DESIGN OF SMART ENERGY MONITORING SYSTEM

A

MINI PROJECT REPORT

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BONAFIDE CERTIFICATE

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ABSTRACT

The number of household appliances has drastically increased in the recent years and with this, so has the consumption and demand for electricity. In the face of declining energy resources, there is a need for a solution that can help track, measure and control the consumption of electricity. Conventional energy meters do not provide information regarding power consumption at the device-level, due to which consumers cannot monitor or log the electricity consumed by each appliance. To bridge the gap in device energy consumption data, we propose the design and implementation of an Internet of Things (IoT) enabled, minimalistic, cost-effective and efficient smart energy meter which will aid consumers in obtaining information on the energy consumption of any electrical appliance. This will not only assist consumers in ensuring that their devices function as per the energy rating but also help them access energy expenditure patterns formed over time which will contribute towards awareness and conscious conservation of energy. This can reduce human errors and helps to retrieve the real time meter value and send it to customers mobile phone . This also allows electricity board to modify the variable package price in specific duration. The administrator can analyze the customers power consumption data and generate the report from the data online. The prototype will be able to introduce the billing system to the customers, get the power consumption data from smart meter, keep the data in centralized database and generate the report.

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LIST OF ABBREVIATIONS

AC	:	Alternating Current
API	:	Application Programming Interface
AREF	:	Analog REFerence
BN	:	Backbone Network
GSM	:	Global System For Mobile Communication
GLS	:	General Lamp Service
GNU	:	GNU’s Not Unix
HVAC	:	Heating, Ventilation and Air Conditioning
IC	:	Integrated Circuit
ICSP	:	In Circuit Serial Programming
IJCEM	:	International Journal Of Clinical And Experimental Medicine
IDE	:	Integrated Development Environment
IoT	:	Internet Of Things
LED	:	Light Emitting Diode
MATLAB	:	Matrix Laboratory
PWM	:	Pulse Width Modulated
RMS	:	Root Mean Square
TTL	:	Transistor – Transistor Logic
UART	:	Universal asynchronous receiver/transformer
USB	:	Universal Serial Bus
WIFI	:	Wireless Fidelity

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

Electricity is one of the vital requirement for sustainment of contents of life. It should be used very judiciously for its proper utilization. But in our country we have lot of locality where we have surplus supply for the electricity while many areas do not even have access to it. Our policies of its distribution are also partially responsible for this because we are still not able to correctly estimate our exact requirement and still power theft is prevailing. On the other hand consumers are also not satisfied with the services of power companies. The majority of the time, they get complaints about statistical mistakes on monthly invoices. This allows us to monitor the metre and determine whether or not an issue exists. In previous meter a circular metal strip rotates and according to that rotation we calculate the consuption. As shown in the figure 1.1. With the help of this energy monitoring system we are aiming to receive the monthly energy consumption from a remote location directly to centralised office. In this way we can reduce human efforts needed to record the meter readings which are till now recorded by visiting every home individually.

Conventional electric meters supplied by the Government’s electricity supply boards measure the power consumption of the whole residence or industry on a monthly basis. This implies that consumers have no means to monitor the power consumption of individual appliances. Due to the lack of communication facility in these meters, consumers cannot access or log the energy consumption either. Also, since the billing system only acknowledges the overall consumption in this setting, consumers are unaware of their daily behavior with respect to energy consumption. This means that they also lack of awareness regarding the operational behaviour of their electrical appliances.

Energy consumption monitor will allow users to identify a device-level expenditure trend and utilise that information to deliberately regulate their energy consumption. This data may also be utilised by consumers to identify and replace inefficient and energy-intensive appliances with more energy-efficient alternatives.

Figure 1.1 Smart metering

1.2 NEED FOR ELECTRICITY CONSUMPTION

More than 8% of the electricity you buy is probably based due to the design of your equipment and the way it has been installed. This is in addition to the energy wasted by running equipment for longer than neccesary. Electricity is the most expensive form of energy available - about 8 times the cost of coal and 6 times the costof gas – this expensive fuel must be used wisely.

Careful and systematic monitoring will be required to identify energy saving opportunities. It is essential that energy demand and cost of every aspect of the buisness are well understood, so that areas of the greatest waste can be identified and tackled and the solutions for one situation can be applied to similar areas.

The consumption pattern of electrical energy in indian domestic sector is as follows:

Table 1.1 Consumption of electricty

Application	**% age of Consumption**
Lighting	35 to 40%
Fanning	20 to 25%
Refrigeration	10 to 15%
HVAC	15%
Other(gadget etc.)	10 to 15%

The Table 1.1 refers to percentage of electricty that each applainces consumes. Thus the electricty which is one of the main energy source must be saved for future generation. The system takes this as the base of the project. This system helps in saving electricity by helping the user to keep track of the energy used and to know the future energy usage. The system alerts user when the energy value the user entered is going to be crossed so that the user can keep track of the energy used. In this way system supports in saving electricty

1.3 INTERNET OF THINGS

The IoT is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. A thing can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has builtin sensors to alert the driver when tire pressure is low or any other natural or manmade object that can be assigned an Internet Protocol (IP) address and is able to transfer data over a network. Increasingly, organizations in a variety of industries are using IoT to operate more efficiently, better understand customers to deliver enhanced customer service, improve decision-making and increase the value of the business. An IoT consists of web-enabled smart devices that use embedded systems, such as processors, sensors and communication hardware, to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with the devices for instance, to set them up, give them instructions or access the data.

The connectivity, networking and communication protocols used with these webenabled devices largely depend on the specific IoT applications deployed. The internet of things helps people live and work smarter, as well as gain complete control over their lives. In addition to offering smart devices to automate homes, IoT is essential to business. IoT provides businesses with a realtime look into how their systems really work, delivering insights into everything from the performance of machines to supply chain and logistics operations.

The future of IoT has the potential to be limitless. Advances to the industrial Internet will be accelerated through increased network agility, integrated AI and the capacity to deploy, automate, orchestrate and secure diverse use cases at hyper scale as portrayed in figure 1.2. In our project, the Internet of Things concept is used to measure the energy consumed by the electical device.

