# VISVESVARAYA TECHNOLOGICAL UNIVERSITY

**Jnana Sangama, BELAGAVI**

# "IOT BASED SMART ENERGY METER "

Mini Project report submitted in partial fulfillment of the requirements for the award of

**BACHELOR OF ENGINEERING**
**In**
**ELECTRICAL & ELECTRONICS ENGINEERING**

Submitted by


| | |
|---|---|
| **MANOJ B G** | **1DT20EE017** |
| **PRAYAG C B** | **1DT20EE020** |
| **SHREYAS S** | **1DT20EE027** |


Under the Guidance of


**Prof. Dr. K SHANMUKHA SUNDAR**
**Designation of guide, Dept. of EEE,**
**DSATM, Bangalore**


**Department of Electrical & Electronics Engineering**

**DAYANANDA SAGAR ACADEMY OF TECHNOLOGY & MANAGEMENT**
Udayapura, Kanakapura main Road, Opp: Art of Living, Bangalore – 82

## Dayananda Sagar Academy of Technology & Management

## Department of Electrical & Electronics Engineering

# ***CERTIFICATE***

Certified that the Mini Project Work entitled **"IOT BASED SMART ENERGY METER"** is a bonafide work carried out by **Mr. MANOJ BG** (1DT20EE017), **Mr. PRAYAG CB**(1DT20EE020) and **Mr. SHREYAS S** (1DT20EE027) in partial fulfillment for the award of Bachelor of Engineering in **Electrical & Electronics** Engineering of the Visvesvaraya Technological University, Belagavi during the year 2022-2023. It is certified that all the corrections/suggestions indicated for internal assessment have been incorporated in the report deposited in the departmental library. The Mini Project Report has been approved as it satisfies the academic requirements in respect of Mini Project Work prescribed for the said degree.

| Signature of Guide | Signature of HOD | Signature of Principal |
|---|---|---|
| Dr. K. SHANMUKHA SUNDAR | Dr. K. SHANMUKHA SUNDAR | Dr. M RAVISHANKAR |

| Name of The Examiners | Signature With Date |
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# DECLARATION

I, the undersigned solemnly declare that the Mini Project report entitled, **“IOT BASED SMART ENERGY METER ”** is based on my work carried out during the course of my study under the supervision of (mention guide name), Associate Professor, Department of Electrical and Electronics, Dayananda Sagar Academy of Technology and Management. I assert that the statements made and conclusions drawn are an outcome of the Mini Project. I further declare that to the best of my knowledge and belief that the Mini Project report does not contain any part of any work which has been submitted for the award of any other degree in this University or any other University

Name and signature

1.MANOJ B G (IDT20EE017)

2.PRAYAG C B (1DT20EE020)

3.SHREYAS S (1DT20EE027)

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# ABSTRACT

This report presents the design and implementation of a Smart Energy Meter system using the ESP8266 microcontroller in conjunction with the Blink application for remote monitoring and control. The primary objective of this project is to develop an efficient energy management system that allows for real-time monitoring of energy consumption and enables remote access for controlling and analyzing energy usage patterns. The ESP8266 microcontroller serves as the central component of the smart meter, while the Blink application provides a user-friendly interface for data visualization and control.

The report provides an overview of the system architecture, detailing the hardware and software components employed. The ESP8266 microcontroller is programmed to facilitate the communication between the energy metering hardware and the Blink application. The Blink application is designed to offer an intuitive user interface for visualizing energy consumption data and providing remote control functionality.

The implementation process is described, including the selection and setup of the ESP8266 microcontroller, integration with the energy metering hardware, and the development of the Blink application. The results of the project showcase the successful real-time monitoring of energy consumption, accurate data visualization, and remote control capabilities achieved through the integrated system.

Challenges encountered during the implementation are discussed, along with potential future enhancements to further improve the system's functionality and performance. The report concludes by emphasizing the significance of the ESP8266 microcontroller and the Blink application in promoting sustainable energy practices and enabling effective energy management.

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# CHAPTER 1:

# Introduction

The development of smart energy metres has emerged as a game-changer in the pursuit of sustainability and efficient resource management in an era where energy consumption and efficiency are major considerations. These sophisticated gadgets offer real-time data monitoring and analysis, enabling users to make well-informed choices regarding their energy usage. The combination of the Blynk IoT application with smart energy metres is one such cutting-edge solution. It harnesses the power of the Internet of Things (IoT) and user-friendly mobile interfaces to produce an intuitive and smooth energy management system.

With a focus on the advantages, features, and prospective uses of this technology, this paper attempts to study the idea of smart energy metres and their integration with the Blynk IoT application. We will obtain a thorough grasp of how this technology transforms current energy monitoring practises by exploring the key features and benefits of it.

In the past, measuring energy use was a laborious, manual procedure that frequently relied on recurring metre readings and projected costs. However, the development of smart energy metres has revolutionised this strategy by making it possible to track electricity, water, and gas consumption in real-time. To give users accurate and current information about their energy usage pattern, these metres make use of cutting-edge sensing technology, data transfer protocols, and analytics capabilities.

## The Blynk IoT Application

Blynk is an intuitive and adaptable IoT platform that makes it easier to create IoT applications. Blynk enables users to simply construct customised dashboards, control devices remotely, and monitor numerous parameters thanks to its user-friendly interface and large collection of pre-built widgets. Users can access real-time energy statistics, receive warnings, and obtain insightful knowledge into their usage patterns by connecting Blynk with smart energy metres. This enables them to make educated decisions to cut down on energy waste and save money.

## 1.1 Objectives

Energy use tracking and management in homes and business buildings will be revolutionised by the deployment of a smart energy metre that makes use of the Blynk IoT application. The major goal is to provide users with real-time access to their energy usage statistics so they may optimise their consumption patterns and make informed decisions regarding energy conservation. By exploiting the capabilities of the Blynk IoT platform, the smart energy metre seeks to give an easy and seamless interface for tracking trends, monitoring energy consumption, and defining energy-saving goals.

## 1.2 Problem Statement

1. Lack of real-time monitoring: Customers find it difficult to adequately monitor their usage because traditional energy metres cannot provide them with information on their energy consumption in real-time.

2. Manual reading of energy use is required by current energy metres, which delays invoicing and increases the risk of human mistake during data collecting and calculation.

