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HOME AUTOMATION USING IOT EDGE COMPUTING AND COMMON SMART ENERGY METER AND APPLIANCE

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Abstract

Physical energy metering is an outdated paradigm. It is expensive, prone to making mistakes, wastes a lot of manpower, and is a burden on consumers since energy companies carry the cost of manually reading the meters. An intelligent power meter is an inexpensive and time-consuming process. The Internet of Things (IOT) is significant in today's modern optimal energy management. Developing intelligent monitoring systems protection and control techniques for household distribution systems, on the other hand, remains a difficult task. This project extends its real use of such techniques by developing an IoT home automation smart energy meter and electric home appliances to monitor and control various household intelligent devices. The main objective of the function is to collect and save voltages, currents, and power data and display it in a consumer-friendly manner. The developed system's performance is investigated under various home electric loads with varying energy consumption profiles. In this case, an Aruduino-based working prototype is used to capture data and send it to the cloud over Wi-Fi. This Blynk mobile application is also used to allow consumers to monitor the process in real time. To automate the process and decrease hardware size and cost, microprocessor technology is used. The experimental results indicate that the proposed method may be utilized to efficiently control residential energy in real time. A comparison of the created system to other existing methods shows that the suggested method is better in terms of implementation cost and execution time.

Keywords: Internet of Things (IoT); Wi-Fi; Smart Home Appliances; Wireless Sensor and Actuator Networks; Smart Meters; Relays; Lights.

I.INTRODUCTION

Electricity prices may attract companies to reduce overall energy use. Providing customers with a better understanding of when and where their energy is used is critical to lowering their electricity costs. Intelligent energy meter can help with this by providing a more accurate picture of electricity usage. It is possible to use the consumption data collected by these devices in order to enhance the facility and reduce energy loss. Home customers can benefit from the placement of power meter because it allows them to understand better their energy use at home. The Wi-Fi displays in these power meter could display real-time prices of energy use, which can assist consumers in planning their energy consumption budgets.

To make the most of home automation environmental resources, all household devices should communicate with one another and with end users. The technique of automatically controlling various home appliances or gadgets and programming them to replace numerous human interactions for handling key house tasks is known as smart home or home automation. The linked sensors and equipment are managed by an IoT-enabled platform, which provides them with global connection and management. Such interconnection enables smart home devices to collect real-time information from many locations, thus enhancing consumer safety and security. Intelligent home systems also offer intelligent protection to guarantee the safety and security of human life by automatically monitoring activity recognition, elderly fall detection, fire detection, smoke detection, gas detection, invasion, and home surveillance. Aside from automation and security, the smart home system offers efficient energy management systems to help us utilize power more efficiently in our houses.

II. ADVANCED IOT CONTROL MODELLING

Intelligent-Techniques

The Internet of Things (IoT) becomes intelligent because of the mix of techniques and computing, software and hardware. Applying intelligent sensors to the Internet of Objects (IoT) improves its capabilities, allowing things to react in a more intelligent manner to a given environment and to assist them in carrying out specified activities. However, despite widespread use of intelligent devices, intelligence in the Internet of Things is primarily concerned with inter-device communication, whereas inter-device communication between users is accomplished via conventional input methods and interface.

The ability to connect

The Internet of Things is made possible through connectivity, which connects ordinary items to one another. Communication between such devices is critical because basic object level interactions lead to the development of information sharing in the Internet of Things network, which really is important. It enables the devices to be network accessible and compatible with one another. New commercial possibilities for the Internet of things may be generated via the networking of intelligent devices and applications that can be enabled by this connection.

The Internet of Things (IoT) Control Networks

It connects devices under control, sensors, and actuators to the controller and remotecontrol devices (smartphones, tablets, laptops, and PCs). Home Network technology is now divided into three types:

- It uses the house's electrical network.
- Wireless Transfer (interfaces for Z-Wave, ZigBee, Bluetooth, Wi-Fi, and RFID)
- Wire line Networks (KNX and LON)

Ethernet , PLC, and IEEE1394 are the most commonly used wired protocols for home networks, while wireless protocols include wireless LAN, Homer, Bluetooth, UWB, ZigBee, and others. BAN, PAN, LAN, MAN, and WAN as networking or communication technologies for connecting smart gadgets in a smart home. WANs and MANs are utilized outdoors. WANs use UMTS, EDGE, GPRS, or satellite technology. A WWAN is a wireless wide area network that can carry data up to 30 kilometers. WIMAX, for MANs, can transfer data up to 20 kilometers. LANs, PANs, and BANs are utilized indoors. Wireless LANs use Wi-Fi and Hyperlink. IEEE 802.3ad is the primary wire. Bluetooth, RFID, ZigBee, UWB are wireless options for PANs. UPnP, VESA, USB, and serial links are wire solutions. Few solutions exist currently for BANs. Body LAN uses the skin to transfer data.

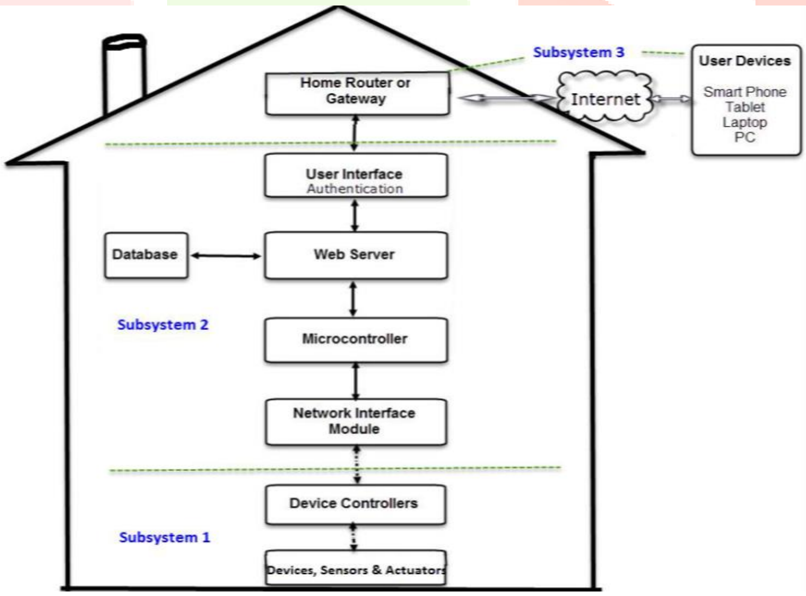


Figure2.1: Internet based home automation

IoT (Internet of Things) application

Platforms, embedded devices, companies' own software, and software are all used to handle the main areas of networking and action in Internet of Things software. In the Internet of Things network, these individual and master apps are responsible for data gathering, device integration, real-time analytics, as well as application and process extension and extension of applications and processes. In order to execute associated activities, they take use of integration with key business systems (e.g., ordering systems, robots, scheduling, and so on).