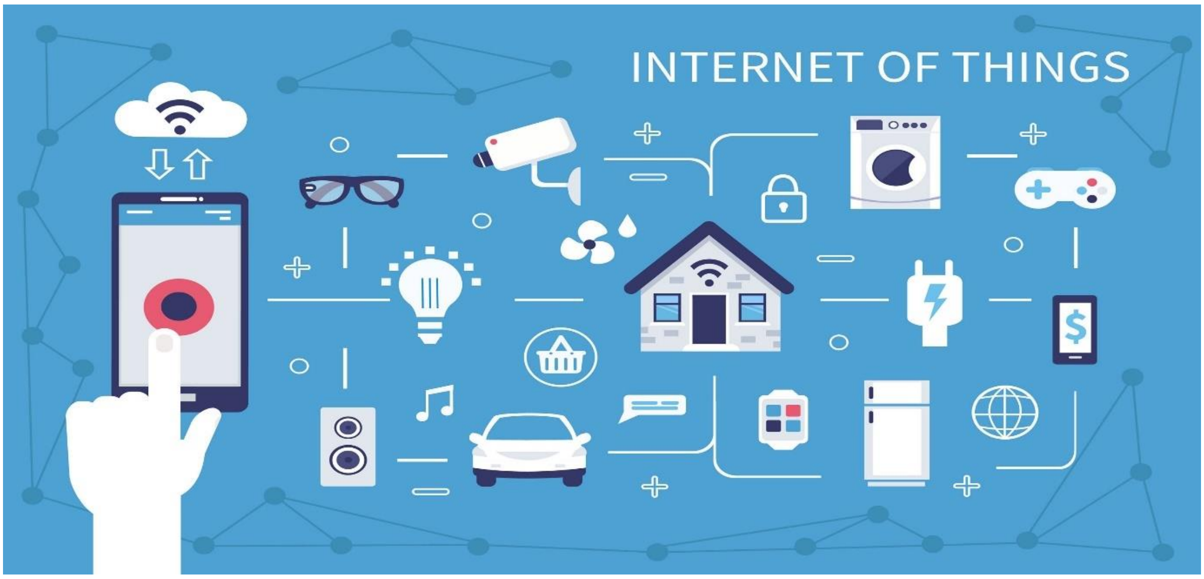

Figure 1.2 Feature of IoT

1.4 SENSORS

A sensor is a device, module, machine, or subsystem that detects events or changes in its surroundings and transmits the data to other electronics, most often a computer processor. Sensors are always used in conjunction with other devices.

Sensors are clearly deeply rooted in our everyday life and business situations. They will be extensively utilized in various fields to respond to social needs in the future. Particularly, with a feature that allows monitoring without human intervention, sensors will make an important contribution to work-style reforms. It might be worthwhile to consider integrating various types of sensors for your IoT business.

Role of IoT Sensors

IoT innovation made it possible to connect everyday things to the internet. Nowadays, almost all entities, such as houses, office buildings, factories, and even cities are connected to the network to collect data and utilize the information for various purposes. The importance of data has increased greatly, with many experts saying “data is the new oil”. Sensors play an important role in creating solutions using IoT. Sensors are devices that detect external information, replacing it with a signal that humans and machines can distinguish.

Sensors made it possible to collect data in most any situation and are now used in various fields - medical care, nursing care, industrial, logistics, transportation, agriculture, disaster prevention, tourism, regional businesses and many more. With the expansion of the fields in which sensors play an important role, the market is still growing with a variety of sensors.

There are a wide range of IoT sensors used to detect and measure various physical phenomena such as heat and pressure as well as the five human senses: sight, hearing, touch, taste and smell.

Example of sensors that detect physical properties:

- Temperture and Humidity sensors
- Acceleration sensors
- Gyro sensors
- Sound pressure sensors

- Odor sensors
- Imaging sensors

In our project, ACS712 current sensor as shown in figure 1.3 smart energy monitoring system can calculate the amount of current generated by the electric appliance.

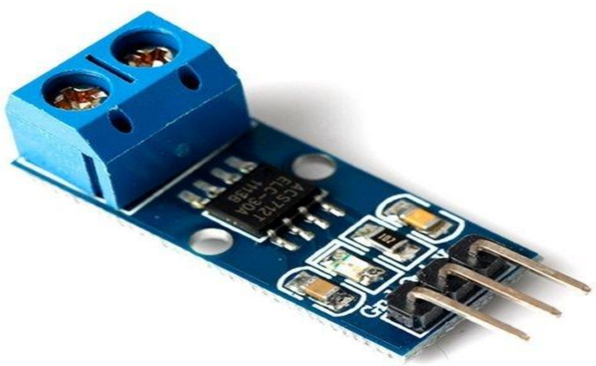

Figure 1.3 ACS712 Sensor

1.5 THINGS SPEAK

ThingSpeak is an open-source software written in Ruby which allows users to communicate with internet enabled devices as shown in figure 1.4. It facilitates data access, retrieval and logging of data by providing an API to both the devices and social network websites. ThingSpeak was originally launched by ioBridge in 2010 as a service in support of IoT applications.

ThingSpeak has integrated support from the numerical computing software MATLAB from MathWorks, allowing ThingSpeak users to analyze and visualize uploaded data using MATLAB without requiring the purchase of a

MATLAB license from MathWorks. This library enables an Arduino or other compatible hardware to write or read data to or from ThingSpeak, an open data platform for the Internet of Things with MATLAB analytics and visualization. ThingSpeak offers free data storage and analysis of time-stamped numeric or alphanumeric data.ThingSpeak stores data in channels. Channels support an unlimited number of timestamped observations (think of these as rows in a spreadsheet). Each channel has up to 8 fields (think of these as columns in a speadsheet). Channels may be public, where anyone can see the data, or private, where only the owner and select users can read the data. Each channel has an associated Write API Key that is used to control who can write to a channel. In addition, private channels have one or more Read API Keys to control who can read from private channel. An API Key is not required to read from public channels. Each channel can have up to 8 fields. One field is created by default. In our project the measured data from aurduino IDE is collected in datasheet and uploaded in thingspeak.

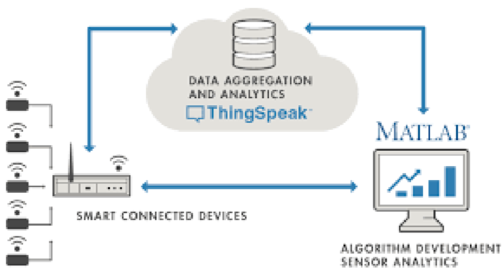

Figure 1.4 Thingspeak

1.6 OBJECTIVE

The main objective of energy consumption system is to devolop a plug-in and use device which can be easily incorporated in any household or industry. The most conspicuous reason is to measure accurate energy consumed by individual devices. To provide remote monitoring of the energy consumption over the internet and to provide an affordable, efficient solution toward making consumer aware about their electrical expenditure behaviour and thereby, encourage consicious conservation of system. hence, the system has been designed to operate as a stand-alone device that can be placed between the electrical appliance and the mains, without requiring any drastic, invasive changes or interruptions.

