IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676, p-ISSN: 2320-3331, Volume 17, Issue 5 Ser. I (Sep. – Oct. 2022), PP 32-40
www.iosrjournals.org

IOT-Based Smart Energy Meter for Efficient Energy Utilization in Smart GRID

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Abstract— *While traditional electricity meters measure the power consumption of a home or business, smart meters can record energy usage in real time. The primary objective of Smart Meters is to reduce energy consumption in households Most importantly, smart meters enable two-way communication between the utility and the home/business. While The Government of India's initiatives like 'Make in India' and 'Smart Cities' need an efficient, reliable, and continuous power supply. India's power sector in the present day is facing a lot of problems like AT & C losses, inefficient distribution, and transmission systems because of age-old infrastructure, and power theft. Advanced energy management and increased use of renewable energy resources are the foremost areas to concentrate on by governments for the development of the country. The government cannot take the initiative for a complete change of electrical equipment across the country but there is a need for changing the way of operation and control of the electrical equipment. For this Ministry of Power has initiated ISGF (Indian Smart Grid Forum) which works very closely with public, private, and research organizations for developing standards and policies to deploy the 'Smart Grid' to assure efficient and cost-effective power for all stakeholders. The smart meter is a very important constituent of the smart grid and is expected to provide cost-effective, social, and ecological advantages for various stakeholders. The most significant key factor that determines the success of smart meters is data analysis which deals with data acquisition, communication, processing, and elucidation that benefits consumers, utility companies, and the government. The idea of a smart grid increases the efficiency of power usage by the introduction of a bi-directional flow of information from utilities to consumers and vice-versa. This can be possible by the introduction of 'Advanced Metering Infrastructure (AMI)'. The information about the electrical consumption of a consumer is recorded promptly and this data is aggregated and analyzed by a 'smart meter' installed at consumer premises. The analyzed data is communicated to utilities using AMI. The AMI includes the advanced communication system including home area networks (HAN), neighborhood area networks (NAN), and wide area networks (WAN). Thus, AMI not only communicates the smart meter data to utilities but also transmits information to the consumer from utilities about the peak demand, and cost of energy consumption enabling the consumer to shift peak loads to some other time. A smart grid using smart metering and AMI technologies establish wide-area monitoring, protection, and control.*

Keywords- *Smart meter, Low-cost sensors and devices, IoT-based meter, Sensor and devices for IoT, Application, and other topics of IoT*

Date of Submission: 07-09-2022 Date of Acceptance: 23-09-2022

I. Introduction

Efficient energy utilization plays a very vital role in the development of the smart grid in the power system. So, proper monitoring and controlling of energy consumption is a chief priority of the smart grid. The existing energy meter system has many problems associated with it and one of the key problems is there is no full-duplex communication. A smart energy meter is proposed based on the Internet of Things (loT) to solve this problem. The proposed smart energy meter controls and calculates the energy consumption using ESP 32, a Wi-Fi module, and uploads it to the cloud from where the consumer or producer can view the reading. Therefore, energy analysis 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.

The internet of Things allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration between the physical world and computer-based systems, resulting in improved efficiency, accuracy, and economic benefit. The increasing generation needs empowered gadgets by wireless technology which includes Bluetooth, Radio Frequency Identification, Embedded sensors, and many more. In that IOT technology has grown from its beginning and now presently widely using it. Electricity plays an important role in our life. Nowadays as the number of consumers is increasing rapidly it became very hard to handle the electricity requirements. Without electricity, it's impossible

to survive, and also it is important to save electricity loss. As the generation increases the consumer's requirements also increase so following it technology improvement is needed. So, we developed the system with faster and improved technology i.e. IoT. The electricity also contains some issues like power theft. Power theft is a measure of crime and it also directly affects the economy of our country. Transmission, generation, and distribution of electricity include the loss of electricity. To avoid losses, we need to monitor the power consumption and losses so that we can efficiently utilize the generated power. Meter tampering is part of power theft and also a crime that we can minimize. Billing is a process, in general, the human operator goes to every consumer's home then providing bills will take a lot of time. To resolve these issues, we developed a system on base on IoT energy meter reading. IoT-based energy meter reading consists of three parts: Controller, Theft detection, and the WIFI part. The controller part plays a major role in the system. Where all the information can send through this controller to the other part of the system and it also stores the information in it. The WIFI part performs IoT operations under the Arduino controller. The energy meter connected with the theft detection part if any temper happens will send the information to the company as well as it will take automatic action by making the power off.

