International Journal of Research In Vocational Studies (IJRVOCAS)
VOL. 3, NO. 3, December 2023, PP. 32~40
Print ISSN 2777-0168| Online ISSN 2777-0141| DOI prefix: 10.53893
https://journal.gpp.or.id/index.php/ijrvocas/index

Monitoring Tool for Electricity Usage in Residential Homes Based on the Internet of Things (IoT) Using BLYNK Application

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To cite this article:

Nofiansah, Marniati, Y., Rumiasih, Yahya, S., Yani, H., & Bofynna, P. A. (2023). Monitoring Tool for Electricity Usage in Residential Homes Based on the Internet of Things (IoT) Using BLYNK Application. International Journal of Research in Vocational Studies (IJRVOCAS), 3(3), 32–40. https://doi.org/10.53893/ijrvocas.v3i3.226

Received: 11 16, 2023; **Accepted**: 12 19, 2023; **Published**: 12 23, 2023

Abstract: Electricity is a basic need of human beings. The consumption of electricity usage is getting bigger and bigger. Electricity usage is usually wasteful due to lack of public awareness and ineffective use of electricity. With this problem, the author aims to design loT-based electric power usage monitoring system in home electrical appliances. This tool is designed using sensors to detect the value of the voltage and current of the load attached to the electricity but still using the BLYNK application as a server and application to monitor the use of electric power through a smartphone application. The measurement results include the data of current, voltage, and electrical power used. This system can also remotely switch appliances ON/OFF. The test was conducted by comparing the results of the power value from the power meter with the power value in BLYNK application. After the test, the results of the comparison between the monitoring tool and the power meter measuring instrument obtained an average power error value of 0.5%. So that the accuracy value of the tool can also be 99.5%. With a large accuracy value, it means that the tool works well and can be used to monitor the use of electrical energy in households.

Keywords: *Internet of Things*, BLYNK, *Monitoring*.

1. Introduction

A monitoring system is defined as a cycle of activities that includes collecting, reviewing, reporting, and acting on information of a process being implemented (Mercy, 2005) [1]. Generally, monitoring systems are used in checking between performance and predetermined targets. The monitoring system can provide information on the continuity of the process to set the steps towards continuous improvement. A monitoring system can also be defined as a routine process of collecting data and measuring progress on programme objects, monitoring changes that focus on processes and outputs. In its implementation, monitoring is conducted while a process is ongoing.

Basically, monitoring systems have two basic related functions, which are compliance monitoring and performance monitoring (Mercy, 2005) [1]. Compliance monitoring functions to ensure the process is in accordance with expectations/plans. Meanwhile, performance monitoring functions to determine the progress of the organization in achieving the expected targets [2-4].

Generally, the monitoring output is a process progress report. The output is measured in descriptive and non-descriptive terms. Monitoring output aims to determine the suitability of the process has been running. Monitoring output is useful in improving the process/activity mechanism where monitoring is conducted.

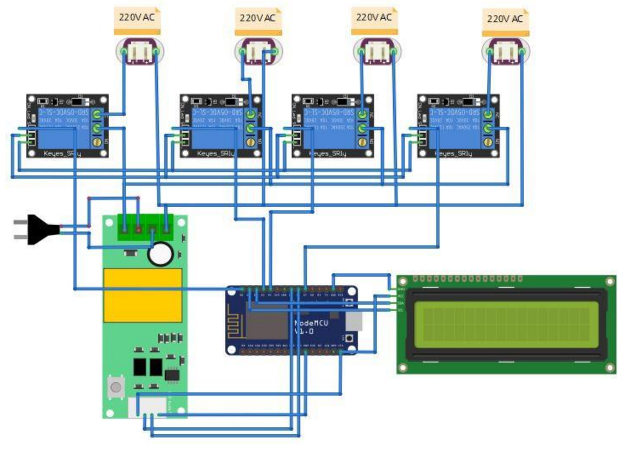
To do monitoring, an internet network is needed, which is now known as the Internet of Things (IoT). The Internet of Things (loT) system can increase efficiency, effectiveness, and connectivity in daily activities. Therefore, utilizing the internet with the Internet of Things that can monitor electricity usage is very important for now[5-8].

BLYNK application is an application designed for the Internet of Things. BLYNK is a platform for Mobile OS (iOS and Android) applications that can make it easier to control, send, and receive data from Internet of Things (IoT) devices through the internet network [9]. This application is able to control hardware from a distance. With BLYNK, you can easily control IoT devices such as sensors, relays, and so on through mobile applications that have been connected to the BLYNK server [10-15].