1.7. EXISTING SYSTEMS

In our project, we look at some of the commercially available smart energy metres and compare their features to showcase our contribution. June's smart energy module offers remote monitoring, data storage, and a specialised application. Limitation of June’s smart energy meter does not support plug-and-play functionality and device-level monitoring. Smartenit smart energy module supports remote monitoring, device level monitoring, data storage and dediacted application. Limitation of smartenit smart energy meter does not support plug and play. Revogi smart energy monitoring supports plug-and-play functionality, a device-level monitoring system, and a dedicated application. Limitation of Revogi smart energy meter does not provide remote monitoring or data storage. The L&T smart energy monitoring system allows for remote monitoring and data storage. Limitation of L&T smart energy monitoring system does not support plug-and-play, device level monitoring, or specific dedicated applications. The P3 International (P4400) offers plug-and-play and device-level monitoring. Limitation of P3 International (P4400) does not support remote monitoring, data storage and specific dedicated applications. BN-Link smart energy meter supports plug-and-play functionality as well as device-level monitoring. Limitation of BN-Link does not supports remote monitoring, data storage, or specific applications.

1.8 PROPOSED SYSTEM

We proposed to design a system that can be used easily with any electrical appliances without the need for complex rewiring thereby assuring affordability and easy to access consumption information. The system is built using Arduino UNO with ESP8266 onboard wifi module along with current sensor. The system will not impact the working of device whose consumption is being measured. Using a ThingSpeak channel information can be easily accessed, visualized and monitored. To implement an energy monitoring system through which the consumer can be equipped with information of the energy expenditure of individual or multiple electrical appliances. This will help them ascertain an expenditure pattern at the device-level and use this data to consciously manage their energy consumption. Also, this information can be used by the consumer to detect and replace faulty and energy-intensive appliances with their energy efficient counterparts. There is a dire need for an energy measurement device that is lightweight, minimalistic and efficient, which can be easily incorporated into the existing system. The motivation behind this work is to lower energy expenditure through energy losses by inefficient appliances. This can be achieved by increasing user awareness regarding device-level power consumption, which will contribute towards consumers taking conscious steps towards energy consumption and conservation.

1.9 SCOPE AND LIMITATIONS OF THE STUDY

The idea of the system is applicable for all the electrical device with different in range of size and results in accurate bills. Limitation of this system is older smart meters become dumb once you switch this means that your meter will continue to record your usage however it will lose its smart functionality and it will be no longer able to automatically send your readings to the new supplier.

CHAPTER 2

LITERATURE SURVEY

Barman, Bibek Kanti et all [4] in 2018 proposed the IoT based smart energy meter. The proposed smart energy meter controls and calculates the energy consumption using ESP 8266 12E, a Wi-Fi module and uploads it to the cloud from where the consumer or producer can view the reading. Therefore, energy analyzation by the consumer becomes much easier and controllable. This system also helps in detecting power theft. Thus, this smart meter helps in home automation using IoT and enabling wireless communication which is a great step towards Digital India.

Sun, Qie, Hailong Li et all [7] in 2018 proposed the IoT based smart energy meter. The significant increase in energy consumption and the rapid development of renewable energy, such as solar power and wind power, have brought huge challenges to energy security and the environment, which, in the meantime, stimulate the development of energy networks toward a more intelligent direction. Smart meters are the most fundamental components in the intelligent energy networks (IENs). Furthermore, smart energy meters can also be used to monitor and control home appliances and other devices according to the individual consumer's instruction. This paper systematically reviews the development and deployment of smart energy meters, including smart electricity meters, smart heat meters, and smart gas meters. By examining various functions and applications of smart energy meters, as well as associated benefits and costs, this paper provides insights and guidelines regarding the future development of smart meters.

S. Visalatchi and K. K. Sandeep [13] in 2017 proposed IoT based smart energy meter. Energy theft is a very common problem in countries like India where consumers of energy are increasing consistently as the population increases. Utilities in electricity system are destroying the amounts of revenue each year due to energy theft. Visalatchi newly designed AMR used for energy measurements reveal the concept and working of new automated power metering system but this increased the Electricity theft forms administrative losses because of not regular interval checkout at the consumer's residence. It is quite impossible to check and solve out theft by going every customer's door to door. In this paper, a new procedure is followed based on MICROCONTROLLER Atmega328P to detect and control the energy meter from power theft and solve it by remotely disconnect and reconnecting the service (line) of a particular consumer. An SMS will be sent automatically to the utility central server through GSM module whenever unauthorized activities detected and a separate message will send back to the microcontroller in order to disconnect the unauthorized supply. A unique method is implemented by interspersed the GSM feature into smart meters with Solid state relay to deal with the non-technical losses, billing difficulties, and voltage fluctuation complication.

S. Visalatchi, and K. Kamal Sandeep [2] in 2017 proposed the IoT based smart energy meter. Smart metering is one of the main objectives for the EU member states to ensure the benefit of consumers on the long term. Due to its functionality, smart meters have a wide applicability in: power quality monitoring, energy savings, data awareness and fraud detection. With long-term cost benefits of the smart meters, it is expected that 72% of European consumers will have a smart meter for electricity and 40% for gas by the year 2020. The successful roll-out is depended on each state regulation, interoperability, security and data privacy. In this paper, we reveal the potential of an open source smart metering solution based on an SMX (Smart Meter eXtention) platform, as a low-cost solution for data storag, processing and data analysis.

Patel, Himanshu K., et all [15] in proposed the IoT based smart energy meter. India faces the issue of energy theft at a very large scale. This paper introduces a system that removes human intervention in meter readings and bill generation thereby reducing the error that usually causes chaos and energy related corruption. The proposed system is implemented using a GSM shield module on microcontroller (Arduino®) together with LDR sensor and relay. Existing metering system can be minutely modified to implement the proposed meter. The proposed scheme is to connect an LDR sensor with the blinking LED and send the data to microcontroller via GSM shield. RTC provides delay and acts an interrupt. The system includes a provision of sending an SMS to user for update on energy consumption along with final bill generation along with the freedom of load reconfiguration via SMS. The disconnection of power supply on demand or due to pending dues was implemented using a relay. Hardware implementation results suggest that the accuracy of the proposed system is slightly greater than that of existing smart meters. The cost of system has been estimated to be less than the available smart meters, offering the same functionality. Bilateral communication between user and system sets it apart from the commonly available smart meters.

