Jurnal Mantik, 6 (4) (2023), ISSN 2685-4236 (Online)

Published by: Institute of Computer Science (IOCS)

Jurnal Mantik

Journal homepage: www.iocscience.org/ejournal/index.php/mantik

Internet of things to controlling building electrical equipment

Muhammad Adam[1], Roslina[2], Suprianto[3], Mardiana[4]

[1,3]Department of Electrical Engineering/Engineering/Electrical Engineering, Universitas Muhammadiyah Sumatera Utara, Indonesia.

[2]Department of Computers and Informatics/Informatics, Politeknik Negeri Medan, Indonesia.

[3,4]Department of Electrical Engineering/ Electrical, Politeknik Negeri Medan, Indonesia.

ARTICLE INFO

Article history:

Received Jan 08, 2023
Revised Feb 01, 2023
Accepted Feb 28, 2023

Keywords:

IoT
Nodemcu
Lamp
Control

ABSTRACT

The use of electrical energy that is not used as needed will lead to wastage of electrical energy. Research on the application of the Internet of Things for controlling electrical equipment specifically for the electric load of lighting lamps on the first floor of Building C, the Department of Electrical Engineering, Medan State Polytechnic aims to implement an IoT system for controlling electric lighting with scheduling mode, remote control mode via internet network and light sensor mode. Thus controlling electrical equipment, in this case lighting, can be done easily through automation of the IoT system at any time and anywhere. The specific target to be achieved in this research is implementing an IoT system for controlling lighting electrical equipment in scheduling mode, remote control mode via the internet network and light sensor mode. The method used in this research is the experimental method, which collects data from observations and designs, which is then tested. The research output target is applied vocational products that are implemented in the Department of Electrical Engineering, Medan State Polytechnic. the equipment used is PZEM 004T Sensor, Photocell, RTC DS 3231, NodeMCu ESP 8266, Triac BT 136, MOC3021 Triac Driven Optoisolator, Contactor, Relay, Photocell, CT and other supporting equipment.

Corresponding Author:

Muhammad Adam,
Department of Electrical Engineering/Engineering/Electrical Engineering,
Universitas Muhammadiyah Sumatera Utara,
Jl.Kapt Muktar Basri No. 3 Medan, SumateraUtara,20238, Indonesia.
Email: fatek@umsu.ac.id

1. INTRODUCTION

The word 'internet' can be considered as one of the constant living objects that has developed over the last few years and continues to gain newer heights in the modern era. In other words, it can always be upgraded and changed as it evolves at the same time. Various different technologies with the latest features have become something very interesting which successively attract the attention of the people. And no doubt, this can be said to be the main reason behind the achievements that the internet has received in a very short period of time. Various things related to the internet are increasing rapidly, which can be relatively referred to as the Internet of Things (Malik et al., 2019). With the Internet of Things evolving gradually as the next phase of the Internet's evolution, it becomes important to recognize the various potential domains for IoT deployment, and the research challenges associated with these applications. From smart cities, healthcare, smart agriculture, logistics and retail, to smart living and smart environment, IoT is expected to infiltrate almost every aspect of everyday life. Although the technologies that enable today's IoT have improved tremendously in recent years, there are still many issues that require attention. Since the concept of IoT is generated from heterogeneous technologies, many research challenges will inevitably arise. The fact that IoT is vast and affects almost all areas of our lives, makes it a significant research topic for studies in related fields such as information technology and computer science. Thus, IoT paves the way for new dimensions of research to be carried out (Hussein, 2019). IoT has emerged as a new technology that is used to express modern wireless telecommunications networks, and can be defined as intelligent and interoperable nodes that are interconnected in a dynamic global infrastructure network, also seeks to implement any concept of connectivity from anywhere at any time (H. et al., 2015).