The design of this internet-based electric power monitoring tool is designed to get informations about the power used every day in real time that can be accessed from the internet network anytime and anywhere, so that it can make it easier for users to monitor electricity usage. Electric energy management can also be done by looking at the consumption of electrical energy in the application and then turning off electronic appliances that are not used so that the cost of using electrical energy does not increase. To test this tool, the author will compare the power displayed on the application with the power displayed on the kWh meter. The accuracy level of the monitored household electric power measurement shows above 90% with a percentage error of 2.96 - 7.28.

2. Research Method

The following is a schematic drawing of the tool designed as follows:



Picture 1. Tool Schematic

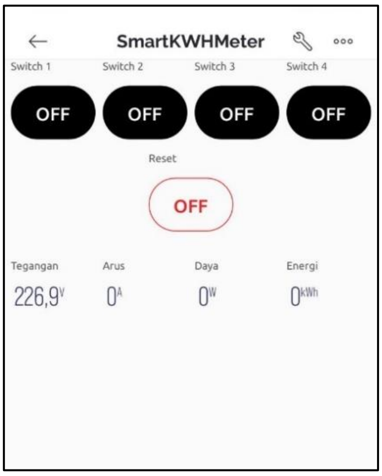
1. **PZEM-004T,** as hardware to measure the parameters of voltage, current, active power, and power consumption (wh). The wiring of this module has 2 parts, which are the wiring of the voltage and current input terminals, and the serial communication wiring.
2. **NodeMcu,** functions as the centre for processing data, which is an open source IoT platform and development kit that used Lua programming language, but can also use Arduino IDE for its programming.
3. **ESP8266,** is a wifi module that functions as an additional device for the microcontroller so that it can be connect between the microcontroller and the wifi network.
4. **I2C LCD,** functions for monitoring on the panel box which will display 32 characters, 16 characters on the top row and 16 characters on the bottom row.
5. **Relay module,** operates based on electromagnetic principles to move the contactor in order of moving the ON to OFF position or the reverse by utilizing electric power (as a switch). This closed and open contactor phenomenon occurs due to the magnetic induction effect that arises from the electric induction coil.
6. **Stop Contact,** is a component of electrical installation that has the function of distributing

electrical energy from the home installation to the load. The load is referred to as an electronic device that requires electricity to operate it.

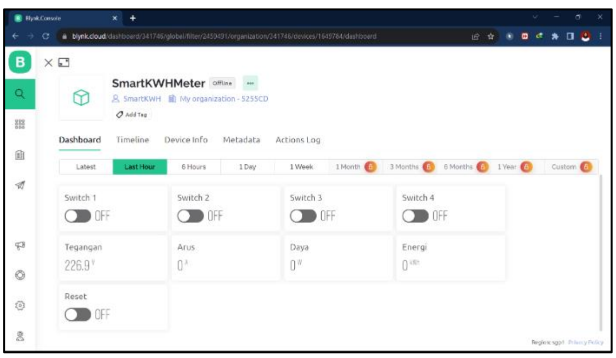
BLYNK Application

The following is how to create a BLYNK User:

1. Download the BLYNK Application.
2. Create an account by clicking Sign Up on the application.
3. After creating an account, enter the ID and password into the programme on the Arduino IDE.
4. After that, login to the BLYNK account that has been registered in the Arduino IDE programme.
5. Next, the application display can be designed by adding widgets as desired/needed.



Picture 2. BLYNK Application Display

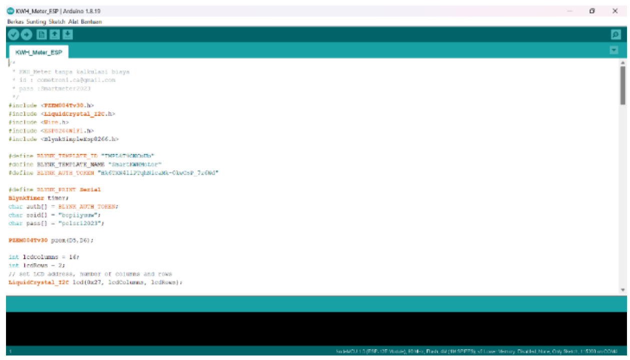


Picture 3. Dashboard Display on BLYNK Website

Before the device can be used, the device must be flashed first with a programme that has been made on the Arduino IDE (which has registered ID, password, and wifi to be used). If it has been flashed, then when the device is turned on, the device will automatically connect to the wifi that has been registered in the programme [17-19]. Next step, login to the BLYNK application using the registered account. Then, the device will automatically connect to the BLYNK application and can be directly accessed through the BLYNK application.

