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Improvements in Iot-Based Monitoring Of Energy Use

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ABSTRACT
The design and implementation of an IoT-based Intelligent Electricity Consumption Warning System are discussed in this study. The technology is designed to offer in-home and industrial settings real-time monitoring and management of power use. Microcontroller, LCD, IOT module, current sensor, relay module, load lamp, and lamp holder are some of the parts that the system consists of. Using a current sensor to measure electricity usage, the system then transmits that data to the microcontroller, which processes and displays it on the LCD panel. Via a user-friendly interface, the IOT module provides remote system monitoring and control.
Keywords-Electrical consumption, Homes, Intelligent Electrical Consumption Warning System, Internet of Things, Real-time monitoring**.**

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I. Introduction

Climate change is an unparalleled threat to humanity. The depletion of natural resources and the accompanying rise in energy use has prompted people and organizations to look for more environmentally friendly alternatives. One of the most effective strategies for doing so is cutting back on energy use, and one of the most promising technologies for doing so is the Internet of Things (IoT).

The Internet of Things (IoT) is a system of interoperable, internet-connected gadgets that can exchange information and coordinate their actions. Many industries, from healthcare to transportation, have already taken advantage of this technology. In the realm of energy management, IoT shows the most promise.

Greenhouse gas emissions, the main driver of climate change, are partly attributable to the energy we use. Therefore, cutting back on energy use is essential to solving this worldwide problem. One system that can aid with this endeavor is an Internet of Things-based Electrical Consumption Monitoring reinforcement.

The Reinforced Electrical Consumption Monitoring utilizing IoT system is a tool for keeping tabs on and controlling power usage in homes and enterprises. The system makes use of state-of-the-art components, such as a current sensor wired to an Arduino microcontroller and a Node MCU connected to the Blynk cloud platform by way of a relay module.

With the use of an LCD screen, consumers may keep tabs on their current electricity consumption. The technology can also send users text messages when their energy consumption hits a certain limit, giving them the opportunity to cut back before they go beyond.

Because of the system's flexibility and scalability, it may be implemented in a wide range of situations, from private residences to public institutions to industrial settings. The Reinforced Electrical Consumption Monitoring utilising IoT system gives consumers access to real-time data on their electricity consumption, which they can then use to make educated decisions about their energy consumption and, ideally, save money.

In addition, the Reinforced Electrical Consumption Monitoring utilising IoT system's users may be able to lessen their impact on the environment by cutting back on energy use; this is crucial in the effort to combat climate change. Therefore, this technology has the potential to significantly contribute to developing a more sustainable and efficient energy system in the future.

There has been a lot of research and development into the Internet of Things' potential applications in energy management over the past few years, and there have been some successful deployments of this technology in a variety of contexts. Smart grids employ IoT to track and control energy use in real time, and smart homes automate and regulate the use of various appliances.

There are some obstacles that must be overcome if the Internet of Things is going to realize its full promise in the realm of energy management. Data privacy and security is a major obstacle. Data collected and transmitted by IoT devices might be extremely damaging if it is compromised. As a result, it is essential to guarantee the safety and confidentiality of information gathered by IoT gadgets.

The incompatibility of IoT gadgets presents another obstacle. There is a danger of fragmentation as more and more IoT devices are introduced to the market, which could lead to compatibility concerns. This may reduce the usefulness of the Internet of Things for energy management and other purposes.

As a result, the Reinforced Electrical Consumption Monitoring utilizing IoT system is a cutting-edge answer that could completely alter the way we handle power. The solution enables users to make educated decisions about their energy consumption by giving them with real-time information on their electricity usage. In addition, the system's users may be able to lessen their carbon footprint by cutting back on energy use, which is crucial in the battle against global warming. IoT has the potential to make a substantial contribution to establishing a more sustainable and efficient energy system for the future, despite the fact that there are problems that must be solved.

II. Literature Review

The current billing system makes use of a guide invoice technology method that requires a full-size staffing level of labor. It justifies a huge array of calculation errors and defects. The client will be taken aback when he receives a high electricity bill at the end of the month because the current equipment is also unable to inform him about his energy use daily. The duty is described in the item and is dependent on a "Smart Electricity Meter," which excels at forecasting his bill so that it may be organized at the end of the month and giving information about his daily electricity usage and fee via a user interface. All of a user's statistics can be viewed or shown on his dashboard once he or she has successfully signed into the portal using accurate statistics.

When a threshold amount is achieved, the device will send the user an SMS telling him about his consumption even when he no longer checks his account on the portal.

A smart grid, which enables intelligent control of the power grid, is the foundation of a smart city. One excellent technique to advance networks and other fields of research is the use of smart grids. However, what it is and how it fits into the current effort to ensure the sustainability of the manufacturing, power, and social sectors must be considered because it is widely spoken about. In some circumstances, a IoTmeter can communicate with other IoTmeters [1].

From the perspective of the consumer, IoT meter's provide a variety of possible advantages. For instance, clients may estimate bills based on the accumulated information and then control their electricity consumption to reduce their electric payments [7].

The national Institute of standards and era (NIST) type is the foundation for the electricity use cycle and stakeholder data [3].