3. Ineffective energy management: When users don't have access to accurate and timely information about energy consumption, they can't identify opportunities for energy savings and decide how to best manage their energy usage.

4. Limited user engagement: Consumers are unable to see their energy use trends and actively engage in energy saving initiatives because traditional energy metres do not actively involve them.

# CHAPTER 2:

# LITERATURE SURVEY

Infrastructure for advanced metres (AMI) In many regions of the world, smart electricity metres are quickly replacing traditional metres. To save energy, cut costs, and improve dependability, the U.S. government and corporate sector are investing billions of dollars in the construction of the smart grid infrastructure. Smart grids ensure that all production equipment is connected and used effectively, offer automatic and real-time management of the electrical networks, enable better consumption measurement, maximise reliability, and enhance the current services, all of which result in energy savings and lower costs.Due to the installation of smart metres and other sensors on the network, the growth of customer facilities, etc., the implementation of smart grid features results in a very high rise in the volume of data that must be processed. A smart metre, for instance, may send the consumer's energy usage every 15 minutes, generating 96 million reads each day from a million metres instead of one metre reading per month from a normal grid.

In order to handle high velocity, significant storage capacity, and advanced data analytics requirements, smart grids also need excellent data management. Indeed, due to their nature, spread, and real-time requirements for specific demands, smart grid data requires complicated treatments. For this type of application, big data approaches are appropriate for sophisticated and effective data management.The large volume of data will help utilities do things they never could do before such as better understanding the customer behavior, conservation, consumption and demand, keeping track of downtime and power failures etc. At the same time, this will present challenges for utilities that lack the systems and data analysis skills to deal with these data.

Today, managing large volumes of data and using advanced analytics to turn the data gathered into information, knowledge, and ultimately actionable plans is the core objective of utilities. In this research, we present a thorough examination of 5-minute smart metre data sets for 100 anonymous commercial buildings in order to investigate time series of electricity use and to create/compare various forecast models that employ a comparable day strategy. The remaining sections of this essay are structured as follows. We go over the history and architecture of AMI smart metre systems in Section II. The associated work is then covered in Section III. We discuss our datasets in Section IV, and we explain our time series forecasting models in Section V. Then, in Section VI, we demonstrate our data analytics and visualisation.

Power systems, like other utilities around the world, are changing from manual/on-site to automated/remote control. In order to change this functionality while ensuring high levels of security, quality, and economic efficiency for the provision of power in a market setting, "smart grids" are a key notion. Numerous EU energy legislative packages have been approved by the European Parliament since 2009 with the goals of enhancing competition in the electricity and gas markets, dividing ownership between companies involved in energy production, transport, distribution, and supply, and lowering carbon emissions across the entire energy value chain. market In order to accelerate the use of smart metres in the electricity and natural gas markets, this legislative framework was developed. The usage of smart metering systems (SMS) by power consumers in each EU Member State is anticipated to reach 80% by the end of 2020. Among the nations with the most ambitious goals for the rollout of smart metres in the electrical market globally are the United States, Canada, China, Japan, Brazil, and South Korea. The majority of European nations have established legislation to control the rollout of smart metres. The anticipated smart metering systems are described as 'a new generation of advanced and intelligent metering devices that have the ability to communicate and transfer the recorded information to the utility company in real time or at least on a daily basis using any communications network; enable a two-way communication between the metre and the central system'.

The SMS consists of information transmission subsystems, information counter management subsystems, measurement subsystems housing the metre, measuring transformers, and equipment for secured access to the metre. The indicator Electricity Technical Losses (ETL) is the difference between the electricity contour and the consumed and invoiced electricity at the level of a region for a specific amount of time. The development of this indicator can be tracked using smart metering systems in order to determine the most effective ways to reduce the costs created. The installation of smart metering systems will be discussed in the parts that follow, first for three pilot projects in Romania and then for the area as a whole. The recorded findings for the ETL indicator over a specific time period will be examined with the goal of demonstrating the necessity and significance of tracking the development of electricity technical losses. A variety of ETL reduction measures will be suggested in the closing sections.

An enormous amount of detailed electricity consumption data is now available because to the expansion of residential advanced metering infrastructure, which automatically measures and transmits electricity usage information at hourly or sub-hourly intervals. There are several potential advantages for the environment, the electricity provider, and the customers in being able to manage and analyse these data. Smart metre data analytics have the potential to assist clients in lowering their electricity use and expenditures by offering comprehensive consumption insights. In recent years, a growing body of study has concentrated on smart metre data analytics due to its potential to help consumers save money and reduce climate change. This paper's main objective is to present a methodology for predicting a customer's total monthly electricity consumption at various points in the monthly billing cycle. This kind of information can be helpful for both the residential customer and the distribution network operator in estimating future residential electricity demand. The residential customer can use it to get a better idea of how much electricity he will use each month and adjust his usage accordingly. Numerous research in the literature have focused on the area of load forecasting, taking into account various aggregation levels and prediction horizons. These studies have mostly concentrated on forecasting aggregated loads, usually at the level of big substations or transmission systems. The introduction of modern metering infrastructure has given utilities access to more precise individual data than ever before, which has increased the number of individual forecasting studies. Few research on individual-level forecasting, a recent area of study, have concentrated on short-term forecasting, mostly day-ahead forecasting. The average daily energy consumption over the previous seven days has been utilised in earlier research on monthly bill forecasting at the level of a single customer to anticipate the overall energy consumption at the end of the monthly billing cycle.

However, because this methodology has only been applied to a small number of data points from a single customer, it is difficult to assess how well it is working. The new paper departs from this earlier work by putting forth a general strategy for monthly consumption forecasting as well as a more extensive case study that assesses the forecast's efficacy over a number of clients and months of data. The main contributions of this paper are a feature augmentation strategy to increase the number of features to 700; a shrinking time window-based forecasting approach that enables us to predict the monthly total consumption at various time horizons; and, finally, a case study that uses smart metre data from 1,000 households in the London area and compares the results. The essay is set up as follows. The introduction to the topic covered in the essay is provided in Section I. The problem scenario is described in Section II. The methodology is described in Section III. The experiment's setup and findings are revealed in Section IV. The important findings and the research's next steps are discussed in Section V, the section that closes the paper.