The Internet, a revolutionary invention, is always changing into new types of hardware and software that no one can escape from. The form of communication we see today is human-human or human-device, but the Internet of Things (IoT) promises a bright future for the internet where the type of communication is machines (U.Farooq et al., 2015). The Internet of Things has received a lot of attention because it includes intelligent devices such as smart sensors and actuators, which enable various applications that increase convenience and efficiency in life (Aboubakar et al., 2022). The application of the Internet of Things (IoT) in various fields continues to grow, namely healthcare, smart homes, smart buildings, smart cities, transportation, and industrial IoT (Umair et al., 2021). IoT awareness can positively influence users' knowledge of IoT privacy and security. Users' knowledge of IoT privacy and security can positively influence users' IoT beliefs and subsequently, users' IoT beliefs can positively influence their continued intention to use IoT (Koohang et al., 2022). The use of the Internet of Things (IoT) can help to improve the ability of disaster prediction, damage assessment, and immediate rescue operations (Tran et al., 2022). IoT applications in each sector are selected and deployed based on their potential economic and social impact, timelines for mass adaptation, and Technological Readiness Level (Yousif et al., 2021).

Security of IoT networks such as supply to the electric power network has emerged as a top national and global priority. To address IoT security issues, several studies continue to be carried out (Istiaque Ahmed et al., 2021). The Internet of Things and smart devices offer large amounts of live data stored in heterogeneous repositories, and hence the need for intelligent methodologies is indispensable (Altohami et al., 2021). The Internet of Things is considered a blessing for the automotive industry to offer great opportunities to inventively create, develop and improve limitless services for the convenience of users. Over time, IoT has developed and developed significantly (Rahim et al., 2021). IoT has evolved rapidly to have a greater impact on everyday life to large industrial systems.(Khraisat & Alazab, 2021).

Huge amounts of energy are consumed by lighting equipment, making increasing efficiency and quickly detecting faults a significant challenge(Gupta & Johari, 2019). design and implementation of a speech recognition system that is integrated with the internet of things can be made to control electrical equipment and doors with raspberry pi as the core element (Abdulkareem et al., 2021). The control system is needed in controlling electrical equipment to support saving electricity. Controlling electrical equipment can have an impact on saving electrical energy and preventing fires caused by negligence in using electricity. The control system has an important role in the development of science and technology and is a tool to control and regulate the state of a system. One of the control systems currently being developed is the Smart

Home/Building control system which is defined as a place/building that uses an intelligent control system to control electrical equipment and others. This research was carried out by designing equipment that can control electric lighting equipment in three modes, namely scheduling mode, remote switching control method using internet networking and light sensor mode using IoT applications. So far, the use of electricity in building C, especially for lighting in the study program rooms, department rooms and in the hallways along building c, Medan State Polytechnic, uses switches that are controlled directly manually. Especially for the light switches in the hallway along the 1st floor of building C, the position of the switch is in a position where not all building users know the position of the switch so that to turn off and on the lights along the 1st floor hallway of building C rely on only one or two people turning it on and off. so that it is hoped that this research will make it easier to control all the lights in the department room, study program room and along aisle 1 building c easily and can be done remotely and closely with scheduling mode, remote on/off control mode and light sensor mode. This research is oriented towards research results that can be used as academic reference material for designing IoT systems for controlling electrical equipment, direct economic impacts in the near future for society and the government

2. RESEARCH METHOD

The method used in this study is an experimental method, namely collecting data and carrying out the design and then testing the results of the design. For electrical equipment control systems, in this case specifically for lighting, it uses three control modes, namely scheduling mode, remote on-off control mode using the internet network and light sensor mode. The equipment used consists of 4 units of 20 Ampere contactor, 4 units of optocoupler, 4 units of Triac, DC power supply, 2 units of MCB, 1 unit of photocell, 1 unit of CT, 1 unit of PZEM sensor, 1 unit of RTC, 1 unit of NodeMcu ESP 8266, and some other supporting equipment. All the equipment is placed in a panel box with a size of 40 x 50 cm.