DISCOMs in states without smart meters are now being forced to make consumers send photos of their meter readings, or to bill provisionally based on the previous bills because of social distancing restrictions. Smart meters negate the need to be physically present. At times like these, remote meter reading would also be a huge boon for the sector as a significant chunk of DISCOM revenue is lost due to billing inefficiencies.

A recent report by Energy Efficiency Services Limited (EESL), the agency responsible for the implementation of smart meters across the country, showed that all states where smart meters were installed had good results with an average increase in the billing of nearly 25%. In the New Delhi Municipal Council (NDMC) area of the national capital, with a billing efficiency of over 99%, revenue has gone up by 500 (~$7) per month per meter.

Aside from bringing in additional revenue to DISCOMs, smart meters can also help consumers monitor and regulate their consumption so they can save money on power bills. The increase in revenue can help DISCOMs clear their dues to generators on time, as well. Smart meters have far-reaching benefits within the entire power sector. "There is no solution that has shown as much value to the entire power sector as smart meters. If utilities are to come out of their financial crisis in this country, there is no better option," said Saurabh Kumar, Managing Director at EESL.

"Last year's billing efficiency was 83%, meaning 17% was not billed at all. Total power consumption in the country was 1.3 trillion units then, and 17% of that would be about 220 billion units. Multiply that by 5 (~$0.07)/kWh, and you arrive at an overall loss of well over 1.1 trillion (~$14.7 billion) which is significantly more than the 900 billion (~$11.98 billion) package announced by the government," Kumar explained stressing the need to plug these losses.

Mercom https://mercomindia.com/indias-energy-sector-funding-streams/ recently reported that the financial stimulus given by the central government to DISCOMs might not solve the sector's issues. It is only through modern and innovative solutions like smart meters that the power sector can move forward.

II. Ease of Use

Traditional Electricity Meters

In India, mostly electricity utilization of a consumer is recorded by a traditional electromechanical meter or an electronic meter (with a digital display). The bills are generated by utility personnel just by recording usage for a specific period (monthly or bimonthly). This traditional process has no relation to advanced monitoring or control. In general, the traditional meter has the following architecture as shown in the figure below.

Fig: Traditional Electromechanical Meter Architecture

Smart Meters

The smart meter is the future of the power industry and serves as an interface between the consumer and the utility company. The smart meter records the power usage of the consumer and communicates this data promptly to the utility center. For a smart meter, it is very essential to collect precise and appropriate data promptly which includes gathering data, its communication, and storage. The smart meter allows the bi-directional flow of information, as shown in the figure below, from consumer to utility and vice versa. The systematic analysis of the data acquired will lead to many prospective decisions by the utility center that assures the efficiency and reliability of the smart grid. This allows the utility center for better monitoring and control. The data communication on a real-time basis allows the utilities with advantages like real-time pricing, outage

detection, identification of power theft, avoids meter data tampering, and provides better service. With the data received promptly, utilities shall have a better opportunity to work better with increased stability.

Smart meters can cut domestic or commercial energy consumption by giving a lot of useful information to the consumer, but this information is useful only if the consumer looks into it. Smart meter gives the best home energy management solutions for smart homes using wireless technologies like (Zigbee or WiFi). Several sensors and actuator-based appliances are commissioned in smart buildings to manage the connection of electrical load remotely based on the consumer choice or utility decisions envisaging the necessity of the smart meter.