Hengyu, Tan et all [5] in 2020 proposed the IoT based smart energy meter. Smart energy meters have been widely used in the smart grid of various countries, but the current measurement methods of smart energy meters can not solve the traceability problem under the actual load current and power factor in the process of use, which leads to the inaccuracy of only meters in the field environment, and there is an unknown measurement risk. In order to achieve the accurate on-site verification of smart energy meters in normal working conditions, this paper studies the accuracy of smart energy meter field calibration standard device under different current and power factors, develops the error correction method under non-standard conditions. The correction method adopts the method of establishing reference standard value arrays under non-standard conditions to achieve fast and accurate on-site verification and effective measurement performance evaluation of the smart energy meters in use, to explore the measurement work for on-site calibration of smart energy meters under current and power factor in the actual environment.

Yaghmaeee, Mohammed Hossein and Hossein Hejazi [16] in 2018 proposed the IoT based smart energy meter. Internet of Things (IoT) can be used to furnish intelligent management of energy distribution and consumption in heterogeneous circumstances. In the recent years, by the growth of IoT and digital technologies, smart grid has been becoming smarter than before. The future power grid needs to be implemented in a distributed topology that can dynamically absorb different energy sources. IoT can be utilized for various applications of the smart grid including distributed power plant monitoring, power generation and consumption prediction, power consumption monitoring, energy storage management and various area of energy production. In this paper, by using the IoT capabilities, we have designed and implemented a smart energy metering platform consisting of smart plugs, gateway and cloud server.

Bhutta, Faiz M [6] in 2017 proposed the IoT based smart energy meter. In buildings, various kinds of energies like cooling, heating, hot Water, lighting, electricity and gas are used on daily basis to provide safety and comfort to occupants. The national and global trend is to transform a conventional building to smart building by making use of smart technologies. The main objective of smart energy technology is to reduce the energy cost and environmental impact in building life cycle. All engineers, planners and designers are looking for applications of smart technologies in buildings to achieve the goal of lowest possible energy cost with zero environmental impact on building life cycle. Also the conventional cities are being transformed into smart cites which are financially and ecologically viable through the use of smart energy technologies and systems. Use of Renewable Energy is one of the pillars for attaining smart building and smart cities infrastructure. Technologies like smart metering, smart Lighting, smart grid and Energy Internet, Renewable, Distributed, Net metering, LED, Smart Building Energy Management Systems (SBEMS), Insulations, Day Lighting, Smart HVAC systems are the major technologies being used to achieve a smart Building architecture. Many countries have set up targets to reduce the carbon footprint by 10 to 30% by deploying smart and renewable energy technologies coupled with energy efficiency improvements and conservation actions. Future prospects for smart technologies are very bright and it is future technology revolution toward achieving sustainable energy goals. By deploying the smart energy technologies, conventional buildings can be transformed to Smart energy buildings leading to sustainable and green energy future.

Kumar, Amit and Gopalakrishna Srungavarapu [17] in 2016 proposed the IoT based smart energy meter. Day by day in India we are moving towards technologies so everything started becoming advance. The proposal of smart cities in India has already came which include better way of urbanization. Smart meters are the key component in smart cities. Here we are going to discuss about how smart meters will be helpful in making our energy consumption as well as metering system smart. Concepts of smart cities and smart grid and how they are dependent on smart meters will be discussed here. Smart meters has brought big revolution in the fields of energy and power measurement. Worldwide at so many places smart meters has been already deployed but in India it is just starting of deployment of smart meters here some reports regarding that are also discussed.

Fangxing, Liu et all [14] in 2018 proposed the IoT based smart energy meter. This paper describes a method of online smart meter error calibration using meter reading data. An approach of data analysis using sum meter reading and branch meter reading in tree topology grid is studied. An algorithm based on the combination of K-means clustering and regularization theory is proposed to evaluate the smart meter error. The results of simulations based on real energy consumption data indicate the performance of the method.

Komathi, C., S. Durgadevi et all [18] in proposed the IoT based smart energy meter. This project aims to provide a smart way of measuring the electricity consumption in energy meters using modern electronic gadgets where the communication must be established between the user and the energy meter (which follows modbus communication) for daily update of the consumption. To provide this communication, the unit data received from the energy meter is interfaced with the microcontroller(ARDUINO UNO) through Modbus function code technique. Additionally, RS485 TO TTL CONVERTER is used in the interface setup where it acts as a gateway between energy meter and arduino board where the values from the energy meter is converted into a suitable form understandable by the arduino uno board. The microcontroller provides two functions in which one of them involves measuring the units consumed by the user. Using arduino software application, the user can now read the values in their system which is being used by them. When the user's power consumption exceeds the threshold amount, a service provider named twilio is utilised to send a notification to the user.

CHAPTER 3

SYSTEM DESIGN

3.1 DESIGN OF ENERGY MONITORING SYSTEM

The system is placed between the AC power supply and the device. It reads the energy consumption of the device by means of the current sensor. The Arduino then communicates this consumption data to the WiFi module every two minutes (or any customizable time interval) and the WiFi module in turn updates the ThingSpeak channel, where the consumer can access the information. The system initiates the calibration itself and as a part of this calibration, the system initializes a “zero point”. The zero point is the analogue value measured by the microcontroller when no load is connected to the system. The zero point is then subtracted from subsequently measured current values. During calibration, the system reads the value of the current measured by the sensor and sets it as a reference point of measurement, and then returns this value. By default, this parameter is equal to half of the maximum value on analog input i.e., 512; however, sometimes this value may vary as it depends upon on factors such as power issues. The value obtained from the calibration is then set as the zero point for further measurements. The mains voltage considered for this section is the standard voltage in India which is 220 volts, alternating at 50 Hertz per second. Since this is the similar to most countries in the world including Australia, Europe and the UK, the system can be easily adapted. An overview of the system operation is summarized in Fig. 3.1.

With the help of arduino microcontroller smart energy monitoring system will display the amount of electricity generated by the electrical appliances. Then with the help of WIFI module smart energy monitoring system will store the amount of electricity generated by the electrical appliances in thingspeak.