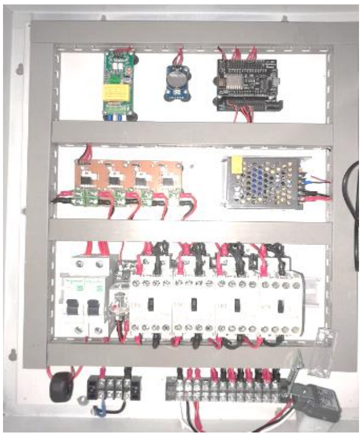

Figure 1. Research Equipment

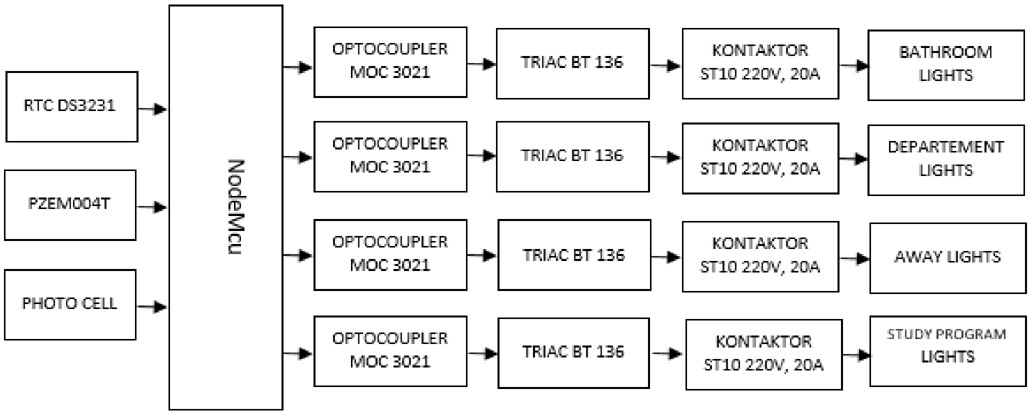

Figure 2. Research Equipment

To run the system according to what is expected according to the block diagram in Figure 2, programming is done on NodeMCU ESP 8266 as the following

```
#define BLYNK_TEMPLATE_ID
#define BLYNK_DEVICE_NAME
#define BLYNK_AUTH_TOKEN
#define BLYNK_PRINT Serial
#include <PZEM004Tv30.h>
#include <SoftwareSerial.h>
#include <Wire.h>
#include "RTClib.h"
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <UnixTime.h>
#include <EEPROM.h>
UnixTime stamp(0);
#define PZEM_RX_PIN D3
#define PZEM_TX_PIN D4
RTC_DS3231 rtc;
char daysOfTheWeek[7][12] = {"Sunday",
"Monday", "Tuesday", "Wednesday",
"Thursday", "Friday", "Saturday"};
char auth[] = BLYNK_AUTH_TOKEN;
char ssid[] = "Galaxy A131270";
char pass[] = "alhamdulillah21";
SoftwareSerial pzemSWSerial(PZEM_RX_PIN,
PZEM_TX_PIN);
PZEM004Tv30 pzem(pzemSWSerial);
const int pinSensor = A0;
const int pinL1 = D5;
const int pinL2 = D6;
const int pinL3 = D7;
const int pinL4 = D8;
byte addMode = 0;
byte addL1 = 1;
byte addL2 = 2;
byte addL3 = 3;
byte addL4 = 4;
byte addJamStart = 5;
byte addMenitStart = 6;
byte addDetikStart = 7;
byte addJamStop = 8;
byte addMenitStop = 9;
byte addDetikStop = 10;
byte dtMode;
byte dtL1,dtL2,dtL3,dtL4;
```

```
byte jam,menit,detik;
byte jamStart,menitStart,detikStart;
byte jamStop,menitStop,detikStop;
unsigned int startTime,stopTime,nowTime;
unsigned long prev;
String Mode;
String sensor;
bool flagGelap,flagTerang;
bool sflagON,sflagOFF;
BLYNK_WRITE(V0){
  int val = param.asInt();
  if(val == 1) {
    EEPROM.write(addMode,1);
    EEPROM.commit();
    Mode = "AUTO";
    Blynk.virtualWrite(V3, Mode);
    Serial.print("MODE : ");
Serial.println(Mode);
    flagGelap = false;
    flagTerang = false;
  }
}
BLYNK_WRITE(V1){
  int val = param.asInt();
  if(val == 1){
    EEPROM.write(addMode,2);
    EEPROM.commit();
    Mode = "MANUAL";
    Blynk.virtualWrite(V3, Mode);
    Serial.print("MODE : ");
Serial.println(Mode);
  }
}
BLYNK_WRITE(V3){
  int val = param.asInt();
  if(val == 1) {
    EEPROM.write(addMode,3);
    EEPROM.commit();
    Mode = "SCHEDULE";
    Blynk.virtualWrite(V3, Mode);
    Serial.print("MODE : ");
Serial.println(Mode);
    sflagON = false;
    sflagOFF = false;
  }
}
BLYNK_WRITE(V8){
  int val = param.asInt();
  if(Mode == "MANUAL"){
    if(val == 1){
      L1ON();
    }else{
      L1OFF();
    }
  }
}
BLYNK_WRITE(V9){
  int val = param.asInt();
  if(Mode == "MANUAL"){
    if(val == 1){
      L2ON();
    }else{
      L2OFF();
    }
  }
}
```

```
BLYNK_WRITE(V10){