People today use electricity carelessly, regardless of the supply. As a result, the supply and demand are not balanced. The spotlight is shifting to more and more energy production as a result of the frightening rate at which the global energy crisis is growing. Due to a lack of adequate and effective historical data on energy usage, developing countries are dealing with an acute problem of power theft and disorganised power management. Power firms have suffered enormous losses as a result, or customers now pay unreasonably high electricity prices. The utilities have increased their energy efficiency efforts significantly in response to rising energy prices and public pressure to reduce carbon emissions. As one grows more adept at using electricity, they can quickly determine how much to utilise and consume. As a result, a lot of new technology has been developed to meet user requests. India is expanding quickly and aims to become a prosperous nation by 2020. After China, the United States, and Germany, India has the fourth-largest capacity in the world with 32,280MW. By 2022, India would need a target amount of 60 GW of electricity. The implementation of smart metres, also known as advanced metering infrastructure, satisfies the fundamental principle of the smart grid (SG) idea. By doing this, issues like blackouts and power shortages will be avoided. The goal of this endeavour is to better comprehend the viability of the solutions offered.

An energy metre that monitors electrical energy in units of KWh is called a smart metre. It is a straightforward gadget that helps users cut costs on their energy consumption bills. They are a part of the Advanced Metre Infrastructure and are in charge of allowing the energy providers to receive automatic metre readings.

The advanced metering infrastructure is made up of the bidirectional communication network, smart metres, and data management system. It contributes to the reliability of the grid and the promotion of energy efficiency in modern power distribution systems by storing customer load profiles and enabling two-way information exchange. Installations of smart metres have several advantages for a variety of system stakeholders. Better access to and data to manage energy use, more precise and timely billing, improved outage restoration, power quality data, early detection of metre tampering and theft, data for improved efficiency, reliability of service, losses, and loading, improved data for efficient grid system design, and data for improved outage restoration are just a few advantages associated with data obtained from smart metres.

Future smart grids will face significant difficulties in collecting and analysing the vast amounts of data generated by integrated devices like distributed storage, intelligent loads, and distributed energy resources. To improve the efficiency, reliability, and sustainability of the smart grid, to give a better understanding of consumer behaviour, and to help define electric tariffs, enormous amounts of data from smart metres used for monitoring and control reasons must be adequately managed. In order to handle enormous amounts of data and related analyses, this big data challenge requires cutting-edge technologies and infrastructure. Analytics is the methodical process of turning data into knowledge that can be used to improve decisions. Descriptive analytics (what the data look like), predictive analytics (what will happen with the data), and prescriptive analytics (what judgements may be made from the data) are the three types of data analytics that are specified. Following these three kinds of analytics, we define load analysis, load forecasting, and load management as the three main application areas in smart grid. In order to better understand the volatility and uncertainty of the load profiles, this work focuses on descriptive analytics in the context of the smart grid. Systems for descriptive analytics enable the description of particular traits of a household based on its electricity usage. It is suggested to use a system based on supervised machine learning. It recognises traits capturing a household's socioeconomic position, housing assets, behaviour, and appliance stock. Other

• energy thief detection; poor or missing data detection and data imputation. For this, supervised learning and unsupervised learning are both used.

• Load profiling, which is the categorization of load curves or consumers based on patterns of electricity consumption. This is accomplished by using both direct and indirect clustering techniques.

This article offers several approaches for analysing household load data, such as comparing daily load profiles, analysing load density, and examining seasonal and irregular elements in the load time series.

One of the main issues for electric utilities is the loss of electrical energy in the transmission and distribution system. There are two types of energy losses in power distribution systems: technical and non-technical losses. The technical ones refer to energy loss as a result of power lost through copper losses, dielectric losses, induction losses, and radiation losses in electrical system components. While non-technical (NT) losses are energy losses incurred by utilities as a result of events outside the power system. Tapping power lines and interfering with metres are the two main ways that NT losses are reduced. Electric utilities suffer enormous losses as a result of energy theft. Theft of energy can take place in three different ways: physically, electronically, or digitally. Modifications include physical assaults. Cyber-attacks can target computerised energy metering systems or remotely intercept communication links to alter the transmitted or stored energy data. assaults against the integrity of the metre data at any time are considered data assaults. The data attacks try to delete a big load appliance from recording, declare zero energy consumption, or reduce the energy data value to a fraction.

These are major difficulties encountered by electric utilities because all attacks try to lower reported energy usage levels and consequently lower energy costs. Power grid development has not been consistent over the world since underdeveloped countries still do not have a fully developed ICT infrastructure on the grid system. However, all nations have access to energy consumption metres for invoicing purposes. The performance of several data-driven machine learning models that can be used to secure smart grid in terms of identifying energy theft is compared in this paper. The energy consumption data at the customer level is used to create the models. The identification of energy theft is carried out using each individual's consumption trends.

Therefore, these data-driven models can be used in emerging nations as well. Recent research has focused on identifying energy theft using mathematical and data-driven non-machine learning modelling. However, the existing research has some drawbacks, including the necessity for particular hardware, the need for user intervention for sophisticated feature extraction based on electrical domain expertise, and the poor detection accuracy of Support Vector Machines (SVM) or Logistic Regression models. An LSTM-based energy theft detection model is suggested in this paper. The suggested remedy deals with the problems of class disparity as well as the significant amount of missing data (in our case study, 25% of the data were missing). The long-term dependency feature of the LSTM model helps the model, and the experimental findings demonstrate that the suggested model performs better than the currently employed methods in the literature. The remainder of this essay is organised as follows. The literature overview on various data-driven and machine learning techniques utilised for smart grid applications, such as energy theft identification, is presented in Section II. The approach and evaluation of various data-driven techniques for identifying energy theft are presented in Section III. The results that were obtained are given and analysed in Section IV. Section V explains the findings in detail.

An electricity network that uses smart technology to monitor, manage, and distribute electricity to customers is known as a "smart grid." In order to decrease energy consumption and costs, increase efficiency, maximise transparency, and improve the security of the energy supply, it creates a platform for observation, analysis, control, and communication inside the network. The development of Advanced Metering Infrastructure (AMI) technology has hastened the adoption of smart grids on a global scale. The foundation of smart grid technologies is AMI. AMI is an infrastructure that has a specific number of smart metres connected to the Head End System (HES) either directly from the smart metres themselves or centrally via a Data Concentrator Unit (DCU). The most advanced energy metre currently available measures electrical energy usage with built-in smart technologies that set it apart from a typical conventional metre. Smart metres are made to take into account both the needs of the utility providers and the customers.