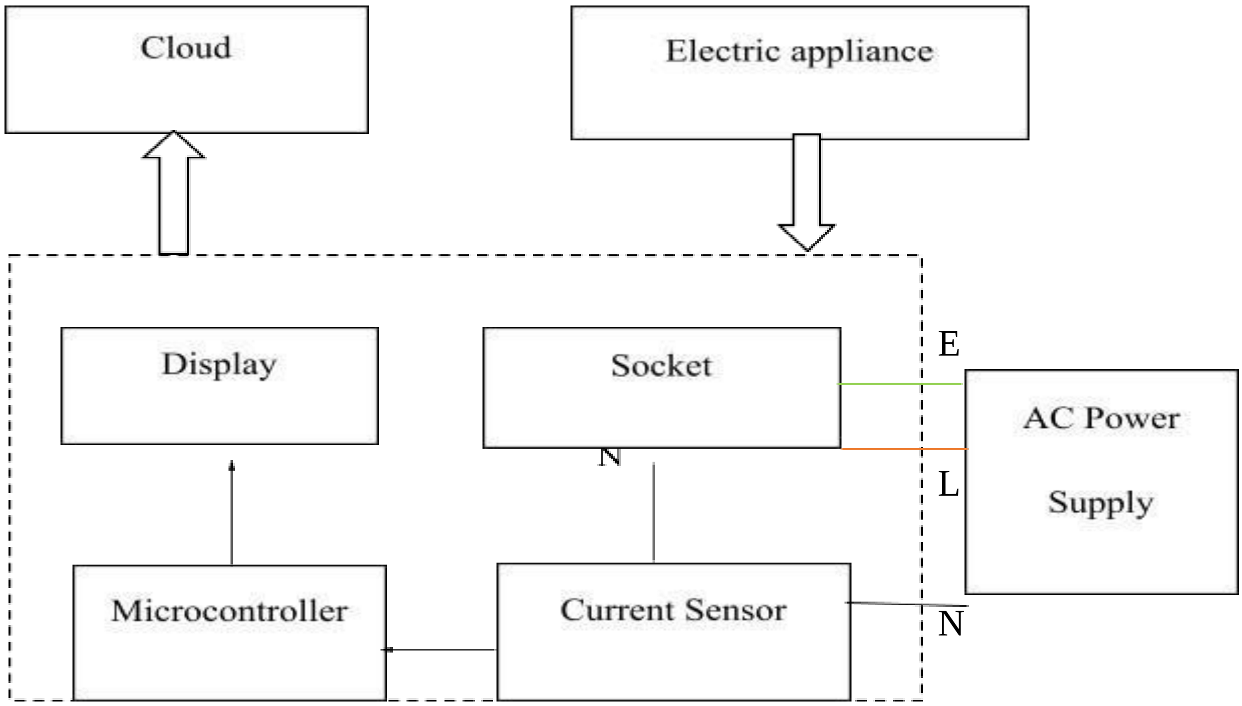

Figure-3.1 Block diagram of smart energy monitoring system

3.2 ARDUINO UNO CONTROLLER

Arduino is open source microcontroller and software development environment and easy to use and understand hardware and software. Arduino is a single board microcontroller has programming language is a simple ‘C’ and ‘C++’ type programming language and C language is easy to learn. Figure 3.2 shows the arduino UNO controller.

Arduino microcontroller is fast made by “Interaction Design Institute Ivrea” in Ivera, Italy; it has aim was design low cost and cheap microcontroller board.

Arduino uses expansion circuit board knows as shield. It has facility to GPD, GDM, and Bluetooth, zigbee, motor and other facility.

This organization has developed 50,000 Arduino microcontroller boards in very short period. In 2011 Google announced the Arduino open accessories development kit, which enable Arduino board to interfaced with Arduino mobile platform.

In a market different Arduino board available for different requirement. They Arduino board are used for ATMGT microcontroller.

The types of Arduino board are,

- Arduino Uno board,
- Arduino mega board and
- Arduino lily pad Arduino board.

In our project we have used Arduino Uno board has a digital input/ output pins, six analog inputs, 6 PWM pins and 16Mhz ceramic resonator a power OICSP heady and a reset button it has on board one USB to serial convert and connect to computer using USB cable.

Features of Arduino Uno board-

- It is based on UNO Microcontroller.
- Input voltage range is 7.12V.

- Digital I/O pins is 14 (of which 6 pin provide PWM output)
- Input voltage range is 7.12V.
- 6 analog input pins.
- 32KB flash memory 0.5KB used by boot leader.
- 16MHz clock speed.
- DC current for I/O pin 40mA.

Figure-3.2 - Arduino Uno board

Pins of Arduino Uno microcontroller-

- **Reset pin-** This pin enable to reset Arduino microcontroller board.
- **IOEF-** This pin act as a reference to the input given to the Arduino board.
- Arduino has 6 analog pins A_0 to A_5.
- There are 14 digital pins from 0-13 among these (3,5,9,1,11) are PMW pins from which analog output taken from the Arduino board.
- There is inbuilt LED on Pin 13.
- **AREF-** This pin is acting as a reference to analog input.

- **RXTX** – used for receiving and transmitting serial data.
- **ICSP** (In circuit serial programming) - this pin enable the use to programmed the chips on the circuit.

3.3 ACS712

Current flowing through a conductor causes a voltage drop. The relation between current and voltage is given by Ohm’s law. In electronic devices, an increase in the amount of current above its requirement leads to overload and can damage the device.

Measurement of current is necessary for the proper working of devices. Measurement of voltage is Passive task and it can be done without affecting the system. Whereas measurement of current is an Intrusive task which cannot be detected directly as voltage.

For measuring current in a circuit, a sensor is required. ACS712 Current Sensor is the sensor that can be used to measure and calculate the amount of current applied to the conductor without affecting the performance of the system002E ACS712 Current Sensor is a fully integrated, Hall-effect based linear sensor IC. This IC has a 2.1kV RMS voltage isolation along with a low resistance current conductor.

Working Principle

Current Sensor detects the current in a wire or conductor and generates a signal proportional to the detected current either in the form of analog voltage or digital output.

Current Sensing is done in two ways – Direct sensing and Indirect Sensing. In Direct sensing, to detect current, Ohm's law is used to measure the voltage drop occurred in a wire when current flows through it.