  int val = param.asInt();
  if(Mode == "MANUAL"){
    if(val == 1){
      L3ON();
    }else{
      L3OFF();
    }
  }
}

BLYNK_WRITE(V11){
  int val = param.asInt();
  if(Mode == "MANUAL"){
    if(val == 1){
      L4ON();
    }else{
      L4OFF();
    }
  }
}

BLYNK_WRITE(V18){
  int val = param.asInt();
    if(val == 1){
      pzem.resetEnergy();
    }
}
 BLYNK_CONNECTED() {
  Blynk.sendInternal("rtc", "sync");
}
BLYNK_WRITE(InternalPinRTC) {
  long t = param.asLong();
  Serial.print("Unix time: ");
  Serial.print(t);
  Serial.println();
  stamp.getDateTime(t);

Serial.print(stamp.year);Serial.print(":");
Serial.print(stamp.month);Serial.print(":")
;Serial.println(stamp.day);

Serial.print(stamp.hour);Serial.print(":");
Serial.print(stamp.minute);Serial.print(":"
);Serial.println(stamp.second);
  Serial.println(stamp.dayOfWeek);
  rtc.adjust(DateTime(stamp.year,
stamp.month, stamp.day, stamp.hour,
stamp.minute, stamp.second));
}
BLYNK_WRITE(V13) {
  TimeInputParam t(param);
EEPROM.write(addJamStart,t.getStartHour());
EEPROM.write(addMenitStart,t.getStartMinute
());
EEPROM.write(addDetikStart,t.getStartSecond
());
EEPROM.write(addJamStop,t.getStopHour());
EEPROM.write(addMenitStop,t.getStopMinute()
);
EEPROM.write(addDetikStop,t.getStopSecond()
);
EEPROM.commit();
Serial.println(String("Start: ") +
t.getStartHour() + ":" + t.getStartMinute()
+ ":" + t.getStartSecond());
  Serial.println(String("Stop: ") +
```

```
t.getStopHour() + ":" + t.getStopMinute() +
":" + t.getStopSecond());
  startTime = ((t.getStartHour() * 3600) +
(t.getStartMinute() * 60) +
t.getStartSecond());
  stopTime = ((t.getStopHour() * 3600) +
(t.getStopMinute() * 60) +
t.getStopSecond());
  Serial.println(String("Start Time: ") +
startTime);
  Serial.println(String("Stop Time: ") +
stopTime);
}

WidgetLED Lamp1(V14);
WidgetLED Lamp2(V15);
WidgetLED Lamp3(V16);
WidgetLED Lamp4(V17);

void setup() {
  Serial.begin(9600);
  Blynk.begin(auth, ssid, pass);
  EEPROM.begin(512);
  if (! rtc.begin()) {
    Serial.println("Couldn't find RTC");
    while (1);
  }
  if (rtc.lostPower()) {
    Serial.println("RTC lost power, lets
set the time!");
    rtc.adjust(DateTime(F(__DATE__),
F(__TIME__)));
  }
  pinMode(pinL1,OUTPUT);
  pinMode(pinL2,OUTPUT);
  pinMode(pinL3,OUTPUT);
  pinMode(pinL4,OUTPUT);
  cekEprom();
  delay(3000);
}
void loop() {
  Blynk.run();
  if (millis() - prev >= 1000) {
    prev = millis();
    float voltage = pzem.voltage();
    float current = pzem.current();
    float power = pzem.power();
    float energy = pzem.energy();
    float frequency = pzem.frequency();
      float pf = pzem.pf();
```