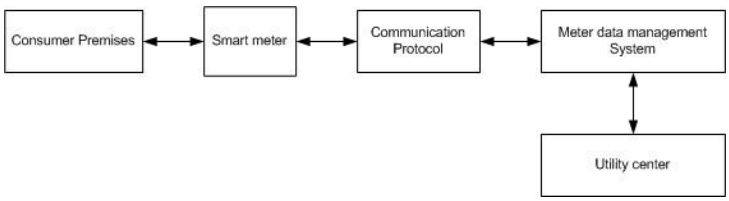


Fig: Smart Meter Architecture

III. Literature Review

Using IoT about IoT, the internet of things as an emerging field and IoT-based devices have created a revolution in electronics and IT. The foremost objective of this project is to create awareness about energy consumption. efficient use of home appliances for energy savings. Due to manual work, the existing electricity billing system has major drawbacks. This system will give information on meter readings, and power cuts when power consumption exceeds the specified limit using IoT. The Arduino ESP-32 microcontroller is programmed to the objectives with the help of its inbuilt Wi-Fi module. It is proposed to overcome all the disadvantages of the already existing energy meter. All the details are sent to the consumer's mobile through the IoT and the Wi-Fi module and it is also displayed on the LCD. It is time-saving and it helps to eliminate human interference using IoT.

[1] Streetlight is the major source of light against the darkness of the night. The street light ensures safety in urban and rural areas and increases the visibility of the roadways. As a result of rapid and modern infrastructure development, new innovative technology is needed in the energy sector. A GSM-based smart light improves efficiency by using timed controlled switching of street lights, which automatically turn On/Off according to the needs. The major advantage of these systems is that they are less costly to implement, also they are highly scalable. We have put forth a solution for the smart lighting system. Through a single touch, energy can be controlled it is more eco-friendly.

[2] The system will replace the traditional meter reading method with GSM based smart energy metering system using IoT. The sensed units automatically send on cloud generating using IoT. It is a very efficient and low-cost system because this model reduces the miscommunication between the user and the controller. An efficient systematic approach is used for the design to acquire accurate measurements for the energy meter. The prevention of malpractice gives an accurate accounting of units.

[3] The proposed design and implementation of an Innovative Internet of Things based on a smart energy meter. This model describes its design along with its working. It will make the leading to be handy and measure the energy consumption accurately. Here the energy wastage is reduced and also brings awareness to all. An innovative method by which an IoT-based smart exam application can be used to obtain information. The metrics values can be determined by using a Biometric Smart Pen (BISP), through which handwritten characters, words, and gesture movements can be recognized and can be used for further analysis. Smart exam applications help analyze how much is spent on a question through which improvements can be brought into action. In

[4] Involves development of smart energy meter. It is used to monitor the energy usage of different applications and provide other features like an advanced billing system and high accuracy. Meter can control energy supply and usage of energy based on load requirement and measure the cost of power consumed. Consumers get a clear idea about their use & cost.

[5] As mentioned the system takes reading from the energy meter automatically and sends them to the server side. At server side receives readings and processes them and generates a bill for corresponding reading and generates a pdf for bill payment. This pdf is stored at a remote location. The necessary information's are send to the customer via SMS. The system consists of a power LED. Each time LED is blinked. Arduino module monitors the blinking of LED and the count is stored in EEPROM. If the Arduino module is off count will be stored in EEPROM and Arduino module check the current day of the month. On 1 day of the month, the blink count, and it will be sent to the server side. Arduino modules have a unique id. This id is sent along with the blink count to the server side. This is done by configuring with network and parameters are sent via GSM module in server URL and that URL will hit. Before hitting the URL, At server side will have a database it contains all details about the user. MYSQL is used for performing each of the operations in the database like insertion,

deletion, updating, etc. When URL is hit, the server checks the parameter list in the URL and compares it with the database, these details are fetched using the SELECT query. After fetching details, generate the bill for the corresponding blink count. The cost for one count is already set in the database. After calculating the bill for the corresponding blink count, create a pdf for the bill and stored it at a remote location. Customer name, pdf link generated, and the number of the user which is separated by using (:) and are sent to GSM module. GSM module extracts the message part and sends it to the user via SMS.