A wide range of hardware and software solutions must be implemented in order to integrate smart metres into the electrical grid. The smart metre is the central component of the smart grid deployment and is primarily concerned with giving data and information to the Head End System (HES) upon request. By giving immediate information on events like power theft detection, tampering, etc., smart metres secure the utility. This in turn helped the smart metre gain popularity across the globe. The use of smart metres is still in its early stages in India. But many wealthy nations, including Australia, Canada, the United States, and the United Kingdom, have already adopted smart metres on a considerable basis. The IS16444 (2015), IS15959 (Part I, 2011), and IS15959 (Part II, 2016) standards for smart metres are used in India. The Centre for Development of Advanced Computing (CDAC) has created a smart metre that complies with Indian requirements and is ready to incorporate upcoming revisions because these standards were just recently established and are still undergoing amendments. The demand side control and load limiting capabilities of smart metres are its standout features. The utility can determine an individual customer's trend in energy usage by routinely monitoring and analysing data from smart metres provided by the HES. This enables the utility to plan ahead for an adequate supply of electricity without risking transformer trips that render a whole neighbourhood powerless.

If a customer's energy use exceeds the allowed load, the utility can remotely disconnect that customer's supply through the smart metre without disturbing the neighbourhood. Only the robust analysis techniques used at HES make this type of demand side management practicable.

As a result, the utility can better manage and keep an eye on the smart grid, which boosts its dependability and efficiency. The utility can set higher prices during peak times thanks to the programmable tariff zones function in smart metres, which helps to flatten the demand curve. The users can also be given access to their energy usage data from smart metre readings, allowing them to use that data to lower their energy consumption.

Energy conservation and waste elimination are two of the European Union's (EU) top priorities. The European Commission for Energy Efficiency claims that there is a huge opportunity to reduce consumption, particularly in energy-intensive industries like manufacturing, construction, and residential. As an EU member, Greece is required to reach particular environmental goals by 2020 in order to lower its carbon emissions by 20%. This includes meeting 18% of its energy consumption with RES. In order to evaluate the existing Greek interconnected Electric system (GIES) and validate the likelihood that Greece would be able to meet the EU targets, Kalampalikas and Pilavachi built a model for this purpose. The study supports the use of renewable energy. The evaluation criteria for both studies are based on three factors: energy, environment, and economy. Didden and D'haeseleer analyse the research and activities that are currently being conducted on Demand Side Management (DSM) in the European energy market in their study, which identifies several problems that will need to be resolved when DSM is put into practise.

They specify that the EU nations should pick one of the examined DSM frameworks and should not implement more than one, as this will raise uncertainty and bureaucracy and have unintended consequences, resulting in inefficiency. Faruqui et al. claim that smart metres in particular could fill the gap since they could make it possible to offer dynamic pricing, which lowers peak demand and lessens the need for building and operating pricey peaking power plants.

The need for industry, consumer, and public services also plays a significant impact, but because these demands are intimately related to economic growth, this study will concentrate on residential demand. It is clear that the percentage is quite high (more than one third), and Psiloglou et al. described the causes of this high demand in a comparative study. The study that the authors offer in their paper compares the air temperature and electricity usage in two cities during a given time period. Both Athens, Greece, and London, United Kingdom, are discovered to have electricity peaks in the winter, while Athens has a second, similarly significant peak that is noticeable in the summer.

# CHAPTER 3:

# METHODOLOGY

AC Mains supply is given to the NodeMCU is Wi-Fi device which has a microcontroller in it. This connects the local router through IoT. The status of these parameters can be obtained through mobile or laptop.

WIFI is used for data communication. WIFI is configured with NodeMCU. The Data from the current senser is sent to WIFI module and it reaches the user mobile phone. In this system the user can switch on/off the mains or home appliances from their Android smart phone app. The WIFI module transmits and receives the data from cloud and sends to NodeMCU and the NodeMCU controls the relay to switch on and off the circuit of the home.

## 3.1 Block Diagram

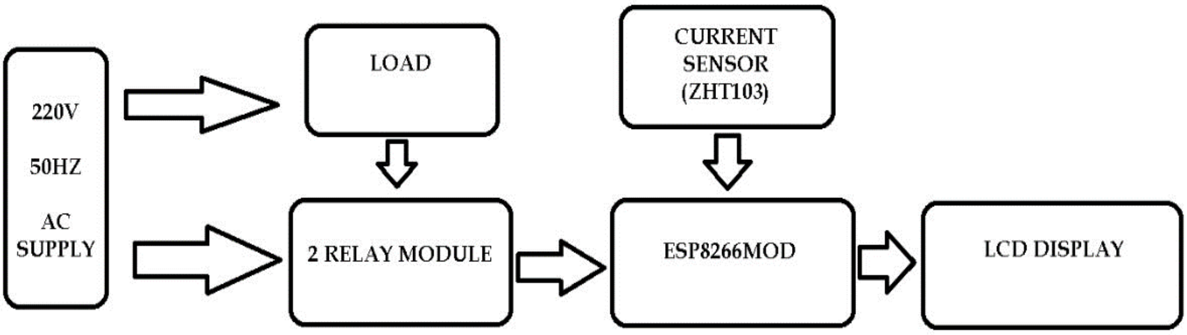
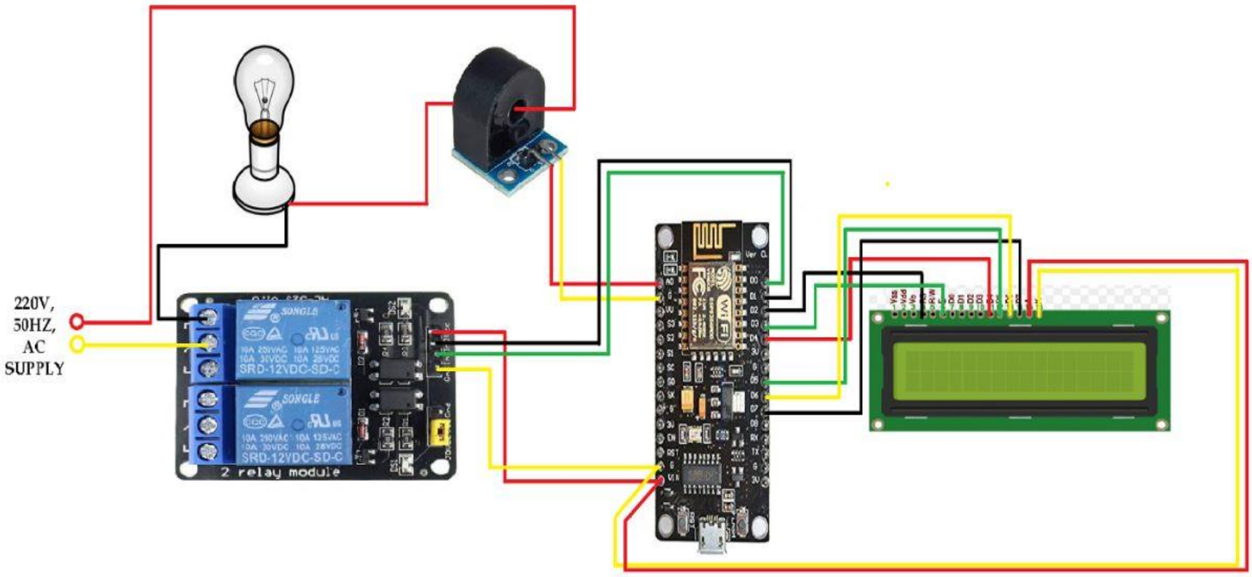