A current-carrying conductor also gives rise to a magnetic field in its surrounding. In Indirect Sensing, the current is measured by calculating this magnetic field by applying either Faraday's law or Ampere law. Here either a Transformer or Hall effect sensor or fiberoptic current sensor are used to sense the magnetic field. ACS712 Current Sensor uses Indirect Sensing method to calculate the current. To sense current a liner, low-offset Hall sensor circuit is used in this IC. This sensor is located at the surface of the IC on a copper conduction path. When current flows through this copper conduction path it generates a magnetic field which is sensed by the Hall effect sensor. A voltage proportional to the sensed magnetic field is generated by the Hall sensor, which is used to measure current. The proximity of the magnetic signal to the Hall sensor decides the accuracy of the device. Nearer the magnetic signal higher the accuracy. ACS712 Current Sensor is available as a small, surface mount SOIC8 package. In this IC current flows from Pin-1 and Pin-2 to Pin-3 and Pin-4. This is shown in the figure 3.3.

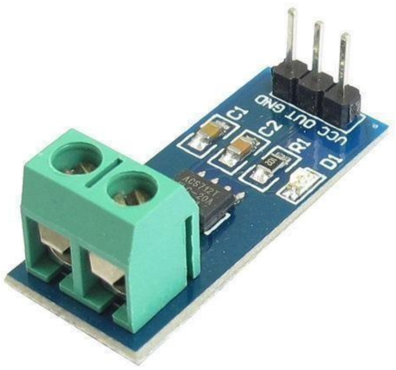

Figure 3.3 – CURRENT SENSOR

3.4 ARDUINO IDE

The Arduino Integrated Development Environment is a cross-platform application that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of thirdparty cores, other vendor development boards.

The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the wiring project, which provides many common input and output procedures.
User-written code only requires two basic functions, for starting the sketch and the mainith the GNU toolchain, also included with the IDE distribution.

3.5 SOFTWARE SERIAL LIBRARY

The Arduino hardware has built-in support for serial communication on pins 0 and 1. The native serial support happens via a piece of hardware (built into the chip) called a UART.This hardware allows the Atmega chip to receive serial communication even while working on other tasks, as long as there room in the 64 byte serial buffer.

The SoftwareSerial library has been developed to allow serial communication on other digital pins of the Arduino, using software to replicate the functionality (hence the name "SoftwareSerial").

It is possible to have multiple software serial ports with speeds up to 115200 bps.

A parameter enables inverted signaling for devices which require that protocol.

3.6 THINGSPEAK LIBRARY

ThingSpeak is an analytic IoT platform service that allows you to aggregate, visualize and analyse live data streams in the cloud. ThingSpeak has integrated support from the numerical computing software MATLAB from Mathworks, allowing ThingSpeak users to analyse and visualize uploaded data using MATLAB without requiring the purchase of a MATLAB license from MathWorks.

3.7 MODULES

3.7.1 CONNECTION SET UP

- During Connection Set-up, connect the Arduino board with current sensor (ACS 712).
- Current sensor out is connected to Arduino A0. Arduino Vcc is connected to sensor Vcc.
- Current Sensor and Arduino Gnd is connected to each other.
- Then we connected negative wire from current sensor to bulb and positive to plug-in.
- After this, bulb is connected with plug-in, then we tested the bulb is glowing or not as shown in figure 3.1.
- The connection is correct and the bulb is glowed.

3.7.2 DATA COLLECTION

- During Connection set-up, we tested the connection and the bulb.

- In this module, Arduino board is connected to the pc or laptop using Arduino.
- Then using the port options in Arduino IDE we selected the Arduino Board.
- To measure the energy consumed by bulb, we wrote a bit of code to work on the IDE.
- After Uploading the code the energy consumed by the bulb will be displayed in the s,erial monitor.
- We used two different watts bulbs to measure different energy consumed.

Table 3.1 Measured currents from bulbs

GSL BULB (current)	LED BULB (current)
0.05	0.03
0.05	0.02
0.04	0.03
0.05	0.03
0.05	0.02

The above table represents the current measured from two different bulbs.

3.7.3 MEASURING ENERGY CONSUMPTION

The root mean square current, I_{rms}, is computed using Equation (1) and provided to Equation (2) for computing instantaneous power, P, and this in turn is used to calculate total energy consumed, Wh, using Equation (3). Table 2 provides the description of attributes used for the calculations.

$$I_{rms} = \text{Measured Current Sample} * \text{Sensitivity} / \text{ADC} * \text{VREF} \quad (1)$$

$$P = V * I_{rms} \quad (2)$$

$$Wh = Wh + P * ((\text{Currenttime} - \text{Lasttime}) / 3600000) \quad (3)$$

In this phase, after getting the current values from serial monitor, creat a dataset and upload the current values. Then create two new channels in the ThingSpeak library. Give the channel names as LED bulb and GLS bulb. Using the import options in ThingSpeak library export the both dataset. After few seconds, the graph will be displaed depending upon their current values.