Arduino IDE Programme

The programming of the microcontroller using the C language. The programme is as follows:



Picture 4. Arduino IDE Display

```
/*
 * KWH_Meter without cost calculation
 * id : cometroni.ca@gmail.com
 * pass :Smartmeter2023
 */
#include <PZEM004Tv30.h>
#include <LiquidCrystal_I2C.h>
#include <Wire.h>
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

#define BLYNK_TEMPLATE_ID "TMPL6T9ONCuUb"
#define BLYNK_TEMPLATE_NAME "SmartKWHMeter"
#define BLYNK_AUTH_TOKEN
"Hk6TXN41iPTqhNicaMk-0kwCsP_7z6Wd"

#define BLYNK_PRINT Serial
BlynkTimer timer;
char auth[] = BLYNK_AUTH_TOKEN;
char ssid[] = "bopiiyuuw";
char pass[] = "polsri2023";

PZEM004Tv30 pzem(D5,D6);
```

```
int lcdColumns = 16;
int lcdRows = 2;
// set LCD address, number of columns and rows
LiquidCrystal_I2C lcd(0x27, lcdColumns, lcdRows);

float tegangan,energi,daya,arus;
int value1,value2,value3,value4,value9;

BLYNK_CONNECTED() {
  //get data stored in virtual pin V0 from server
  Blynk.syncVirtual(V1);Blynk.syncVirtual(V2);
  Blynk.syncVirtual(V3);Blynk.syncVirtual(V4);
  Blynk.syncVirtual(V5);Blynk.syncVirtual(V6);
}

void setup() {
  Serial.begin(9600);
  Blynk.begin(auth, ssid, pass, "blynk.cloud", 80);
  timer.setInterval(1000L, myTimer);
  pinMode(D3,OUTPUT); pinMode(D4,OUTPUT);
  pinMode(D7,OUTPUT); pinMode(D0,OUTPUT);

  // initialize LCD
  lcd.init();
  // turn on LCD backlight
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("Hello, World!");
  lcd.setCursor(0,1);
  lcd.print("==Pio Agma==");
  delay(1000);
  digitalWrite(D3,HIGH);digitalWrite(D4,HIGH);
  digitalWrite(D7,HIGH);digitalWrite(D0,HIGH);
  Blynk.virtualWrite(V1, value1);digitalWrite(D0,value1);
  Blynk.virtualWrite(V2, value2);digitalWrite(D3,value2);
  Blynk.virtualWrite(V3, value3);digitalWrite(D4,value3);
  Blynk.virtualWrite(V4, value4);digitalWrite(D7,value4);
}

void loop() {
  Blynk.run();

  float voltage = pzem.voltage();
  tegangan = pzem.voltage();
  if( !isnan(voltage) ){
    Serial.print("Voltage:      ");      Serial.print(voltage);
Serial.println("V");
  } else {
    Serial.println("Error reading voltage");
  }

  float current = pzem.current();
  arus = pzem.current();
  if( !isnan(current) ){
    Serial.print("Current:      ");      Serial.print(current);
Serial.println("A");
  } else {
    Serial.println("Error reading current");
  }

  float power = pzem.power();
  daya = pzem.power();
  if( !isnan(power) ){
    Serial.print("Power:        ");      Serial.print(power);
Serial.println("W");
  } else {
    Serial.println("Error reading power");
  }

  float energy = pzem.energy();
  energi = pzem.energy();
  if( !isnan(energy) ){
    Serial.print("Energy:      ");      Serial.print(energy,3);
Serial.println("kWh");
  } else {
    Serial.println("Error reading energy");
  }

  float frequency = pzem.frequency();
  if( !isnan(frequency) ){
    Serial.print("Frequency:  ");  Serial.print(frequency,   1);
Serial.println("Hz");
  } else {
    Serial.println("Error reading frequency");
  }

  float pf = pzem.pf();
```

```
  if( !isnan(pf) ){
    Serial.print("PF: "); Serial.println(pf);
  } else {
    Serial.println("Error reading power factor");
  }

  tampil();
  Serial.println();
  timer.run();
  delay(1000);
}

void tampil(){
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print(tegangan,0);lcd.print("V  ");
  lcd.print(arus,2);lcd.print("A  ");
  lcd.setCursor(0,1);
  lcd.print(daya,0);lcd.print("W  ");
  lcd.print(energi);lcd.print(" kWh");
}

void myTimer()
{
  // This function describes what will happen with each timer tick
  // e.g. writing sensor value to datastream V5
  Blynk.virtualWrite(V5, tegangan);
  Blynk.virtualWrite(V6, energi);
  Blynk.virtualWrite(V7, arus);
  Blynk.virtualWrite(V8, daya);
}

BLYNK_WRITE(V1)
{
  value1 = param.asInt(); digitalWrite(D0,value1);
}
BLYNK_WRITE(V2)
{
  value2 = param.asInt(); digitalWrite(D3,value2);
}
BLYNK_WRITE(V3)
{
  value3 = param.asInt(); digitalWrite(D4,value3);
}
BLYNK_WRITE(V4)
{
  value4 = param.asInt(); digitalWrite(D7,value4);
}
BLYNK_WRITE(V9)
{
  energi = 0;
  value9 = param.asInt();
  Serial.println(value9);
  pzem.resetEnergy();
}
```