Fig.3.1 Block Diagram Of Smart Energy Meter

The power supply provides the power to the meter. It can be a battery, or a mains power supply is given through relay module and the load. Positive terminal is connected through current sensor to the supply and Negative is directly connected to supply.The current sensor measures the current flowing through the load.The data from the current sensor is sent to the NodeMCU.then the NodeMCU calculates the units consumed by the load and the input current is displayed.

Using blynk application the load can be shutdown manually or it will be automatically shutdown when the consumption of units exceeds.After all this process the bill will be generated.

## 3.2 Circuit Diagram



## 3.3 Hardware and Softerware Requirement

### 3.3.1 Hardware

- Current Sensor
- Relay Module
- LCD Display
- NodeMCU
- Load
- Connecting wires

### 3.3.2 Software

- NodeMCU ESP8266

## 3.4 Current Sensor

Popular and frequently used for measuring current is the ZHT103 current sensor. It is based on the Hall effect principle, which makes use of the magnetic field produced by a conductor's current to measure the current's strength. A magnetic core and a Hall effect sensor integrated circuit (IC) make up the ZHT103 current sensor.

Usually, the sensor is positioned close to the conductor where the current is flowing. A magnetic field is produced as current flows through the conductor, and this magnetic field interacts with the Hall effect sensor. This magnetic field is detected by the sensor, which then produces a proportionate voltage output. To accurately represent the current magnitude, the output voltage is subsequently analysed and calibrated. The ZHT103 current sensor has benefits including galvanic separation between the measured current and the measuring circuit, high accuracy, low power consumption, and non-contact measurement. It has uses in a number of industries, including industrial automation, energy management systems, motor control, and power monitoring.

## Features:

- Analogue output
- Current range of 0.3 to 5A
- 1000:1 Transformation
- PCB board size: 18.3 x 17mm
- Onboard sampling resistor

## 3.5 Relay Module

Relay modules are electronic parts that serve as a connection between a microcontroller or digital circuit and high-power electrical loads. It is made up of an electromechanical relay with many switching channels and a control circuitry.

The relay itself is a switch that may be electrically operated to open or close a circuit and enable or prevent the flow of current to the connected load. The control circuitry for the relay module is designed to separate the low-power control signals from the microcontroller from the high-power demand. When a control signal is applied to the relay module, igniting the coil of the relay, the contacts really move. The relay module can manage a wide range of voltages and currents.

The relay is one kind of electro-mechanical part that performs the function of a switch. DC is used to power the relay coil, which opens or closes contact switches. In a single channel 5V relay module, a coil and two contacts, such as normally open (NO) and normally closed (NC), are frequently present.


## 5V Relay Module Specifications

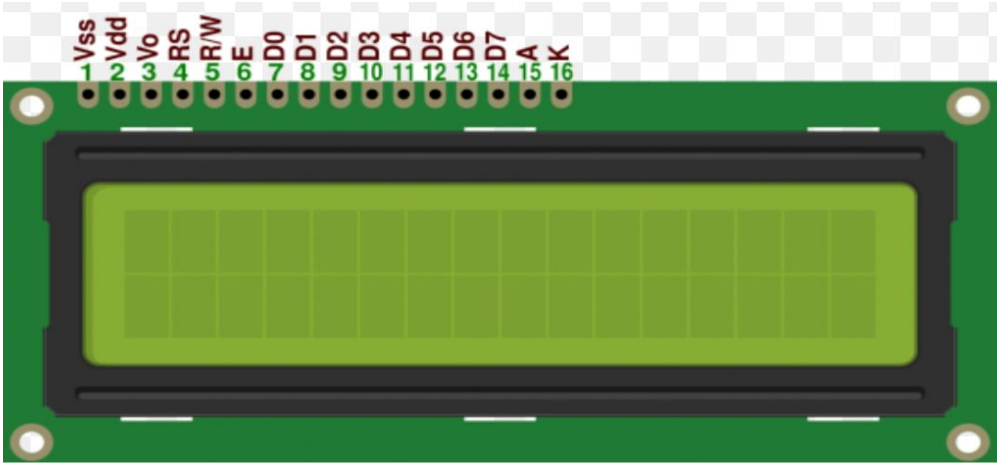
- Normal voltage: 5V DC.
- Normal current: 70mA.
- Maximum load current: 10A/250V AC, 10A/30V DC.
- Maximum switch voltage: 250V AC, 30V DC.
- Operate time: ≤ 10ms.
- Release time: ≤ 5ms.

## 3.6 LCD Display

An LCD display 16 x 2 is a liquid crystal display module with the ability to display 16 characters per line and 2 lines of text. It is a popular type of alphanumeric display that is commonly used in many electronic devices, such as digital metres, calculators, and microcontroller-based projects. The 16 x 2 LCD screen has a grid with 16 columns and 2 rows, giving it a total of 32 character positions. Each character slot may be filled with any combination of letters, integers, symbols, or specifically defined characters.