CHAPTER 4

SYSTEM SPECIFICATIONS

4.1 HARDWARE SPECIFICATIONS

1. Arduino UNO MicroController
2. ACS712
3. USB cables
4. Sensors
5. Intel Core i5 10th gen

4.2 SOFTWARE SPECIFICATIONS

1. Arduino IDE
2. ThingSpeak Library
3. Software Serial Library
4. Windows10

CHAPTER 5

EXPERIMENTAL SET-UP AND RESULTS

5.1 EXPERIMENTAL SET-UP

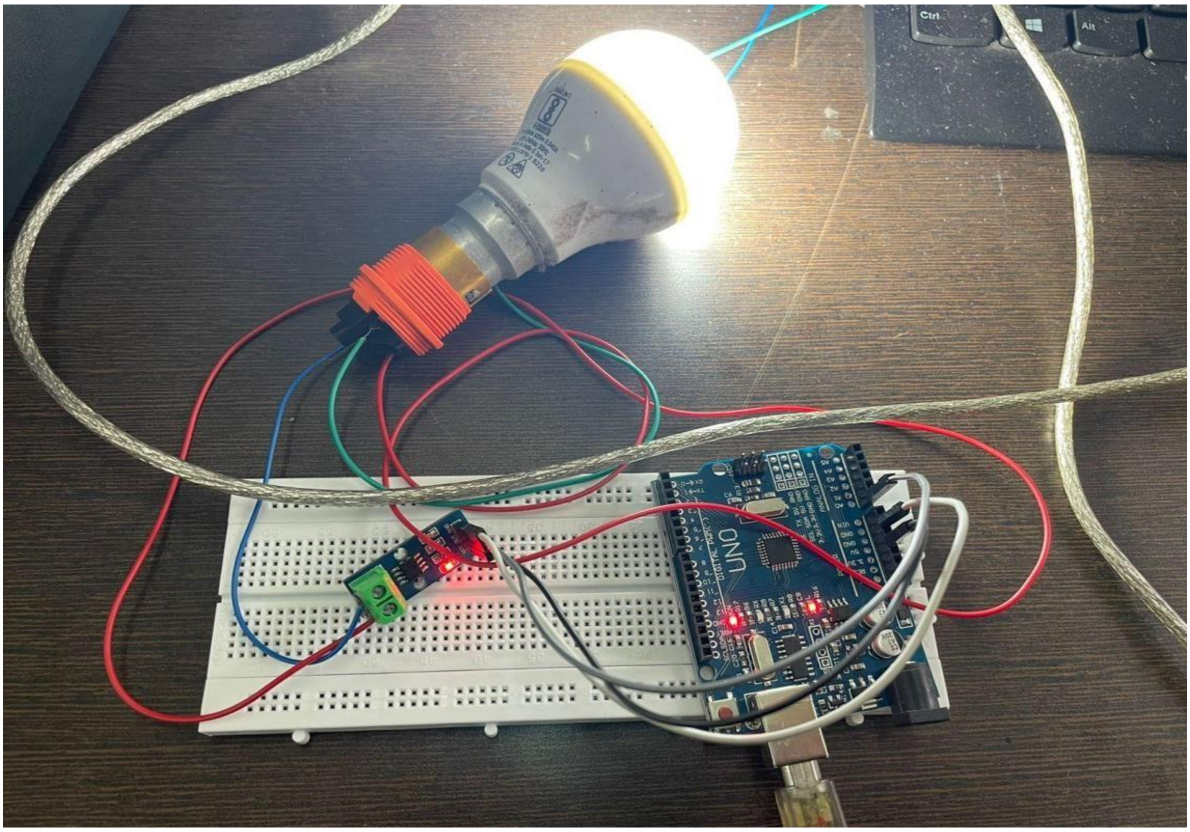

Figure 5.1 – set-up

Here, first we have connected from arduino to ACS712(current sensor). There are three ports in current sensor. The three ports are connected to the ports in arduino using cables. Then we have implemented another connection from bulb to plugin and and plugin to current sensor. The negative port in current sensor is connected to bulb and the positive port is connected to the plugin through the wires. Finally we have connected from plugin to bulb that is shown in figure 5.1. Then connect the pugin to switch board. Once the swith is on, the light will glow.

5.2 RESULTS

5.2.1 LED BULB(7W)

First we have implemented our test with low watts bulb. Using the power measuring formula, keeping the volatage and power as constants, we have found the current values manually. Then in implementation we get the desired output. The figure 5.2 shows the output.

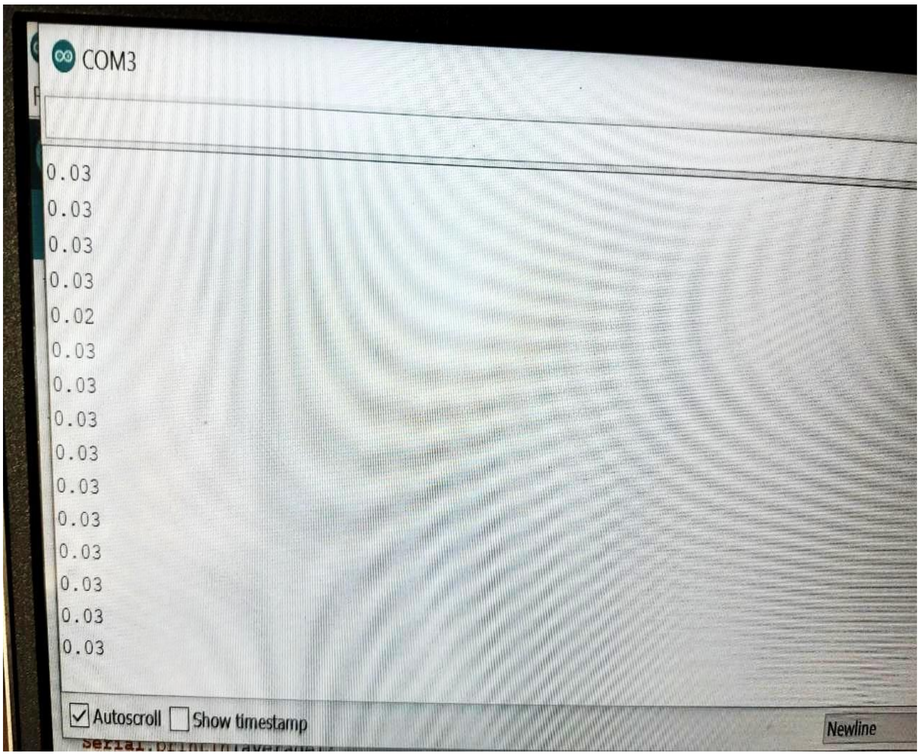

Figure 5.2 – LED output

5.2.2 GLS BULB (60W)

Then we have tested with high watts bulb, whose watt is 60. Then by implementing we get the desired output. Figure 5.3 shows the current values.

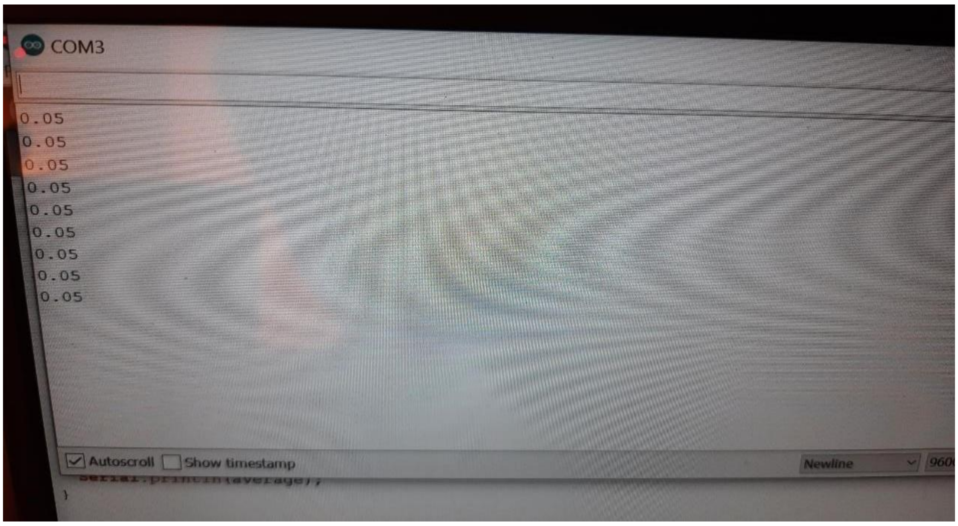

Figure 5.3 – 60W bulb output

Storing amount of electricity generated by a LED bulb.