3. Result and Analysis

Table 1. Testing the Tool Control System Under No Load

Relay	Experiment		
	1	2	3
Relay 1	√	√	√
Relay 2	√	√	√
Relay 3	√	√	√
Relay 4	√	√	√

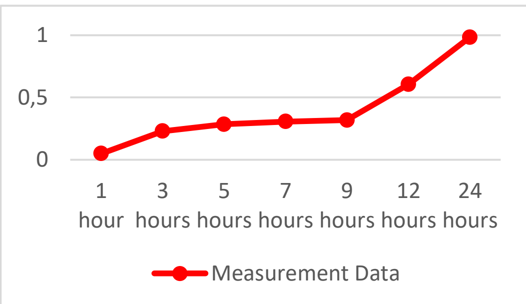
Table 2. Testing the Tool Control System When Using a Load

Relay	Experiment		
	1	2	3
Relay 1	√	√	√
Relay 2	√	√	√
Relay 3	√	√	√
Relay 4	√	√	√

Table 3. Measurement Results Using a Power Meter

Measurement Time	Power Usage (kWh)	Image Power Meter	Description
1 hour	0,05		1. Smartphone charger 2. Fan
3 hours	0,229		1. Fan 2. Rice cooker 3. Electric pot

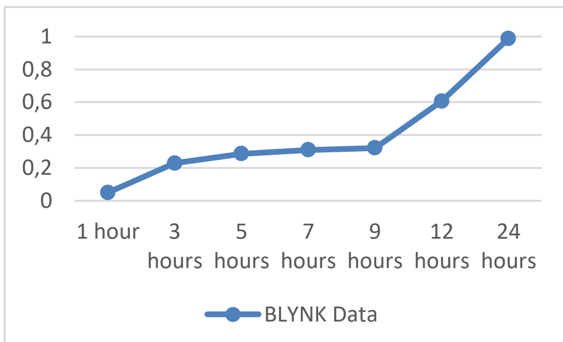
5 hours	0,285		1. Rice cooker 2.Smartphone charger
7 hours	0,307		1. Charger 2. Ringlight 2 pieces
9 hours	0,318		1. Ringlight 2 pieces
12 hours	0,604		1. Rice cooker 2. Electric pot 3. Fan 4. Laptop charger
24 hours	0,983		1. Fan 2. Smartphone charger



Picture 4. The chart of Power Measurement Results Using a Power Meter

Table 4. Power Monitoring Results Using BLYNK Application

Measurement Time	**Power Usage (kWh)**	**Display on BLYNK Application**	**Description**
1 hour	0,05		1. Smartphone charger 2. Fan
3 hours	0,229		1. Fan 2. Rice cooker 3. Electric pot
5 hours	0,287		1. Rice cooker 2. Smartphone charger
7 hours	0,31		1. Charger 2. Ringlight 2 pieces
9 hours	0,322		1. Ringlight 2 pieces
12 hours	0,606		1. Rice cooker 2. Electric pot 3. Fan 4. Laptop charger
24 hours	0,987		1. Fan 2. Smartphone charger

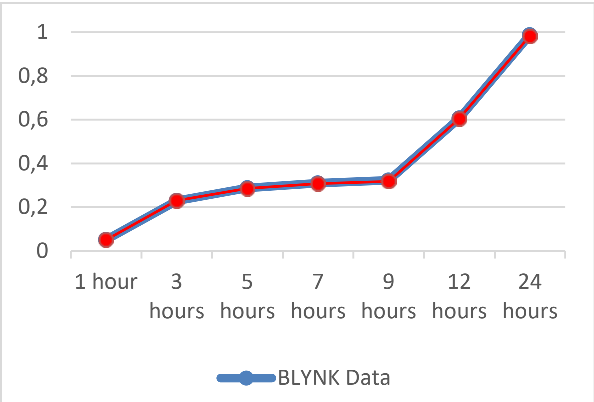


Gambar 5. The Chart of Power Monitoring Results Using BLYNK Application

Furthermore, the comparison of the measurement results using a power meter with the measurement results using the BLYNK application is conducted, which aims to calculate the %Error so that it can calculate and determine the %Level of accuracy [18-22]. The data can be compared as follows:

Table 5. Comparison of Measurement Result

Time	Power Usage (kWh)		Error (%)
	BLYNK Application Monitoring	Power Meter Measurement	
1 hour	0,05	0,05	0 %
3 hours	0,229	0,229	0 %
5 hours	0,287	0,285	0,7 %
7 hours	0,31	0,307	0,9 %
9 hours	0,322	0,318	1,2 %
12 hours	0,606	0,604	0,3 %
24 hours	0,987	0,983	0,4 %
Average Error (%)			**0,5 %**



Picture 6. Comparison Chart of Measurement Results

The %Error calculation of the tool that has been made is calculated using the formula:

$$\%\boldsymbol{Error} = \frac{\boldsymbol{Tool\ Result - Measurement\ Result}}{\boldsymbol{Measurement\ Result}}\ \boldsymbol{x\ 100\%},$$

Calculation :

1) 1 Hours

$$\%\text{Error} = \frac{0,05-0,05}{0,05}\ \text{x}\ 100\%$$

$$\%\text{Error} = \frac{0}{0}\ \text{x}\ 100\%$$

$$\%\text{Error} = 0\%$$

2) 3 Hours

$$\%\text{Error} = \frac{0,229-0,229}{0,229}\ \text{x}\ 100\%$$

$$\%\text{Error} = \frac{0}{0}\ \text{x}\ 100\%$$

$$\%\text{Error} = 0\%$$

3) 5 Hours

$$\%\text{Error} = \frac{0,287-0,285}{0,285}\ \text{x}\ 100\%$$

$$\%\text{Error} = \frac{0,002}{0,285}\ \text{x}\ 100\%$$

$$\%\text{Error} = 0,7\%$$

4) 7 Hours

$$\%\text{Error} = \frac{0,31-0,307}{0,307}\ \text{x}\ 100\%$$

$$\%\text{Error} = \frac{0,004}{0,307}\ \text{x}\ 100\%$$

$$\%\text{Error} = 0,9\%$$

5) 9 Hours

$$\%\text{Error} = \frac{0,322-0,318}{0,318}\ \text{x}\ 100\%$$

$$\%\text{Error} = \frac{0,004}{0,318}\ \text{x}\ 100\%$$

$$\%\text{Error} = 1,2\%$$

6) 12 Hours

$$\%\text{Error} = \frac{0,606-0,604}{0,604}\ \text{x}\ 100\%$$

$$\%\text{Error} = \frac{0,002}{0,604}\ \text{x}\ 100\%$$

$$\%\text{Error} = 0,3\%$$

7) 24 Hours

$$\%\text{Error} = \frac{0,987-0,983}{0,983}\ \text{x}\ 100\%$$

$$\%\text{Error} = \frac{0,004}{0,983}\ \text{x}\ 100\%$$

$$\%\text{Error} = 0,4\%$$

After calculating the %Error, the average %Error is then calculated using the formula :

$$\boldsymbol{Average}\ \%\boldsymbol{Error} = \frac{\boldsymbol{Total\ number\ of\ experiment\ percentages}}{\boldsymbol{Number\ of\ experiments}},$$

Calculation :

$$\text{Average}\ \%\text{Error} = \frac{0\%+0\%+0,7\%+0,9\%+1,2\%+0,3\%+0,4\%}{7}$$

$$\text{Average \%Error} = \frac{0{,}35\%}{7}$$

$$\textit{Average \%Error}$$

If the Average %Error value is known, then we can calculate the accuracy level of the monitoring tool using the formula:

%Rate of Accuracy = 100% - Average value %Error,

So,

%Rate of Accuracy = 100% - 0,5%

= ±99,5%

4. Conclusion

The results of testing and analysis can be concluded as follows:

1. Internet of Things (IoT) based electric power usage monitoring tools can monitor and control electrical appliances from a distance without any distance limitations. With the condition, the monitoring tool and the smartphone used to access BLYNK are connected to an internet connection.
2. The Internet Of Things (IoT) based electric power usage monitoring tool has a high accuracy rate of 99.5%, while the error value is very small at only 0.5%. Because the accuracy value is almost close to 100%, this indicates that the designed tool is good at monitoring and controlling electric power in residential homes.

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