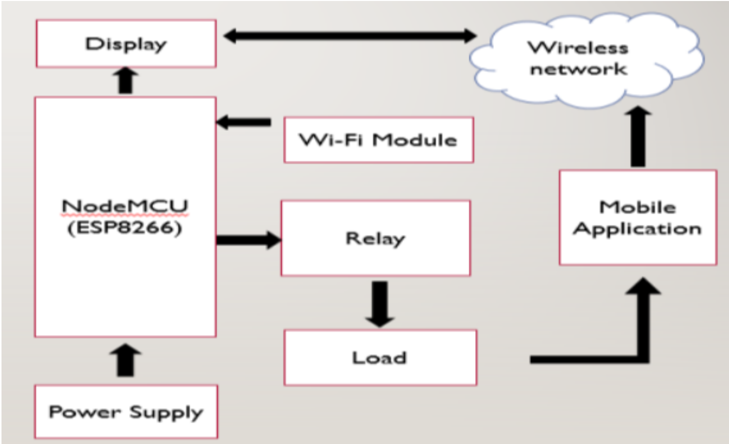


Figure2.2: System schematic representations

The System schematic representations in the above figure shows the project's functionality. The Node MCU is the system's microcontroller. The user utilizes the smartphone app to control the appliances. The mobile application understands the person's voice or switching command and transmits it to the Node MCU device over a Wi-Fi network. So the Wi-Fi module (integrated into the Node MCU) lets the microcontroller establish a Wi-Fi connection with a device and receive wireless instructions from an application. After receiving the signal, the Node MCU uses a relay to switch on/off the appliance. There is a physical link between the Node MCU, relay, and the final the microprocessor, relay, and final appliances are powered by a power supply unit. The application status is also shown on a display device.

OVERVIEW

The steps below explain how to create a Blynk account and generate a device ID.

This ID uniquely identifies a device on the Blynk server.

Step-1: Download the Blynk app from the Play Store on your smartphone.

Step-2: Create a Blynk account.

Step-3: The application generates a new ID when undertaking a project for a device.

Step-4 T: his is added to the programmer before it is installed.

Step -5: In order for the Blynk server to work, each device must have its own unique ID.

As soon as the unique Id has been created, the next step would be to include it into the embedded C code that would be used to establish connection between the Node MCU and the Blynk Server. This procedure is described in more detail below.

Step-1: Node MCU connects via Wi-Fi

Step-2: The Wi-Fi network's SSID and password are added to the code.

Step3: Create a new project in Blynk.

Step-4: Upload the code with the user's unique ID to Node MCU.

Step-5: Switches in Blynk correspond to GPIO pins in the code and hardware.

Arduino-IDE: Arduino-based boards were used as microcontrollers, and the IDE was developed by Atmel. The Arduino IDE was used to create and upload programmes to the Arduino Mega 2560 board, which was controlled by the Arduino Uno board. The Node MCU was programmed using the "ESP8266 Core for the Arduino IDE" open-source library, which was likewise programmed using the Arduino IDE.

Android Studio:

The Android Studio IDE was used to create the smartphone app for this project, which was written in the Dart programming language and developed with the Flutter architecture.

Platform for the data center:

A NoSQL Database with real-time streaming capabilities was utilized on the cloud platform to hold data about users and Blynk Boxes. The Firebase Real-time Database was chosen for our implementation since it has well-documented libraries for both the Android/iOS/Web platforms and the Node MCU platform. The Firebase Real-time Database's streaming functionality was utilized to transmit instructions to Blynk Boxes in real time. Any cloud-based solution (for example, MQTT in [13]) that enables real-time communication between the Node MCU and the Blynk Mobile App will likewise function.

Figure2.3: Hardware components: Arduino board, LED, Node MCU, Relay module

Design of Software:

The Blynk system is comprised of three major components: 1. the microcontroller (Arduino), 2. The communications (NodeMCU/ESP8266 and the cloud), and 3. The Blynk mobile application (Android and iOS).

The microcontroller (Arduino):

To communicate with the Node MCU via serial communication, the Arduino makes use of the Connection between two devices library supplied by the Arduino. The Arduino has been designed to always listen to the Node MCU for instructions, regardless of the state of the world. These instructions are received in the form of JavaScript Object Notation (JSON) objects, which are then processed and carried out. Originally, the JSON format was intended to contain just two fields: a "command" field and a "payload." There is a boom in the instruction that specifies whether the Node MCU is to modify or read the status of the Arduino-connected relays or both. The payload field holds information about user-defined relay states obtained from the Blynk Mobile App, and it is null only while the Node MCU is requesting relay states from the Blynk Mobile App. The Arduino reads or writes the relay states in accordance with the JSON data provided by the Node MCU to the Arduino board.

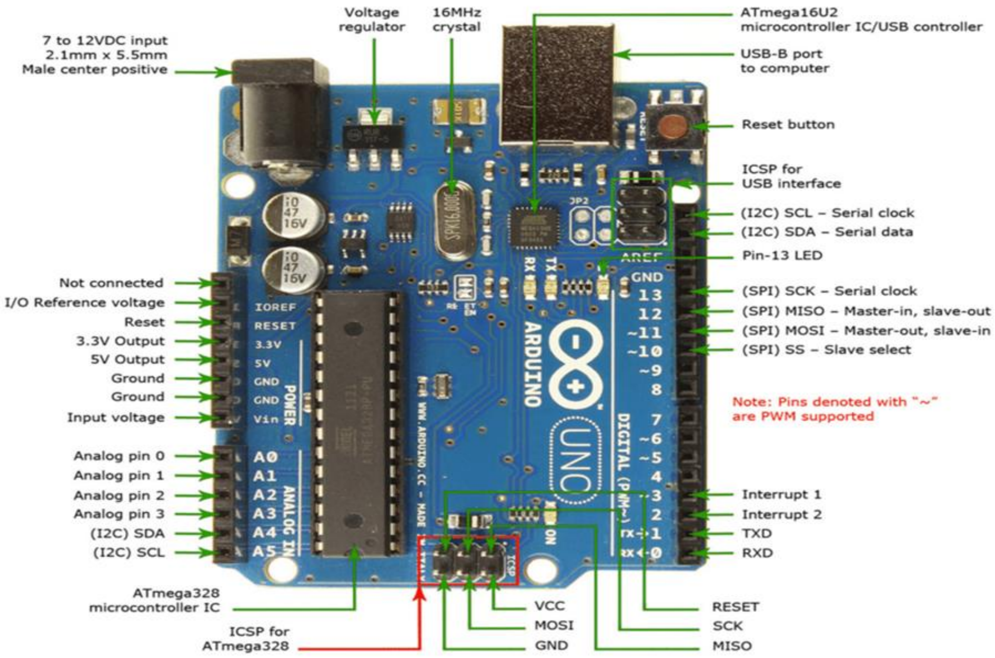


Figure2.4: The microcontroller (Arduino)

Node MCU/ESP8266: The Node MCU (that includes an ESP8266 Wi-Fi module) was designed to connect to a NoSQL cloud-based database (the Firebase Real-time Database) upon start-up of the device. The commands for each Blynk Box are saved in a separate child node for each Blynk Box, which would be termed "relays". The relay statuses are represented by Boolean values (True or False). When a user makes a modification (turning anything on or off), the Blynk Mobile App changes the Boolean value to True or False, depending on the situation. Because of Real-time streaming, the Node MCU gets the data for the modified child node in real time and sends the necessary instruction to the Arduino, which then in turn activates the relay in the appropriate location.