Figure 5.4 – Uploading LED current data

The above figure 5.5 displays the amount of electricity generated by a LED bulb stored in thingspeak library.

Storing amount of electricity generated by a 60watt bulb

Figure 5.5 - Uploading 60W bulb current data

The above figure 5.5 displays the amount of electricity generated by a 60watt bulb stored in thingspeak library.

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 CONCLUSION

In this work, we have presented an Internet of Things-based smart energy meter that can be deployed in households and industries to measure power consumption at the device-level without disrupting the current operation of the appliances and without the need for complex rewiring. The smart energy meter is cost-effective to build since it uses Arduino Uno along with a WiFi module and a current sensor. During the testing of the system, it was found to be capable of extracting energy expenditure information, which is then relayed to the ThingSpeak channel. It minimises the cost and saves human power by avoiding human involvement.

6.2 FUTURE WORK

The consumers can view, monitor and log the consumption data. This can help them in ensuring if their appliances are working well within their expected power ratings. Furthermore, as the consumers are equipped with their consumption behavioural data, they can consciously reduce their energy consumption and hence, minimize energy expenditure. Possible future enhancements to the system could include the augmentation of the proposed system with existing electrical sockets, thus creating an integrated energy consumption tracking network and features such as load forecasting

REFERENCES

[1] Y. Devadhanishini, R. K. Malasri, N. Nandinipriya, V. Subashini and P. G. Padma Gowri, "Smart Power Monitoring System Using Iot," 2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS), Coimbatore, India, 2019.

[2] Metering, Automated Smart, S. Visalatchi, and K. Kamal Sandeep. "Smart energy metering and power theft control using arduino & GSM." In 2017 2nd international conference for convergence in technology (I2CT), pp. 858-961. IEEE,2017.

[3] Automatic Electric Bill Generation System- Syed Assra Shah, Bachelor of Engineering (ECE), University Of Kashmir J&K, Srinagar, India, IOSR Journal of Electronics and Engineering (IOSR-JECE), (Jul.- Communication Aug. 2017)

[4] Barman, Bibek Kanti, Shiv Nath Yadav, Shivam Kumar, and Sadhan Gope. "IOT based smart energy meter for efficient energy utilization in smart grid." In 2018 2nd International Conference on Power, Energy and Environment: Towards Smart Technology (ICEPE), pp. 1-5. IEEE, 2018.

[5] Hengyu, Tan, Yao Hejun, Huang Yan, Wang Huanning, Zhao Zhihua, and Liu Yuan. "Error Correction Method for Smart Energy Meter Field Calibration System under Non-standard Conditions.

[6] Bhutta, Faiz M. "Application of smart energy technologies in building sectorfuture prospects." In 2017 International Conference on Energy Conservation and Efficiency (ICECE), pp. 7-10. IEEE, 2017.

[7] Sun, Qie, Hailong Li, Zhanyu Ma, Chao Wang, Javier Campillo, Qi Zhang, Fredrik Wallin, and Jun Guo. "A comprehensive review of smart energy meters in intelligent energy netwsorks." IEEE Internet of Things Journal 3, no. 4 (2015): 464-479.

[8] Mobile Based Electricity Billing System (MOBEBIS) – M.R.M.S.B. Rathnakya, I.D.S.Jayasinghe, EnitJayanth, S.Iswarnajith, M.A.S.C.Manamendra, G.Wimlaratne, International Journal of Scientific and Research Publications, Volume 3, Issue 4, April 2013.
[9] Ashna.K, Sudhish N George. “GSm Based Automatic Energy Meter Reading System with Instant Billing”, 2013.
[10] S.Arjun, Dr.Sidappa Naidu, “Hybrid Automatic Meter Reading System”, in July 2012 International Journal of Advanced Research in computer Science and Software Engineering.
[11] Tarek Khalifa, Kshirasagar Naik and Amiya Nayak “A Survey of Communication Protocols for Automatic Meter Reading Applications” in IEEE Communications Surveys & Tutorials, vol. 13, no. 2, second quarter 2011.
[12] Sehgal VK, Panda N, Handa NR, Naval S & Goel V, “Electronic Energy Meter with instant billing”, Fourth UKSim European Symposium on Computer Modeling and Simulation (EMS), pp.27-31. (2010).
[13] S. Visalatchi and K.K. Sandeep, “smart energy metering and power theft control using arduino & GSM”, 2017 2nd International conference for convengence in Technology(I2CT), 2017.
[14] Fangxing, Liu, He Qing, Hu Shiyan, Wang Lei, and Jia Zhengsen. "Estimation of smart meters errors using meter reading data." In 2018 Conference on Precision Electromagnetic Measurements (CPEM 2018), pp. 1-2. IEEE, 2018.
[15] Patel, Himanshu K., Tanish Mody, and Anshul Goyal. "Arduino based smart energy meter using GSM." In 2019 4th International Conference on Internet of Things: Smart Innovation and Usages (IoT-SIU), pp. 1-6. IEEE, 2019
[16] Yaghmaee, Mohammad Hossein, and Hossein Hejazi. "Design and implementation of an Internet of Things based smart energy metering". In 2018

IEEE International Conference on Smart Energy Grid Engineering (SEGE), pp. 191-194. IEEE, 2018.
[17] Kumar, Amit, and Gopalakrishna Srungavarapu. "Power quality assessment of table based direct power control for active front-end rectifiers." In 2016 IEEE 1st International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES), pp. 1-6.IEEE, 2016.
[18] Komathi, C., S. Durgadevi, K. Thirupura Sundari, TR Sree Sahithya, and S. Vignesh. "Smart Energy Metering For Cost And Power Reduction In House Hold Applications." In 2021 7th International Conference on Electrical Energy Systems (ICEES), pp. 428-432. IEEE, 2021.