Controlling the display is made simpler by a standard integrated circuit driver found in display modules like the Hitachi HD44780. This driver allows for a straightforward interface with microcontrollers or other control systems.

The controlling device communicates with the 16x2 LCD display via a series of control lines (such as data lines, enable, read/write, and control signals) in order to control the behaviour of the display. Through the data lines, the characters or specially created patterns to be shown are delivered.




## Features:

• Backlight: To enhance visibility in low light, these LCD panels usually come with an integrated backlight.

• Character Generation: The display module may generate conventional ASCII characters as well as custom characters that users can design for specialised purposes.

• Cursor control: The cursor's position on the LCD screen can be adjusted to indicate where to type the next character or to highlight a specific character.

• The "Home" button can be used to navigate to the home position, which is the first character of the first line, and the display can be cleared to remove all characters.

• Shift Function: The display module lets you shift the displayed text while also allowing you to scroll or modify the emphasis of specific characters.

## 3.7 NodeMCU ESP8266

We have the ideal level of adaptability to execute the majority of our duties thanks to excellent hardware like Node MCU. It has built-in Wi-Fi, is Arduino compatible, and can power our IOT devices. Regardless of whether you're using our cloud solutions or a gateway. Node MCU is an open-source, free IOT platform. It is made up of hardware based on the ESP-12 module and firmware that utilises the ESP8266 Wi-Fi SoC from Espressif Systems. The firmware is frequently intended when the term "Node MCU" is used, not the development kits. The firmware uses Lua as its primary programming language.


### 3.7.1 Pin Layout

The ESP8266's pin numbers DO NOT correspond to the numbers on the pins. For instance, the board's pin D1 really maps to GPIO5, not GPIO1 as you might assume. The above diagram shows how to understand the mapping.

The mapping list between Node MCU pins and GPIO is also provided below for your convenience:

- D0 = GPIO16
- D1 = GPIO5
- D2 = GPIO4

• D3 = GPIO0

• D4 = GPIO2

• D5 = GPIO14

• D6 = GPIO12

• D7 = GPIO13

• D8 = GPIO15

• D9 = GPIO3

• D10 = GPIO1

(Auxiliary constants for the board LED; not a board pin.) LED_BUILTIN = GPIO16

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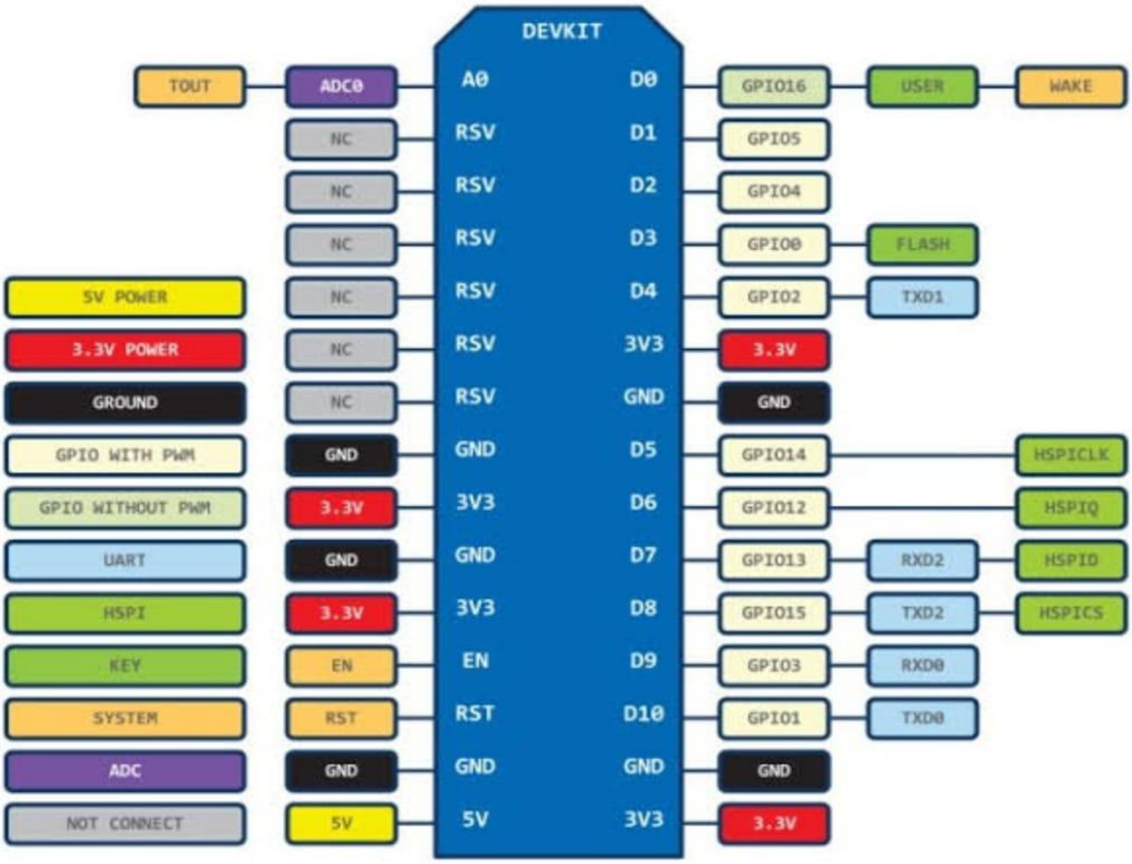


Because there are numerous ESP8266 types available, your ESP8266 board may not exactly match the one pictured below:

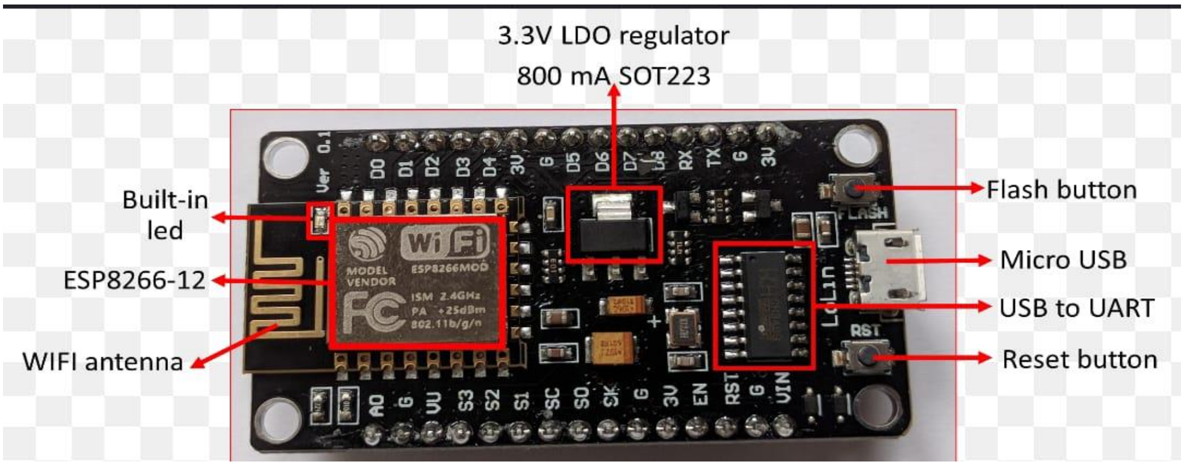


FIG 3.7.2 NODEMCU

The ESP8266-12 block in the image above contains the processor, memory, and WiFi module. Connectivity to external sensors, a USB port, a voltage regulator, and other features are ensured by the remaining parts. If you're interested in computer architecture, have a look at the functional diagram for the ESP8266-12:

The ESP8266-12 architecture

. • The Central Processing Unit (CPU) with SRAM (Static Random Access Memory)

The ESP8266 is powered by a 32-bit CPU with 16-bit instructions. The Harvard design makes both instructions and data memory completely independent. The ESP8266's Read-Only Memory (ROM) houses a starting boot loader and a few library software. The remainder of the code must be stored on external Serial flash memory, which only supports serial data access (reads or writes large contiguous groups of bytes serially rather than addressing individual bytes).Depending on your ESP8266, the amount of flash memory that is immediately available could vary.

Like any other microcontroller, the ESP8266 has a variety of GPIO (General Purpose Input/Output) pins that can be used to "control" external sensors. Only 11 of the 34 17 GPIO pins on our ESP8266 are functional because six of them are required to communicate with the main-board flash memory chip. A digital number that the ESP8266 can store and process can be created from the voltage level using the analogue input that is also there. It also has WIFI communication capabilities, enabling you to connect the ESP8266 to a WiFi network, access the internet, run a web server, enable smartphone connections, etc. Another advantage of an ESP8266 is its capacity to be programmed like any other microcontroller, particularly any Arduino.

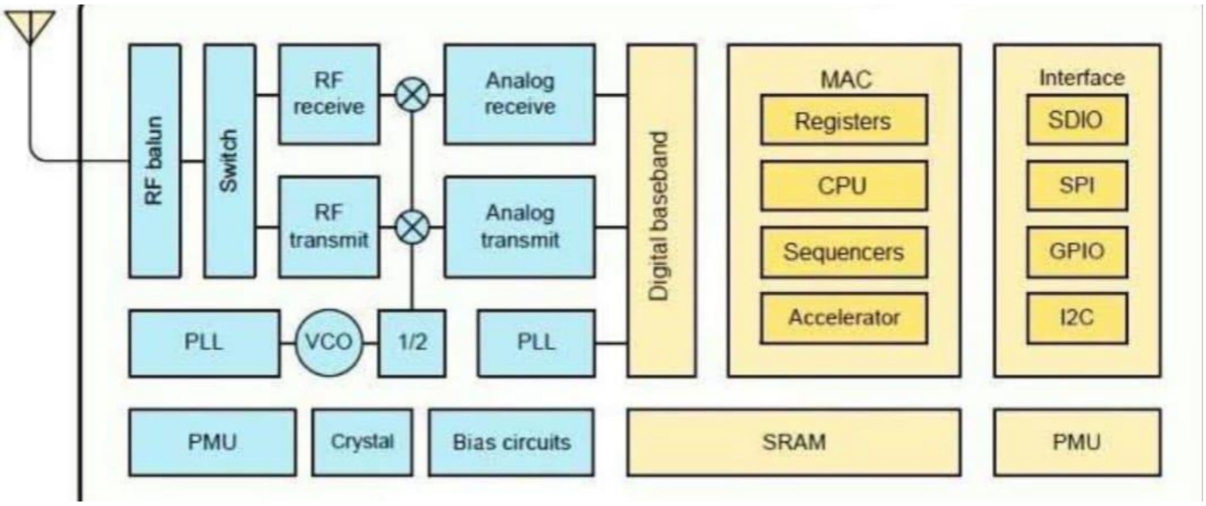


FIG 3.7.3 ESP8266-12's Functional diagram

## 3.8 Advantages of project

- Accuracy
- Efficiency
- Real-time monitoring
- Energy conservation
- Cost savings
- Remote control

## 3.9 Application of project

- Energy monitoring
- Demand response
- Load management
- Fault detection
- Grid optimization
- Renewable energy integration

## CHAPTER-4

# RESULTS AND DISCUSSIONS

IoT-based smart energy metre have gained a lot of attention recently due to their ability to monitor and control energy consumption in real-time. These metres take advantage of the Internet of Things' (IoT) ability to collect data from a variety of sensors and devices, encouraging efficient energy consumption and reducing waste. In this section, we present the conclusions and feedback from the implementation and evaluation of an IoT-based smart energy metre.

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The IoT-based smart energy metre was able to track and record energy usage trends in real-time. The electrical system's main power source and a few specific appliances were among the locations where the metre installed sensors to gather data. Lower energy expenditures and overall cost savings resulted from the wireless communication methods used to transmit this information to a central server.

Real-time Data Analysis: To glean insightful information, real-time analysis of the collected energy use data was conducted. The discovery of patterns and trends in energy usage through advanced analytics techniques enabled users to comprehend their own energy consumption patterns and make informed choices for energy saving. Quick corrective steps were made possible by the generation of real-time alerts for unexpected energy use or potential waste.

Cost Savings and Improved Energy Efficiency: The deployment of a smart energy metre powered by the Internet of Things brought about cost savings and improved energy efficiency. By giving real-time data on energy use, users were able to identify equipment or processes that consumed a lot of energy and optimise their use. If users have the ability to remotely monitor energy usage, they can plan appliances to run during off-peak hours to benefit from cheaper electricity costs.