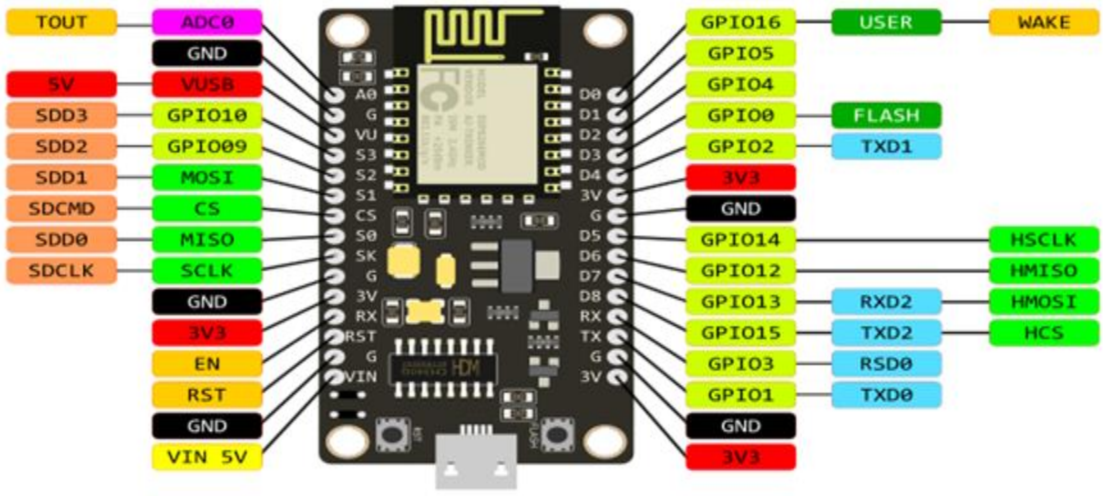
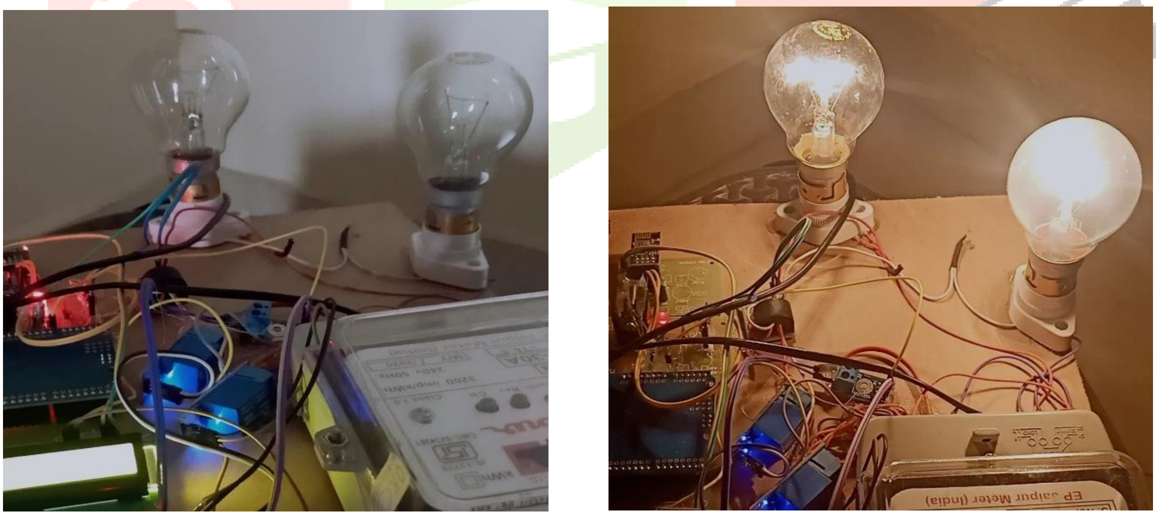


Figure2.5: Node MCU (that includes ESP8266 Wi-Fi module)