Figure 2. Program Code.

3. RESULTS AND DISCUSSIONS

The research on electrical energy saving systems and their control needs to be carried out because a very large amount of electrical energy is consumed for lighting, therefore it is necessary to carry out efficiency. The application of wireless technology is used which connects equipment to a Wi-Fi connection while for street lighting there is a problem with internet coverage (Gupta & Johari, 2019). Starting from Gupta's research, this research will develop this research in one building location, namely building C of the Medan State Polytechnic, which on all sides of the building can be reached for Wi-Fi connections. Meanwhile, street lighting is not included in the scope of this research. The application of the Internet of Things to control electrical equipment, especially the electric load for lighting lamps on the 1st floor of Building C, the Department of Electrical Engineering, Medan State Polytechnic is made in three control modes, namely scheduling mode, remote control mode via the internet network and light sensor mode. Scheduling mode will turn on and turn off electrical equipment automatically according to the planned schedule. Scheduling mode is carried out from 07.00 to 18.30 WIB according to the teaching and learning process activities in building C with a total power of 931 watts. The electricity consumption of 931 watts remains for 11.5 hours or in the form of electrical energy of 10.7065 Kwh. The use of this electrical energy if paid in the form of money is IDR 18,196.-. In the situation before the scheduling method was implemented, the electrical energy used could not be determined with certainty because turning on and turning off electrical equipment was only by the manual method so that if turning on the electricity was late, the teaching and learning process activities were disrupted even though it could save electricity but if turning off electrical equipment was late it would cause waste of electricity. For application with light sensor mode, it is used specifically for lighting electrical equipment in the hallway of the building c, where the lighting is when it is sunny, the lights with a total power of 150 watts do not need to be turned on, but if it is cloudy weather, the lighting needs to be turned on for lighting, for that sensor mode light is applied to the apparatus. Meanwhile, the remote control mode with the IoT system is carried out for situations where there are student holidays. During student holidays, of course, the use of electrical equipment in the form of lighting is not all activated, as well as temporary office space. For this reason, remote electrical control needs to be activated in remote control mode with IoT. So that the use of electricity can be done effectively and sparingly. Tests for controlling electrical equipment using IoT are carried out without an electrical load so as not to interfere with teaching and learning activities and processes and are represented and indicated by indicator lights on the control panel for remote control from Labuhan Batu district, Panai Hulu subdistrict, Ajamu Village. The test results are obtained by planning which requires time, cost, program and careful observation. The test results have shown results as expected. The user interface is designed using an Android phone which is initiated by installing the blynk IoT application from the Play Store menu. The menus and buttons in the blynk application are already available in the application and what is done to make the design is to utilize the facilities provided to be modified according to the wishes of the user in this study the display that the user wants as shown in Figure 3 below.