[6] A smart meter is an electronic device to measure and manages power consumption. The proposed system replaces a regular electricity meter with a hall sensor and ESP8266 interfaced with Arduino UNO to transmit data. Data was collected from various households and sent directly to the Arduino UNO module. From the Arduino UNO module, data is transferred to the Arduino YUN module through ESP 8266 Ethernet shield. From Arduino YUN module data stored at tempo cloud. Users can access the data from the Temboo cloud. Therefore server uses the details of the user and can retrieve them using their Id. Regular updates from the server are sent to the user through SMS or email. The electricity bill is generated every month and sent to the user. If the user doesn't pay the bill, the electricity connection is automatically interrupted using a relay switch. Here hall sensor senses the amount of current consumed using the current sensing theory. The phase wire is passed through the hole of the hall sensor. When current is passed through phase wire, it is measured from the magnetic field generated. Therefore potential differences are referred to as a hall voltage. The advantage of the hall sensor has measured the current without breaking the system. Per capita power consumption is rapidly increasing with the increasing population. When users are concerned about the electricity bill and power consumption, there is a high chance of reducing per capita power consumption. This system increases privacy and will reduce health hazards compared to previous systems.

[7]ZigBee is a low-cost, low-powered wireless networking standard based on mesh topology. This system is based on ZigBee technology. The consumer side consists of an energy meter, microcontroller, LCD, voltage sensor, ZigBee module, and power supply unit. The microcontroller continuously monitors the energy meter. When the user temper the meter, theft is detected then the meter tempering signal sends to the microcontroller via an optocoupler. Theft signal display at LCD at the consumer side. The microcontroller directly interfaces with the ZigBee module. The theft signal sends to the server-side through the ZigBee module LCD energy consumption in the unit, power status, theft status, and monthly bill. The electricity side consists of a ZigBee module and a personal computer system. The monthly bill status will send with help of the "send bill" button. If theft is detected, the power is switched off with help of the "cut-off" button. The power supply can be restored using the "Restore" button. This communication takes place wirelessly via the ZigBee module.

[8] IoT Based electricity bill generation is technology. It is used to gather information from the energy meter and its transfer to the database. Database analyses this information for billing purposes. Energy is stored in chemical form. Using kernel programming, reading will be taken from the energy meter. Kernel programming will give battery status and is sent to the server through Gateway. On the server side calculated bill will be sent to the customer through the browser and GPRS Gateway. This system avoids human intervention in electric bill generation. If the user gets wrong information he has to visit the electricity board for correction. These errors are avoided by taking reference to meter readings and sending details to the server and maintaining the database in real-time. This system avoids the use of paper and provides fast meter readings. Here we take the laptop battery for reference. In the future, it may possible to take readings directly from the meter and send data to the server in real-time.

[9] The system gives a wireless GSM-based energy meter. It is associated with a web interface. Here the electric energy meter is integrated with GSM based wireless module. Also, each entity has remote access to the usage of electricity. On the other end, There will be a PC with a GSM receiver. it contains the database which acts as the billing point. The GSM-based energy meter reads the live meter reading and is sent to the billing point periodically and it will be updated on the central database. At the end of each month, the due amount and complete monthly usage are sent back to each customer. The energy meter consists of dedicated IC MCP3905A, LCD, 8-bit PIC Microcontroller PIC16F877 and GSM Modem. An RTC module is used that will record the usage detail it counts consumption in seconds, minutes, hours, date of the month, day of the week, and year with leap year compensation valid up to 2100.

[10] According to here GPMC (GSM-based power meter and control system) is developed which consists of the integration of single phase IEC61036, standard compliance digital KWh power meter. This system keeps track of the energy meter reading each day. A unique id is given for each energy meter and it is interlinked with the customer's unique id mobile number. So the reading with the user id number is sent to the electricity board department as well as the user. Also, the electricity e-billing system is connected with the electricity department and it will keep the track of SMS, meter reading, and bill generated. At end of each month calculated bill is sent to the appropriate user from the server. The GPMC also features a distribution control system that controls the power of the appliance. The system gives meter readings at any time the customer request. The

system provides a powerful and efficient tool for evaluation and forecasting. It will reduce unwanted power consumption and it is a very cost-effective method.

[11] In the microcontroller ATmega328P and GSM-based energy metering system detect and control the energy meter from power theft and solve it by remotely reconnecting and disconnecting the line of a particular consumer. In the majority, energy theft is an important problem because the population increase will lead to energy consumption high. Therefore utilities in the electricity system are destroying the total amount of revenue due to energy theft. Here single-phase digital energy meter uses a current sensor and voltage sensor to estimate the Kwhr consumed by the applied load. During any unauthorized tapping or access to the service then any of these sensors will give zero and also the product of current and voltage will also be zero resulting in no energy measured in the energy meter. Here solid state relay(SSR) is used to disconnect and reconnect the supply line. Arduino continuously monitors the value in the voltage and current sensor respectively then it will be displayed on the LCD Display. This system gives the advantages of both hardware and utility and the customer.