Demand Response and Load Management: The IoT-enabled smart energy metre made Demand Response and Load Management techniques viable. By observing energy usage patterns, peak demand periods were identified, and load-shedding or load-shifting mechanisms were implemented. Users could schedule some appliances or processes to run during off-peak hours to minimise the load on the electrical grid during periods of peak demand. This improved the stability of the grid and increased the overall sustainability of the energy system.

## CHAPTER-5

# CONCLUSION

## FUTURE SCOPE

As these cutting-edge devices continue to change how we consume and manage energy, the potential for smart energy metres is extremely positive. Due to technological advancements and rising concerns about energy efficiency and sustainability, smart energy metres are well-positioned to play a significant role in shaping the future of energy management.

Future scope must include the integration of smart energy metres into the larger smart grid system. As smart grids proliferate, energy metres will be crucial nodes that enable two-way communication between utility providers and customers. Real-time monitoring, analysis, and optimisation of energy use will be available because to the bidirectional information flow. Customers that use smart metres receive detailed information about the trends in and costs associated with their energy use.

## CONCLUSION

Conclusively, the application of smart energy metres has shown to be a significant advancement in the field of energy management. By adopting these tools, utility companies and customers can both benefit immensely. Consumers can use smart energy metres to make informed decisions about their energy usage, which improves energy efficiency and lowers costs. They accomplish this by sending real-time energy use data. With the ability to remotely monitor and control energy usage, utility companies may also optimise energy distribution, identify and address issues more rapidly, and eventually boost the overall dependability and stability of the system. Additionally, there are opportunities for the creation of smarter energy systems when smart energy metres are combined with cutting-edge technology like the Internet of Things (IoT) and data analytics.

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# SOFTWARE USED IN NODEMCU ESP32

```
#define BLYNK_TEMPLATE_ID "TMPL3NEiga_p8"
#define BLYNK_TEMPLATE_NAME "energy meter"
#define BLYNK_AUTH_TOKEN "kbbWOeC8GzEUADD-TnVY2enwo7W_IvLh"

#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
char ssid[] = "Prayag";
char pass[] = "12345678";

#include <LiquidCrystal.h>
const int rs = D2, en = D3, d4 = D4, d5 = D5, d6 = D6, d7 = D7;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);
int volValue=A0;
int readValue;
float Value;
float Voltage;
int count;
int unit;
int flag;



void setup()
{
  Serial.begin(115200);
  Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass, "blynk.cloud", 80);
  lcd.begin(16, 2);
  pinMode(volValue,INPUT);
```

```
  Serial.begin(9600);
  pinMode(D0,OUTPUT);
  pinMode(D1,OUTPUT);
  digitalWrite(D0,HIGH);
  digitalWrite(D1,HIGH);
}


void loop()
{
  Blynk.run();
  readValue = analogRead(volValue);
  Voltage = (5./1023)*readValue;
  Value = Voltage/10.680;
//  Serial.println(Value);
  lcd.setCursor(0,0);
  lcd.print("CA:");
  lcd.setCursor(0,1);
  lcd.print(Value);
  lcd.setCursor(5,0);
  lcd.print("Count:");
  lcd.setCursor(6,1);
  lcd.print(count);
  lcd.setCursor(12,0);
  lcd.print("Unit:");
  lcd.setCursor(13,1);
  lcd.print(unit);
  delay(500);

if((Value<=0.02)&&(Value>=0.01))
```

```
{
    count++;
    lcd.setCursor(5,0);
    lcd.print("Count:");
    lcd.setCursor(6,1);
    lcd.print(count);
    delay(3000);
 }
 if((Value<=0.06) && (Value>=0.03))
{
    count++;
    lcd.setCursor(5,0);
    lcd.print("Count:");
    lcd.setCursor(6,1);
    lcd.print(count);
    delay(1000);
 }
   if((Value<=0.10) && (Value>=0.07))
{
    count++;
    lcd.setCursor(5,0);
    lcd.print("Count:");
    lcd.setCursor(6,1);
    lcd.print(count);
    delay(500);
 }
 if(count==5)
 {
    unit++;
    lcd.setCursor(12,0);
```

```
  lcd.print("Unit:");
  lcd.setCursor(13,1);
  lcd.print(unit);
  delay(100);
  count=0;
}
 if(unit >= 7)
  {
     lcd.clear();
    digitalWrite(D0, HIGH);
    digitalWrite(D1, HIGH);
    int  Amount=unit*7;
  lcd.setCursor(0,0);
  lcd.print("Bill generated:");
  Blynk.virtualWrite(V4,"Bill Generated:");
  Blynk.virtualWrite(V4,"\n");
  delay(2000);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Total Bill");
  lcd.setCursor(0,1);
  lcd.print(Amount);
  Blynk.virtualWrite(V3,"Total Bill:");
  Blynk.virtualWrite(V3,Amount);
  Blynk.virtualWrite(V3,"\n");
  delay(2000);
  unit=0;
  Amount=0;
  flag = 0;
  }
```

```
  if(flag==1)
  {
     digitalWrite(D0, HIGH);
     digitalWrite(D1, HIGH);
     int  Amount=unit*7;
     lcd.setCursor(0,0);
     lcd.print("Bill generated:");
     Blynk.virtualWrite(V4,"Bill Generated:");
     Blynk.virtualWrite(V4,"\n");
     delay(2000);
     lcd.clear();
     lcd.setCursor(0,0);
     lcd.print("Total Bill");
     lcd.setCursor(0,1);
     lcd.print(Amount);
     Blynk.virtualWrite(V3,"Total Bill:");
     Blynk.virtualWrite(V3,Amount);
     Blynk.virtualWrite(V3,"\n");
     delay(2000);
     unit=0;
     Amount=0;
     flag = 0;

    }
    lcd.clear();
}

BLYNK_WRITE(V0)
 {
   if(param.asInt() == 1)
```

```
  {
    digitalWrite(D0, LOW);
  }
  else
  {
    digitalWrite(D0, HIGH);
  }
}

BLYNK_WRITE(V1)
{
  if(param.asInt() == 1)
  {
    digitalWrite(D1, LOW);
  }
  else
  {
    digitalWrite(D1, HIGH);
  }
}

BLYNK_WRITE(V2)
{
  if(param.asInt() == 1)
  {
    flag = 1;
  }
}
```