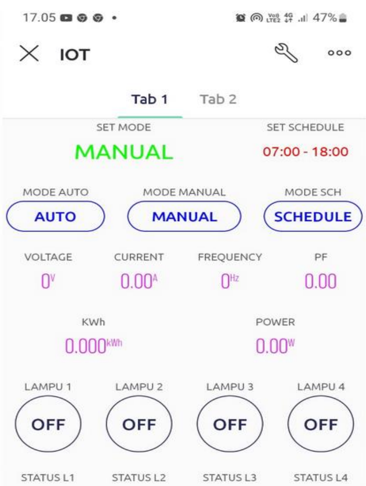

Figure 3. IoT display on handphone

The set mode display is used to indicate the final status of the user-selected mode. The mode created consists of three modes, namely auto mode, manual mode and schedule mode. If the user uses auto mode on an Android cellphone by activating the auto button, IoT will give commands to nodemcu to select only input from the light sensor while input for other modes is temporarily disabled. Electrical equipment in the form of lighting will turn on if the light sensor detects dark conditions around the photocell and vice versa if the light sensor detects bright conditions, the lighting will be deactivated. If the user uses auto mode on the cellphone, Android through the blynk application will send an order to lock the use of manual mode and schedule mode and will execute commands through the blynk application according to the user's wishes in controlling electrical equipment or lighting loads remotely or at close range. Lighting load groups consisting of four loading groups can be activated through the IoT application and can be selectively determined by the user with the manual mode. For schedule mode, the user through the IoT application can determine the activity of the four groups of lighting according to the desired time, for example the time specified for the lights to turn on from 07.00 WIB to 18.30 WIB, then automatically at that time the lights will turn on and outside of that time the lights will turn on. will turn off as before. This time setting can be done through existing facilities in IoT applications through the settings menu for activation time or in the set the time section. By activating the schedule mode through the blynk application, nodemcu through the creation of a program programmed on nodemcu previously ordered that all activities in other modes be temporarily deactivated until the user chooses another mode. Or in other words, during the schedule mode operation, other modes will not work. Settings for nodemcu are carried out using Arduino software version 1.8.19 which supports the facilities desired by the user and can be used free of charge in settings for communication between nodemcu and the blynk application. If using several other paid features, automatic control through the blynk application with nodemcu will require periodic usage fees for software facilities and of course this is economically unprofitable for the user. For controlling electrical equipment using manual mode which can be effectively controlled remotely with the blynk application design for IoT. The test was carried out over a long distance, namely from the Labuhan Batu Regency, Panai Hulu District, Ajamu Village, which is 317 km from Medan City.

Figure 4. Testing for lamp 1 which is controlled from Ajamu with a video call using whatsapp

In Figure 4, shows the results of testing for lamp 1 or the mains room lamp by controlling electrical equipment, in this case the lighting. From the test it shows that for lamp 1 which represents the load of lighting lamps in the main room, in this case it is represented by an indicator light. The displayed quantities of electricity are voltage, current, frequency, power factor, kwh and power obtained through the PZEM004T sensor which is placed on the power channel. The indicator light that lights up is accompanied by a measured voltage of 239 volts, current of 0.07 A, frequency of 50 Hz, power factor of 0.28, kwh of 0.005 and power of 4.8 watts.

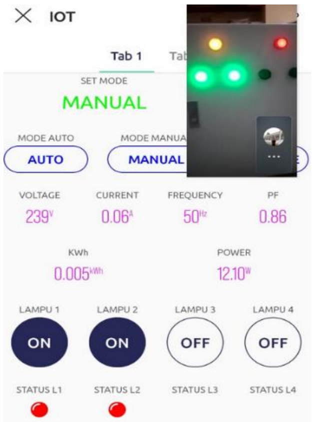

Figure 5. Testing for lights 1 and 2 from Ajamu with a video call using whatsapp.

The second test was carried out using lamp load 1 and lamp load 2 which represent the lamp load group in the department room and study program room. The results of the operation of the PZEM004T sensor show that the measured voltage is 239 volts, current is 0.06 A, frequency is 50 Hz, power factor is 0.86, kwh is 0.005 and power is 12.10 watts. The non-linearity of the measured current is caused when the button for lamp 2 is activated simultaneously with lamp 1 immediately taking a photo via a WhatsApp video call is taken so that just before a change in the current value occurs from the display of the Blynk IoT application.