[12] The system uses GSM technology to automate the energy meter. GSM is efficient technology available since it gives a good range for efficient data transmission and a large number of users can be added. Here the meter readings are automatically sensed and sensed unit is sent to the billing point through GSM. Then the corresponding bills are calculated in the units of measure and they will send to the corresponding user at the correct time. The digital GSM power meter is installed on every consumer unit. it will work digitally and show the current, power, and voltage on the LCD Display. When the load is applied the electrically powered devices consume some amount of current. It will automatically be sensed by the sensor and sensed units of current can be sent to the billing point also displayed on the LCD.

[13] Utility Power metering application is described using the design of a high fi electronic current sensor. A low permeability core material with a current transformer makes up the sensor which yields a tolerance that also ensures immunity to powerful dc magnetic fields. Flux-change sense winding and the secondary winding of the feed-forward of the voltage are used to configure the transformer. The error due to magnetizing current that will be high with a low permeable core will be minimized. Neither core-gapping nor the Hall Effect sensor will be required here. This is a low-cost solution since we are combining it with simple analog electronic circuitry. A load management which is intelligent and a power metering utility with a suitable current sensor design. Winding of the flux change sense and the secondary winding which control the voltage of magnetizing branch and magnetizing current error.

[14] The number of non-renewable energy resources that are available on the earth is limited. Because of that, we require ways for the efficient use of energy is SMART ENERGY concept has been introduced for this purpose. For future energy use, the need for concepts like SMART ENERGY is critical. This paper presents a survey on smart electricity meters. It gives importance to the major aspects like the metering process, different stakeholder interests, and this purpose. The paper also gives insight into the importance of cloud environments. Even though these concepts have some bad effects in the future these concepts will be a way of life for all with the help of the survey conducted and discussed in this paper it helps to identify the current limitations in smart metering.

[15] The design of the Automotive meter reading is based on Zigbee. The implementation of a Wireless Sensor Network (WSN) and Automatic Meter Reading (AMR) in indoor environments based on Zigbee is described in this paper. Utility data is remotely collected using Automatic Meter Reading. These utilities include water, gas, electricity, etc. The main focus is on electricity power monitoring. Using this we can remotely control power service, and monitor power quality which will help the consumption for prepaid billing.

[16] The system adopts a new concept for automatic billing and metering system. The consumer would receive messages about the consumption of power and if it reaches the maximum amount it will alert the consumer to recharge automatically using GSM technology. An overview of the prepaid energy meter is discussed. It will minimize electricity theft in a cost-efficient manner.

IV. Research Methodology

We need to select the current sensor as well as the voltage sensor so that the current & voltage can be measured and thus, we can know about the power consumption & total power consumed. The best current sensor available in the market is SCT-013. This is SCT-013 Non-Invasive AC Current Sensor Split Core Type Clamp Meter Sensor which can be used to measure AC up to 100 amperes. Similarly, the best voltage sensor is the AC Voltage Sensor Module ZMPT101B. The ZMPT101B AC Voltage Sensor is the best where we need to measure the accurate AC voltage with a voltage transformer.

Using the SCT-013 Current Sensor & ZMPT101B Voltage Sensor, we can measure the all required parameters needed for Electricity Energy Meter. We will interface the SCT-013 Current Sensor & ZMPT101B Voltage Sensor with ESP32 Wi-Fi Module & Send the data to the Blynk Application. The Blynk Application Dashboard will display the Voltage, Current, Power & total unit consumed in kWh.

