.07. So, the regression equation is Y_{reg} = + bx = -0.07 + -0.99 x. Number of residues to the power of two SSR = $\sum(R)^2$ = 0.107 UA_{2} = $\frac{SSR}{\sqrt{n-2}}$= $\sqrt{\frac{0,107}{4}}$ = 0.08. Figure 5 shows that the ACS712 sensor test graph is linear.

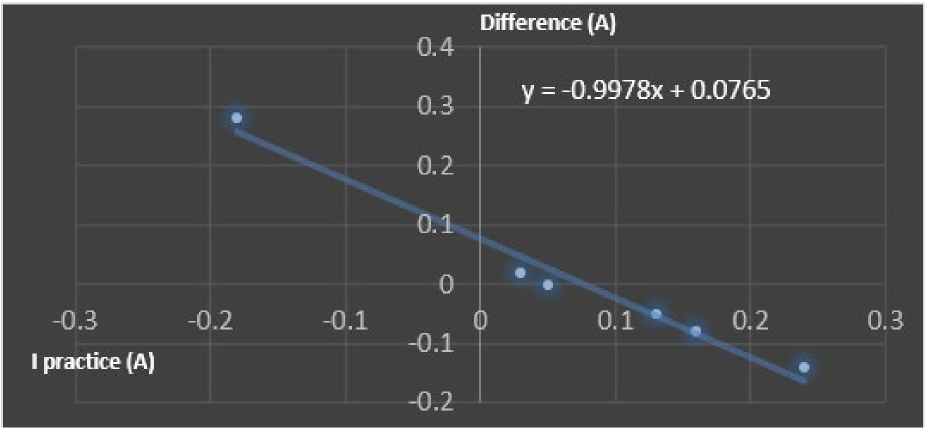

Figure 5. Graph of ACS712 Sensor Testing

3.2 ZMPT101B sensor test

The ZMPT101B voltage sensor is equipped with a booster amplifier to increase the negative voltage to be suitable for voltage measurement using a microcontroller. With its accurate signal function, the ZMPT101B voltage sensor is suitable for connecting with a microcontroller. The sensor can be used with an operating voltage of 250 VAC and outputs a suitable analog signal converted into a digital signal by the microcontroller. This sensor has four pins, including pins 1 and 2 for the main input and pins 3 and 4 for the output [12]. The ZMPT101B voltage sensor has 4000V voltage insulation and operates optimally at temperatures from 40°C to 70°C. The ZMPT10B sensor test is run to verify that the sensor is functioning properly [13]. Before testing the sensor, manual calibration using the tuning process must be carried out to create a suitable measurement curve. Testing the voltage sensor was carried out with two data acquisition times, namely at 04.00 WIT and 16.00 WIT. The test shows voltage data from each lamp is shown in Table 3.

Table 3. ZMPT101B Sensor Test Results with PLN Voltage Comparator using a Multimeter

No	Lamp Power	Time	PLN Voltage (V)	Lamp Voltage(V) (X)	Difference (Y)	$(x-\overline{x})^2$
1	24 Watt	04.00 WIB	214	211.75	2.25	7.29
		16.00 WIB	214	213.92	0.08	0.28
2	18 Watt	04.00 WIB	214	214.53	-0.53	0.006
		16.00 WIB	214	213.81	0.19	0.40
3	11 Watt	04.00 WIB	214	214.90	-0.9	0.20
		16.00 WIB	214	217.79	-3.79	11.15
Average Value			214	214.45	-0.45	19,345
			1284	1286.7	-2.7	3.2

Table 4. Calculation of the Standard Deviation of the ZMPT101B Sensor Measurement

XY	X^2	Y_{reg}	R	R^2
476	44838	2.5	2.7	7.29
17.11	45761	-8.003	0.53	0.28
-113	46023	-1.008	-0.08	0.006
40.62	45714	-20.32	0.64	0.40
-193	46182	-0.64	-0.45	0.20
-825	47432	-5.01	-3.34	11.15
$\sum xy$ =-7469	$\sum X^2 = 289824$	$\sum Yreg = -32{,}49$	$\sum R = 0$	$\sum R^2 = 19.3$