Figure 6. Testing for lamp 1, lamp 2, lamp 3 and lamp 4.

The four indicator lights, namely lights 1, lights 2, lights 3 and lights 4 represent the department room lights, study program room lights and hallway lights on the 1st floor and RC 103 room lights. Each light can responsively follow up on orders the blynk

IoT application is quite fast, but some cannot respond quickly because the network signal is not good at that time. The quantity of electricity displayed is the measured voltage of 239 volts, current of 0.1 A, frequency of 50 Hz, power factor of 0.78, kwh of 0.006 and power of 17.7 watts.

Figure 7. Testing for lamp 1, lamp 2, lamp 3 and lamp 4 which are in auto mode

The use of auto mode causes several other modes such as manual mode and schedule mode not to function properly. In figure 5.7. indicates that the auto mode has been previously selected by the user as written in the set mode section with green auto writing. If the auto mode is still used and not changed, then if at that time the on-off button is changed it will not affect the position of the switch from on to off or vice versa, the lights will still follow the auto mode when it is updated. Likewise with measurements on other electrical quantities such as voltage, current, frequency, power factor, kwh, and power will still correspond to measurements in auto mode. In section 2, which is designed in the blynk IoT application user interface, it shows a display for energy use according to the time of electricity consumption. The graphic display represents the energy used at any time and can be recorded in data storage for IoT applications. Measurements of electrical quantities can be directly translated through graphs that can automatically appear if adjustments to certain parts are made.

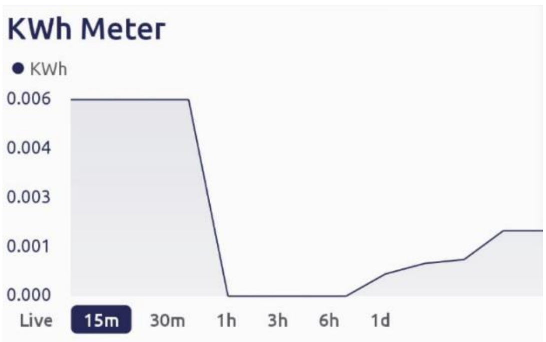

Figure 8. Electrical energy measurements are displayed in the form of numbers and graphs

Electrical energy measurements can be carried out at any time starting from the live measurement range in 15 minutes, 30 minutes, 1 hour, 3 hours, 6 hours, 1 day and so on according to user settings in the IoT application. Data storage cannot be done directly, if you want complete storage of the results of electricity consumption in the form of numbers and graphics, you must register storage and payment to get data records from the start.

4. CONCLUSION

The use of electrical energy according to needs can be carried out by implementing the IoT system where in the conditions before the implementation of IoT for controlling electrical equipment, the electrical energy used was not adjusted to the needs and could not be determined with certainty because it turned on and turned off electrical equipment only by the manual way so that if turning on the electricity is late, the teaching and learning process activities are disrupted even though it can save electricity, but if turning off electrical equipment is too late it will cause a waste of the use of electrical energy. Control of electrical equipment that is controlled via an Android mobile phone by installing the blynk application on the Playstore can control electrical equipment up to a maximum load current of 20 amperes. The use of the MC3021 optocoupler combined with the BT136 triac component and contactor is more stable and safe for switching electrical equipment that uses AC voltage. NodeMCU ESP 8266 with a program designed in such a way can process light sensor input, RTC and application buttons in the blynk application to control four groups of electrical equipment with three control modes. The use of the PZEM004T sensor with a current input equipped with a current transformer and input voltage which is processed and controlled by NodeMCU ESP 8266 and integrated with the blynk IoT application can measure and display the value of voltage, current, frequency, power factor, kwh energy and load power as measured by the amount of electricity.

ACKNOWLEDGEMENTS

The author would like to thank the Medan State Polytechnic for the funding provided from the DIPA POLMED fund in 2022.

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