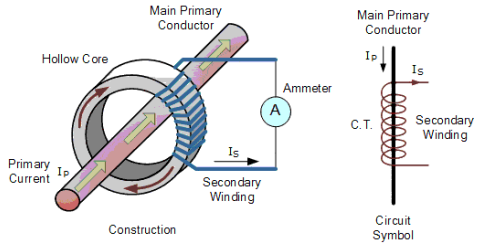
- *Bill of Materials*

S.N.	COMPONENTS	DESCRIPTION	QUANTITY
1	ESP32 Board	ESP32 Development Board (ESP-WROOM-32)	1
2	Voltage Sensor	ZMPT101B AC Voltage Sensor Module	1
3	Current Sensor	SCT-013-030 Non-invasive AC Current Sensor	1
4	LCD Display	16X2 I2C LCD Display	1

- *SCT-013 Current Sensor*

The **SCT-013** is a Non-invasive AC Current Sensor Split Core Type Clamp Meter Sensor that can be used to measure AC up to 100 amperes. Current transformers (CTs) are sensors for measuring alternating currents.

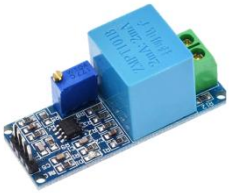
They are particularly useful for measuring whole building electricity consumption. The SCT-013 current sensors can be clipped straight either to the live or neutral wire without having to do any high-voltage electrical work.



Like any other transformer, a current transformer has a primary winding, a magnetic core, and a secondary winding. The secondary winding comprises many turns of fine wire housed within the casing of the transformer.

Specifications:
1. Input Current: 0-30A AC
2. Output Signal: DC 0-1 V
3. Non-linearity: 2-3 %
4. Build-in sampling resistance (RL): 62 Ω
5. Turn Ratio: 1800:1
6. Resistance Grade: Grade B
7. Work Temperature: -25 °C~+70 °C
8. Dielectric Strength (between shell and output): 1000 V AC / 1 min 5 mA

- *ZMPT101B AC Single Phase Voltage Sensor:*



- The ZMPT101B AC Single Phase voltage sensor module is based on a high precision ZMPT101B voltage Transformer used to measure the accurate AC voltage with a voltage transformer. This is an ideal choice to measure the AC voltage using Arduino or ESP32.

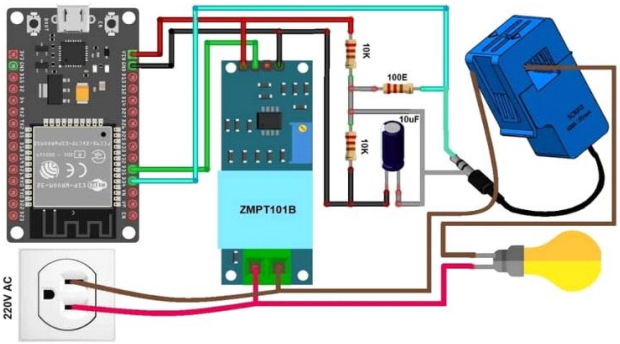
The Modules can measure voltage within 250V AC voltage & the corresponding analog output can be adjusted. The module is simple to use and comes with a multi-turn trim potentiometer for adjusting and calibrating the ADC output.

Specifications:

1. Voltage up to 250 volts can be measured
2. Lightweight with on-board micro-precision voltage transformer
3. High precision on-board op-amp circuit
4. Operating temperature: 40ºC ~ + 70ºC
5. Supply voltage 5 volts to 30 volts

- *Circuit Diagram & Hardware Setup:*

The connection diagram is simple. Both the Sensor, i.e. SCT-013 Current Sensor & ZMPT101B Voltage Sensor VCC is connected to Vin of ESP32 which is a 5V Supply. The GND pin of both modules is connected to the GND of ESP32. The output analog pin of the ZMPT101B Voltage Sensor is connected to GPIO35 of ESP32. Similarly, the output analog pin of the SCT-013 Current Sensor is connected to GPIO34 of ESP32. You need two resistors of 10K & a single resistor of 100 ohms connected along with a 10uF Capacitor.



Apart from the circuit part, the AC wires where the current and voltage needs to be measured are connected to the input AC Terminal of the Voltage Sensor. Similarly, the current sensor clip doesn't have any connection and a single live wire or neutral wire is inserted inside the clip part as shown in the above circuit.

- *16x2 LCD Display:*

We are using a 16x2 LCD here. There is no need to connect the LCD as we will be monitoring the ESP32/SCT-013 ZMPT101B/ Energy Meter Data on Blynk Application. In case you want to connect the LCD, you need so many connections. Connect the PINs 4, 6, 11, 12, 13, and 14 of LCD to ESP32 D13, D12, D14, D27, D26, and D25 pins. Also connect the LCD 1, 5, 16 Pin to GND & 2, 15 Pin to 5V VCC. Use a 10K Potentiometer at Pin 3 of LCD to adjust the LCD Contrast.