Based on Tables 3 and 4, the standard deviation value = $\sqrt{\frac{\sum(x-\overline{x})^2}{n-1}} = \sqrt{\frac{3{,}2}{5}} = 0.35$. The value of uncertainty $UA_1 = \frac{\delta}{\sqrt{n}} = \frac{0{,}35}{\sqrt{6}} = 0.87$. Value of variable = $b = \frac{n\sum xy - \sum x \sum y}{n\sum x^2 - (\sum x)^2} = \frac{-116}{116} = -1$. Variable value = $a = \bar{y} - b\,\bar{x} = -0.45 - (-1)(214.45) = 214$. So, the regression equation is $Y_{reg} = + bx = (214) + (-1)x$. Number of residuals to the square of $SSR = \sum(R)^2 = 19.3$ $UA_2 = \frac{SSR}{\sqrt{n-2}} = \sqrt{\frac{19{,}3}{4}} = 1.09$. Figure 6 shows a linear relationship between the ZMP101B sensor and Y reg.

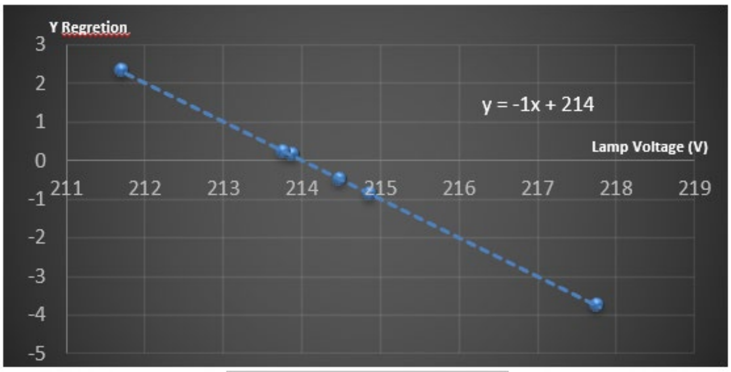

Figure 6. ZMP101B Test Graph

3.3 The Overall System Test

Furthermore, after testing the tools one by one, the entire program is put together so that all sensors can be seen whether they are working well. The test results show that the system can work by controlling three room lights, namely the living room terrace and kitchen, and monitoring the current and voltage emitted by each LED lamp. When the lights are off, this indicates that only the lights are connected to the PLN current. Then the voltage and current from the sensor can still read and display data. However, the data displayed in this case is the voltage and current data from PLN. When the lamp is turned on, the voltage and current sensor read the voltage and current from the lamp. The results of the system test are given in Table 5. The current "1" in Table 5 is meant to read 0.1 decimal places, while "0" is in the range of 0.03 - 0.09 decimal places.

Table 5. Test Results of Home Lighting Control and Monitoring System

No	Room	Lamp Condition	Voltage	Current	Information
1	Terrace	ON	213.09	1	The lamp is on, and the voltage and current for the lamp are read
		OFF	213.1	1	The lights are off, and the voltage and current for PLN are read
2	Living room	ON	208.51	0	The lamp is on, and the voltage and current for the lamp are read
		OFF	208.47	1	The lights are off, and the voltage and current for PLN are read
3	Kitchen	ON	201.69	0	The lamp is on, and the voltage and current for the lamp are read
		OFF	201.55	0	The lights are off, and the voltage and current for PLN are read

Wi-Fi or hotspot is the main thing in the system for controlling and monitoring the current and voltage of the lamp. In this case, the Wi-Fi used is the hotspot of the smartphone. Wi-Fi coverage testing was carried out two times, without barriers and using barriers. The barrier in question, in this case, is the wall. Because the range of smartphones is limited, the Wi-Fi range that can be detected by this tool can be seen in Table 6.

Table 6. Measurement Results of Wi-Fi or Hotspot Ranges

Distance (m)	WIFI Status	
	With Barrier	No Barriers
5	Connected	Connected
10	Connected	Connected
15	Connected	Connected
18	Not connected	Connected
20	Not connected	Not connected

4 Conclusion

This research has successfully designed an IoT-based automatic home light monitoring system by utilizing the Blynk application. This system can monitor the current and voltage usage of each lamp from three rooms simultaneously displayed in the Blynk application using the ACS712 and ZMPT101B sensors, where the Wemos D1 Mini controls the device. Comprehensive testing of the equipment designed in this study showed that the equipment could work smoothly.

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