Figure2.6: Hardware prototype of designed IOT circuit with Arduino

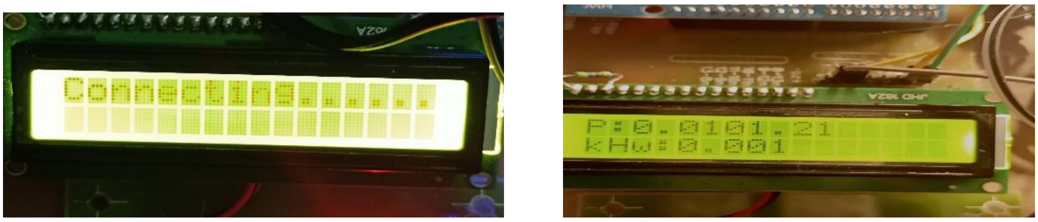


(a) **(b)**

Figure2.7 (a) system in nonworking condition (b) system in working condition

Blynk Mobile Application

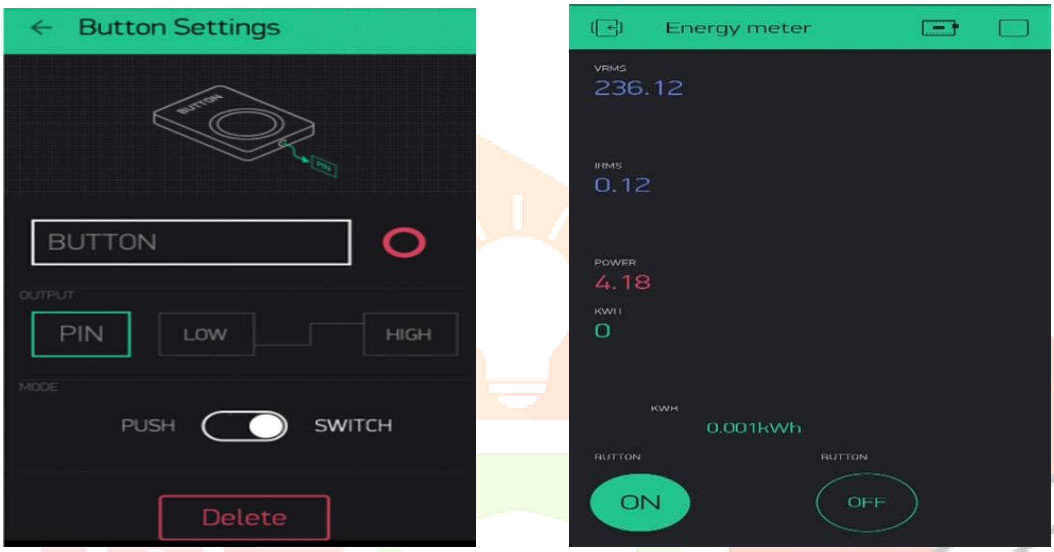
As a result of its creation utilizing the cross-platform application development framework Flutter, the Blynk Phone Application is available for use on all major platforms (Web, iOS and Android). The Mobile App was created to offer a nice, user-friendly interface for its users. A rewards system was developed utilizing the Firebase Database, in which users get points (known as H-points) for updating the system. Customer retention and involvement are proven to increase as a result of such a reward scheme, which ultimately results in improved energy efficiency for Blynk users. A screenshot of the app screen on which appliances (relays) are managed is displayed figure. It is possible to change the default relay names (Relay 1, Relay 2, etc.) to more recognizable ones (for example, Projector, Microwave), depending on how well the relays are connected to the building by an electrician. The consumer's energy meter is monitoring continuously and the number of calories/units is displayed on the LCD. LCD makes the system user-friendly. Sensed ratings are simultaneously displayed on the LCD panel.



(a) (b)

Figure 2.8 (a) LCD display when connecting through Wi-fi module to mobile application

(b)LCD display of the system after connected to the application



(a) **(b)**

Figure2.9(a) Add box page for Blynk mobile application (b) monitoring screen on the Blynk application

III. PERFORMANCE OF INTELLIGENCE METER PURPOSED

To resolve the issues, the system involves home automation as a smart house with intelligence, as well as an e-metering system as a smart grid. The system, in conjunction with the web application, controls smart gadgets in the house, as well as all billing functions from the web application, which operates as a cloud application. The primary goal of this project is to develop an energy consumption meter as well as a control and monitoring system for all service providers. This technology allows a user to login and monitor real-time energy consumption as well as operate the gadgets (home appliances). BEST, TATA Power, MSEB, Reliance, and more energy providers exist.

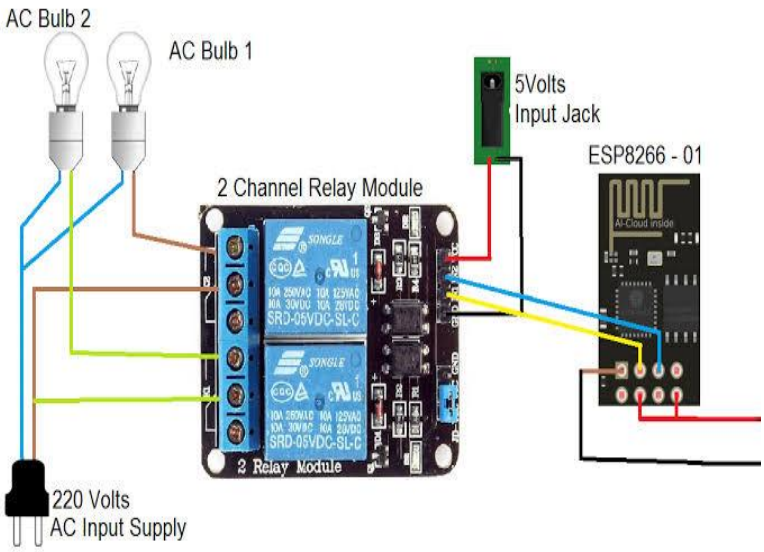


Figure3.1 model of IOT based electric energy meter connections with sensors

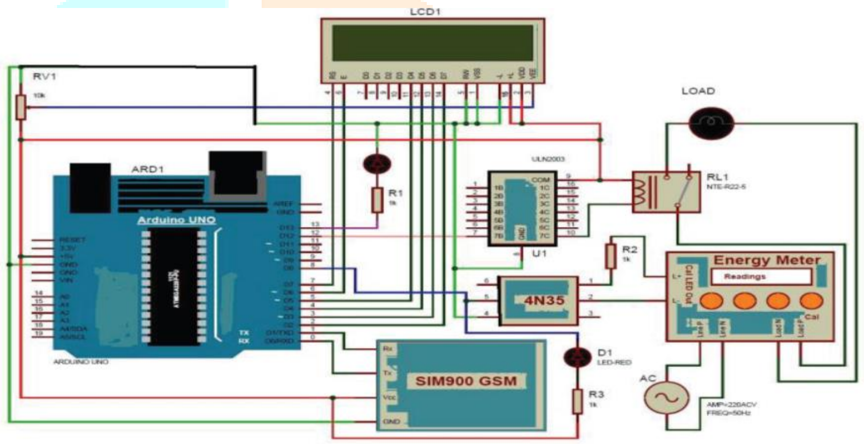


Figure3.2 Diagram of intended circuit for single phase energy meter

The Nodemcu power source is drawn from the main AC power supply. A voltage step down transformer and a rectifier circuit are used to convert a 220V AC supply to a 5V DC supply, as illustrated in Fig. 4.A step-down transformer is used in this circuit to convert 220V AC to 9V AC. A full bridge rectifier circuit then converts the 9V AC to 9V DC. Fig. 22. Rectifier circuit to convert 220V AC to 5V DC. In order to decrease it, a smooth capacitance is placed in parallel. Finally, the 9V DC is converted to 5V DC by the 7805 regulator IC, which is supplied to the Nodemcu. Figure 5 shows the prototype's hardware implementation.

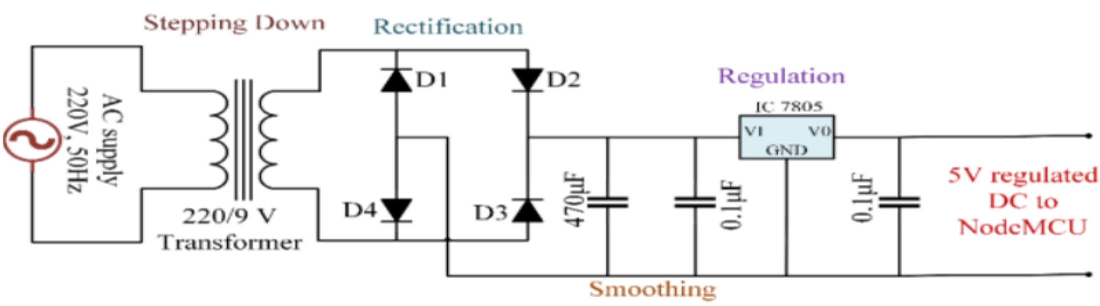


Figure3.3 circuit diagram of a 220v AC supply to 5v DC rectifier circuit

Bluetooth-enabled gadgets

Among many other uses, Bluetooth is widely used in consumer electronics and computers. It is expected to be essential for wearable devices that will link to the IOT through a smartphone in many instances. That's why Bluetooth Low-Energy, or Bluetooth Smart, is so important for IoT applications. While it has a comparable range as Bluetooth, it is intended to use less power.