- *Setting up with Cloud Application:*

Here we are using Blynk as a Cloud Service Platform for IoT. We are using an application that runs over Android and IOS devices to control any IoT-based application using Smartphones. It allows you to create your Graphical user interface for IoT applications. Here we will display the IoT Energy Meter Data on Blynk Application.

- So, download and install the Blynk Application from Google Play Store. IOS users can download it from the App Store. Once the installation is completed, open the app & sign-up using your Email id and Password.
- From the dashboard create a new project and select ESP32 & Wi-Fi Connection.
- Then drag & drop or add 4 widgets and assign the variable as per code and then email the authentication code.
- You will get the authentication code in the mail. Copy this authentication code. This will be used in your code.

V. Results & Discussions

As a result, we can see from the image Vrms is the Live Voltage and Irms is the Current drawn by the Loads. And we can observe the data from Mobile and also from a Web-based dashboard. After 2 sec, the display will refresh and enter the next screen. Where it shows the total consumption of energy in kWh (BOT UNIT). This same data we can read anywhere in the world because of IoT technology.

The results obtained are based on a constructed circuit that is simulated using real-life power system data and hardware prototype trials at the power socket. Monitoring power consumption problems are pervasive in household electric appliances. Therefore, a sustainable design and implementation of smart electricity management of every consumption have been top prioritized to reduce usage and cost for a sustainable society. The proposed smart home electricity monitoring system is sustainable that utilizes the most advanced Internet technologies to impact electric consumption monitoring performance. Monitoring the consumption of electrical appliances, including advanced digital appliances, can directly regulate the usage of air conditioners, water heaters, heaters, dry iron, washing machine, music systems, and lighting systems. Therefore, the proposed system can positively improve lifestyles and habits for a sustainable urban lifestyle with accessible functionalities that can connect the house to an extraordinary remote monitoring center or a mobile device through a mobile app; it is environmentally friendly. Using the proposed system can create awareness of energy usage for the appliances like air conditioners, bulbs, and other home appliances. The significant advantage is that the proposed system can be customized at the controller for future expansion. However, IoT-based systems for the smart home have a few disadvantages, especially concerning the challenge of privacy, bandwidth, and Internet security.

Some limitations for this work, such as the voltage, were assumed to be 240 Vac since no sensor was included for the voltage sensor. However, in our future study, a voltage sensor is considered to measure the real-time voltage from the incoming voltage supply. Thus, the accuracy of the result can be improved further. Other than that, Undervoltage and overvoltage detection can also be included in the voltage sensor used. The control system can be improved further by considering time scheduling, remote switching, automatic switching, temperature switching, and sensor controlling. This will help the users to reduce electricity consumption as well as make life easier.

VI. Conclusion

The system automatically reads the energy meter. The Internet of Things (IoT) links anything from anywhere in the universe. It communicates with almost everything around the world. Communication can be a control signal or identified data from this world. It is a common internet data communication and is communicated in different ways. The Internet of Things (IoT) collects the data of automated objects and helps the machine learn where it needs. The data is stored in the cloud and sent to the energy meter to switch on/off objects.

This paper has proposed and developed an IoT-based smart monitoring and control system for household appliances. The methodology and processes are designed to provide a useful and crucial solution in a monitoring and control system. The proposed system performed better in measuring and monitoring the current, voltage, and power consumption. The entire communication has been done through the Wi-Fi module to display the data on web servers. The data are also monitored in real-time and historically, where the data were stored in the cloud database. The monitoring system makes the system more accessible for customers to view consumption rates clearly in real-time. The control system can fulfill the requirement of safety, can monitor appliances in the household individually or collectively, and can create awareness of electricity consumption. The voltage and current will be monitored on a wider scale in the smart house environment in future work.

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Argha Chatterjee. "IOT-Based Smart Energy Meter for Efficient Energy Utilization in Smart GRID." *IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)*, 17(5), 2022, pp. 32-40.