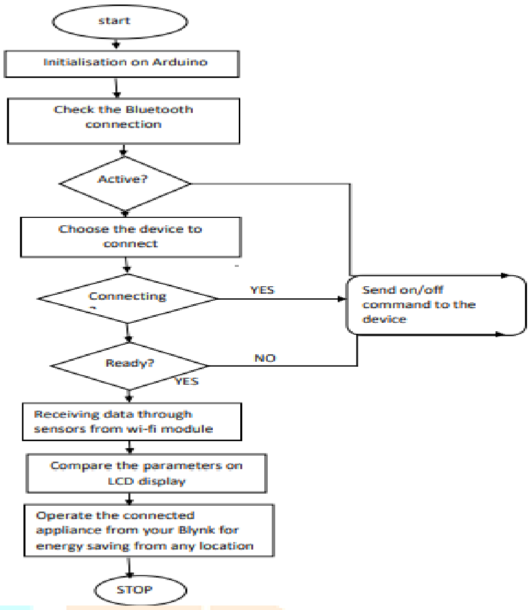


Figure3.4: Flowchart for connecting the device with mobile application

Furthermore, the suggested system has the capability of managing home appliances from a remote location.

The planned system is primarily intended for residential consumers to calculate their electricity consumption and associated costs. Consider b to be the number of times the 'Cal' LED blinks in a month. The total energy consumption (kWh) is calculated using the 'Cal' LED blinking 3200 times per kWh

ai =bi/3200

Assuming s and d are the monthly service and demand charges in (APEPDCL), correspondingly, the relevant cost c may well be computed using the following equation.

Ci= (ai×k) +s+d

In this case, k denotes the per unit price of energy in, the value of which is determined shows the value of k for various used units (a) as according Andhra Pradesh eastern Power Distribution Company (APEPDCL).

Table3.1: The rate of energy per unit of time with respect to paid units

Paid unit(a)	**Rate of Energy (kilowatt-hours) per unit of time**
0-75	3.80
76-200	5.14
20.1-300	5.36
301-400	5.63
400-500	8.70
501-600 and above	9.98

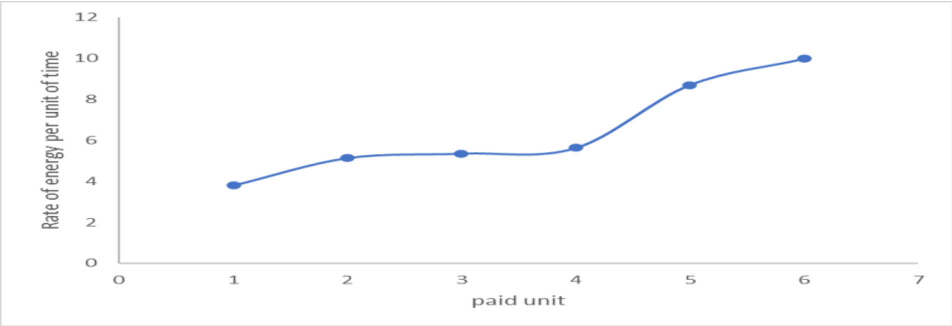


Figure3.3. a) rate of energy of time with respect to paid units as per (APEPDCL).

IV. Intelligent Power Meter Monitoring System

The intelligent power meter monitoring system, shown in Figure 1, is shown. The Arduino, an energy meter, a WIFI module and an Internet of Things module, a relay, and a transformer are all shown in the block diagram. The clamp energy meter that was used in this instance is described below. The transformer accepts 230V alternating current as an input, and the alternating current is converted into low voltage. Using the energy meter, you may keep track of the live current, voltage, and power in kilowatt-hours. These parameters are read by the microcontroller and then transmitted to the cloud through the internet. In addition to being a Wi-Fi device, Node MCU also contains a microcontroller. This creates an Internet of Things connection with the local router. A mobile device or a laptop computer may be used to check on the status of these measures. WI-FI is a data transmission technology that is widely used. The WI-FI network is setup using Arduino. Before sending data to the user's phone; the energy meter's data must be transmitted to Arduino and the WIFI module. It is possible for the users of this system to control the main power and home appliances from their Android smart phone app. The WI-FI module is responsible for sending and receiving data from the cloud, which is then sent to Arduino, which controls the relay, which turns on and off the home circuit.

The following results are the graphs drawn from monitoring the system for three different times in a day

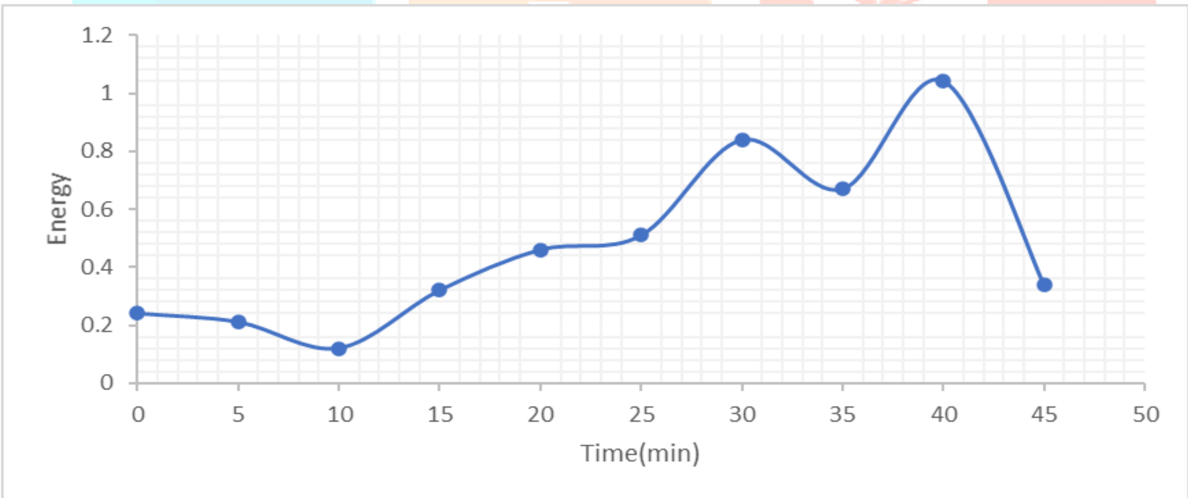


Figure 4.0 Energy consumption data for 45min in a day

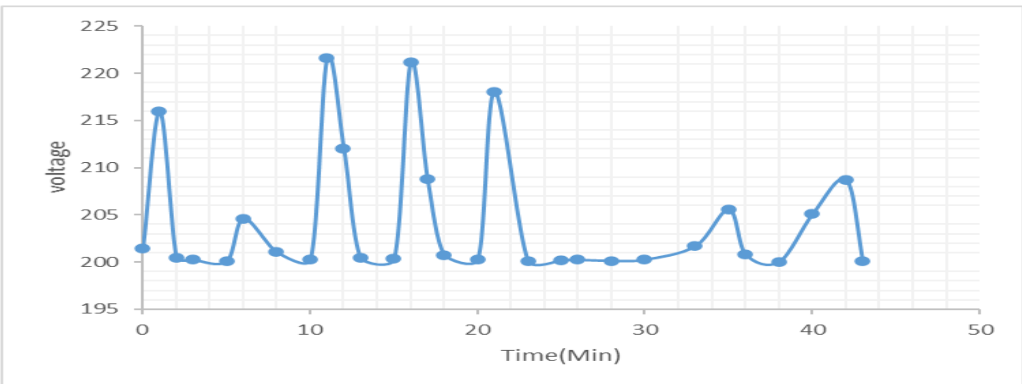


Figure 4.1 (a)voltage drawn with respect to time

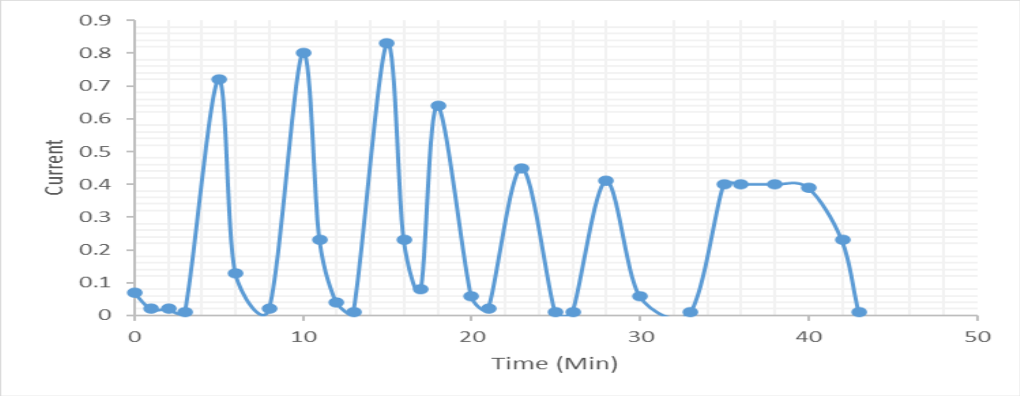


Figure4.2 (b)current drawn with respect to time

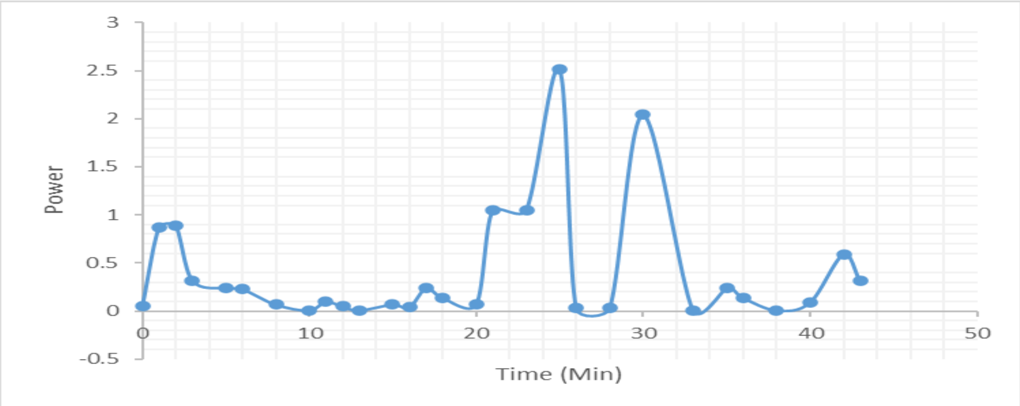


Figure4.3 (c) Power drawn with respect to time

Total Energy Consumption:

Total energy consumption in India is growing at 3.9 per cent during the first subperiod and it has risen to 8.14 per cent during the second sub-period. However, it has declined to 4.5 per cent during the third sub-period. Incongruous to this, commercial energy has grown at 4.06 per cent in the first sub- period, and continued to grow at 5.08 per cent and 5.09 per cent in the succeeding sub-period.

In view of the importance of energy consumption in influencing economic growth and its sustainability and the resultant environmental effects, the present work attempts to study the causal links between energy consumption and GDP of India both at aggregate and disaggregate levels. The IOT home automation energy meter helps us to track per unit cost with the help of Blynk application.

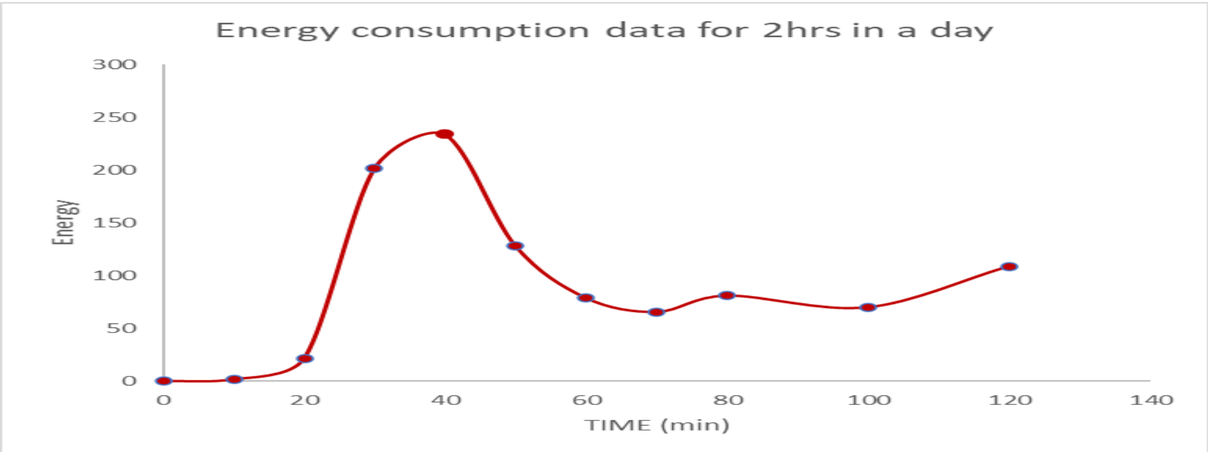
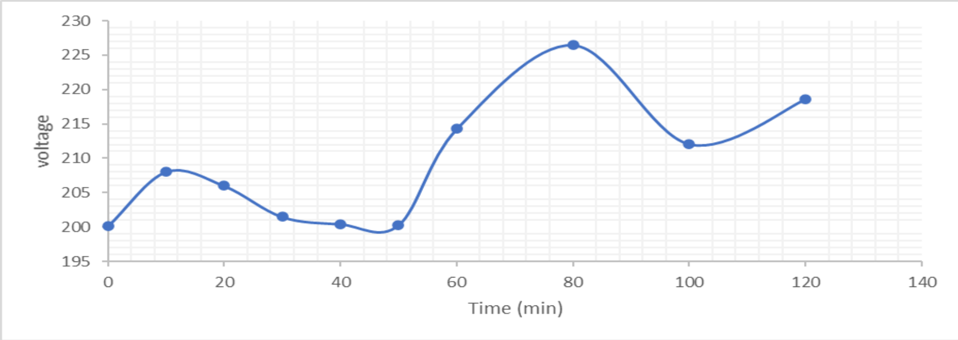
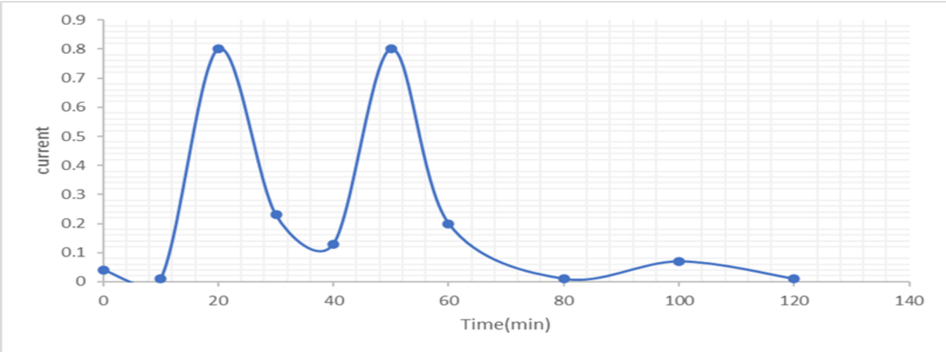


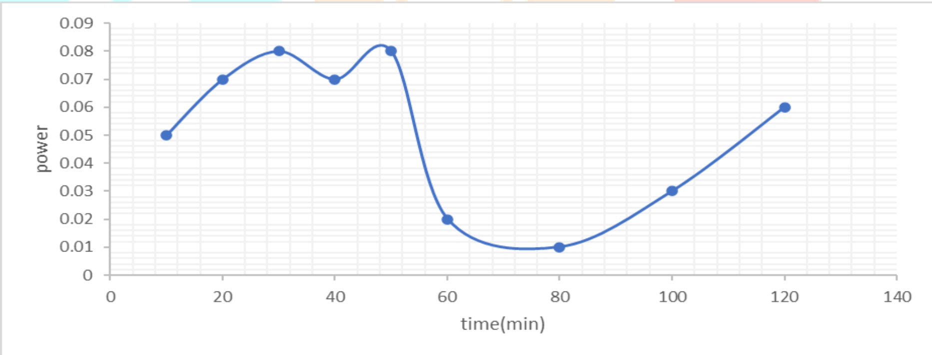
Figure4.4 a) Energy consumption data for 2 hours in a day



(a)



(b)



(c)

Figure 4.4.1 (a)(b)(c) voltage, current and power drawn with respect to time for 2hrs

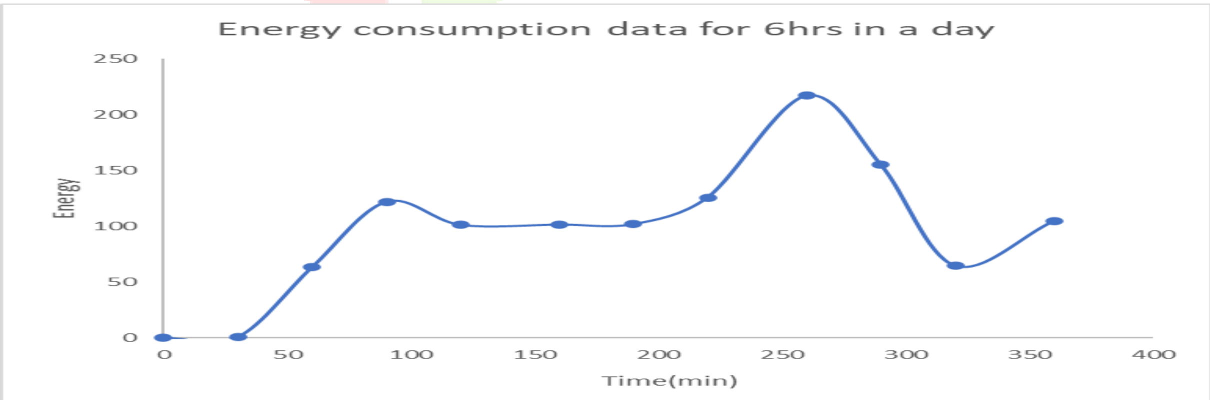
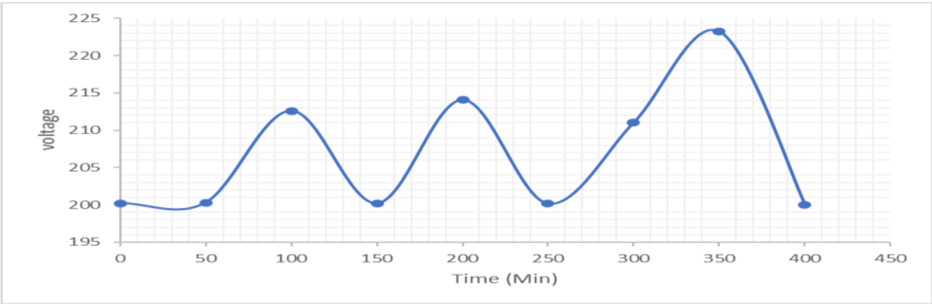
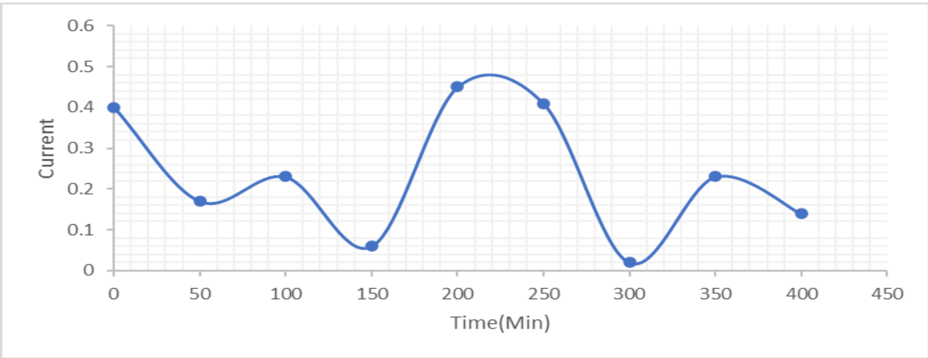


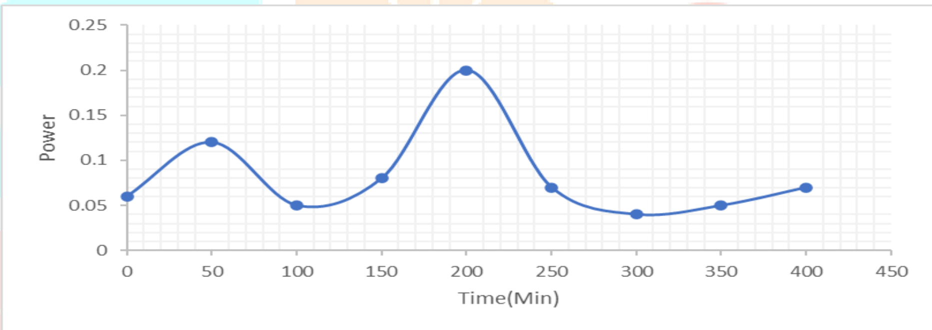
Figure4.5b) Energy consumption data for 6 hours in a day



(a)



(b)



(c)

Figure 4.5.1(a)(b)(c) voltage current and power with respect to time for six hours in a day

Voltage and Current measurement:

The microcontroller board used in this project runs at 5v and it is an opensource hardware. It is basically an at mega 328p microcontroller and at its center which possess 6analog pins and 15 digital . It also has 32 kb memory with 4 kb of SRAM.A 16 Mhz ceramic clock resonator is used in it. The resolution of ADC is 210. The input signals are mapped from the output values of the microcontroller. Analog inputs into the Arduino UNO board are the voltage and current signals. Input end voltage is proportional to the output end voltage, allowing simpler measurement of voltage. To bring the voltages to operational levels a stepdown transformer is used which converts from 230V/6V. The potential divider is fed with the output voltage and consist of two resistances of 2800Ơ and 1000Ơ. A bridge rectifier circuit is fed with the voltage across the 1000Ơ resistance. The rectifier circuit which entails of 1000 f capacitor is fed with the full rectified wave. Large value of capacitance is selected in order to make the time constant large so that the charging and discharging takes place very slowly resulting in less amount of ripple in the waveform. A Zener diode is fed with the output so that a constant output voltage is obtained since the voltage dropping across the zener diode will be constant. Current measurement is done by the Current Sensor, which is a fully integrated hall effect based Linear Current. The current flow through the copper conduction path will generate a magnetic field and then convert to a proportional voltage. The rated values of ACS712-30A are 5V input voltage supply, bandwidth of 80 kHz, 66 to 185 mV/A output sensitivity.

Power factor calculation: $PF = |\cos \varphi| = 1000 \times P(kW) / (V(V) \times I(A))$

At first, the pulses for 120 watt is calculated, which means calculating the number of times the pulse LED blinks in a minute, for a load of 100 watts.

Pulse = (Pluse_rate*watt*time) / (1000*3600)

So pulses for 60 watt bulb in 60 seconds, with energy meter of 3200 imp/kwh pulse rate can be calculated as below:

Pulses = (3200*60*60) / (1000*3600)

Pulses = ~3.2 pulse per minute

Next is to check the Power Factor (PF) in a single pulse:

PF = watt / (hour * pulse)

PF = 120 / 60*3.2

PF = 0.6265 watt in a single pulse

Units= PF*Total pulse/1000

Total pulses in an hour is around 3.2*60=192

Units = 0.6265*192/1000

Units = 0.12 per hour

If a 120watt bulb is lighting for a day then it will consume

Units =0.12*24

Units = 2.88Units

UNITS: The unit of electricity is Kilowatt hour (kWH).

1kWH = 1000 watt for 1 hour.

Example: 1000watt bulb used for 1 hour gives 1kWH**.**

Considering per unit cost is ranging between 6.37 from present to 7.17 rupees. Assuming the per unit cost is 6 rupees the total cost would be 18.85/- rupees a day for a 120 watt bulb.

V. CONCLUSIONS AND FUTURES SCOPE

5.1 CONCLUSIONS

It is shown that the application of the Internet of Things to power management results in a more effective and dependable system when compared to the traditional energy management system. An important aspect of the suggested system is that it collects data from a server through the internet rather than from home appliances. The data is automatically updated after a short time interval via Wi-Fi, which makes it more accessible. Due to

the dual functionality of the Node MCU, which is utilized in this system, there is no need for an extra microcontroller to be used in conjunction with it. Further more this technology has made it feasible to operate household equipment from a distance. An in-depth presentation has been provided on the complete hardware implementation as well as the interface with the internet. A thorough cost study has been carried out in order to ensure the cost efficiency of the project. The total cost of the proposed Internet of Things-based smart energy management system, the suggested method is thus cost-effective, and the add-ons may be connected with the current prepaid meters, which can alleviate some of the system's main shortcomings by adding additional functionality. According to this paper, a solution based on Internet of Things implementation on an automatic meter allows wireless energy monitoring via the Blynk application via a smartphone and raises awareness of energy conservation and consumption reduction through Blynk notifications, thereby reducing energy consumption. The Internet of Things (IoT) technologies enable consumers to control their energy consumption more efficiently by monitoring the energy consumption of their loads through their cell phones. As a result, the concept described in this Project has a great deal of potential for implementation in the distribution system.

5.2. Futures scope

This Project provides a complete overview of smart metering and data analytics. Despite widespread opposition to smart meters because to privacy and health concerns, it is clear that the SG and smart metering are here to stay. The smart meter technology and procedure, many stakeholders, existing analytics technologies and tools, and contemporary technological revolutions such as big data, cloud computing, and IoT have all been highlighted. This project then establishes a framework to tie smart meter data to stakeholders, applications formed by their demands, and the analytics tools and techniques required to satisfy stakeholder needs. The framework would help discover smart metering restrictions.

This study also contributes to the identification of smart meter analytics building blocks that link the various smart metering platforms and identify the primary analytics activities. Big data, real-time analytics, and stream analytics will need to be embedded into processes and workflows for real-time diagnostics.

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