The recent push toward combining and linking a few different systems and components inside the smart grid, as well as information on the cost of interoperability of such systems and components, are also crucial. Multiple systems and additives being able to communicate with one another under the organizational, informational, and technical aspects are appropriate.

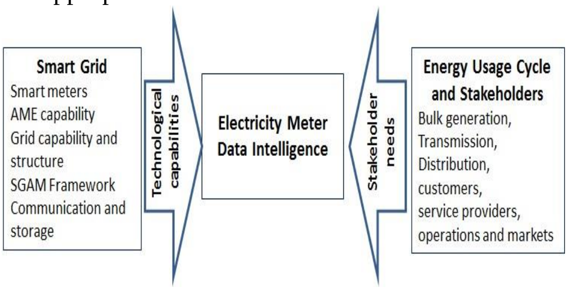

Fig 1: The environment for smart meter data intelligence [3]

2.1 Issues And Challenges

In lieu of redesigning the current grid, efficient grid management can be an alternate approach. The integration of the smart grid, however, represents a viable strategy for managing the current grid due to its technical benefits and improvements to operating capability. The design, implementation, and maintenance of the IoT mere system, however, present numerous problems and difficulties. Several billion dollars are needed to install and maintain the network in order to implement the IoT meter technology in the distribution system. It is challenging to justify the investment. As a result, this expenditure must be achieved in proportion to the anticipated rise in energy demand and the share of dispersed generation [9].

Utility providers would first have difficulties in replacing the outdated energy meters with a IoT meter system. The implementation of IoT meters could be delayed by a lack of adequate infrastructure for coordinating this new technology with the already-in-use ones. Although a number of devices are connected with the IoT meter system, only when all the appliances and devices in the distribution and metering network are included in the communication network can they be used to their full potential. With an increase in clients, device integration becomes even more challenging. Due to problems with the terrestrial environment, some locations may have trouble deploying communication networks [9].

Energy consumption data transmission and collection are automatic ongoing processes, yet they are labor-intensive and expensive. A prevalent belief among many customers in this situation is that because smart meters broadcast data and signals, there may be some privacy and security dangers associated with them. Furthermore, this information might also show who lives there, when they lived there, and which appliances are actually in use. Some consumers might be reluctant to share their energy use information with their neighbor's meter in light of this. The choosing of parameters to be transmitted and administrator authentication to access that information would be the fundamental problems [9].

IoT meters must carry out these utility company control directives in addition to exchanging data and control signals with the base station. A IoT meter and the server at the base station must send enormous amounts of data in order for the system to function. Data administration, maintenance, and storage may be a laborious task. Many technological factors could be taken into account while choosing a communication network. For instance, DNP3 doesn't offer enough security for collaborative operations; as a result, Mander et al. suggest certain security modifications to DNP3 using data object security and a security layer [10].

The deployment of IoT meters and their associated communication networks brings various opportunities and challenges. While they can provide useful information to users about their energy consumption and assist in reducing overall energy usage, there are also potential drawbacks to consider.

One of these challenges is the limited bandwidth and heavy traffic associated with IoT meter communication networks. This may restrict the amount of data that can be transmitted, which could be a concern for some users who require more detailed information. Additionally, integrating devices for modulation, demodulation, and memory can increase deployment costs, which is something that needs to be considered.

Furthermore, sending information about energy consumption over unsecured channels may pose security risks, and utility companies must take measures to ensure proper authentication, software quality, error handling, and protocol security. Inadequate session management can also pose a risk, so it's essential to implement proper security measures.

There may also be logistical challenges, such as limited network coverage, data capacity, and propagation issues, which could affect the overall functionality and reliability of the IoT meter system. Data concentrators can also pose security and space concerns, and it's important to ensure that they are adequately protected.

If using a wired connection, wear and tear on the cable can cause interruptions in transmission, potentially leading to data loss or inaccuracies. Therefore, it's important to use high-quality cables and ensure proper maintenance.

Overall, it's crucial to consider the potential drawbacks when implementing IoT meter systems and take steps to mitigate any issues that may arise. With proper planning, deployment, and maintenance, IoT meters can provide valuable insights into energy consumption and help us make more sustainable choices.[9].

2.1.1 Smart Grid

The smart grid has emerged as the next-generation electricity supply that combines information technology, power system engineering, and communication technologies. It refers to the use of intelligent technologies to improve the traditional electrical infrastructure and promote efficient and sustainable energy usage.

One of the key components of the smart grid is the use of IoT meters, which are installed by distribution units to gather and store data about energy consumption. This data is then stored in semantically aware reservoirs that help the smart grid carry out analytics to optimize energy usage.

To ensure that the smart grid remains functional even during failures and blackouts, it provides self-healing functionality. This means that the system is designed to automatically detect and repair any faults, ensuring uninterrupted energy supply.

The digitization of the grid using wired and wireless communication channels such as WiMAX, WIFI, and fiber optics is a crucial aspect of intelligent technology that enables the smart grid to function efficiently. Through the use of these communication channels, the smart grid can collect and analyze data in real-time, allowing for better decision-making and energy management.

In summary, the smart grid represents a significant advancement in the energy industry, offering numerous benefits such as improved efficiency, sustainability, and reliability. With the use of intelligent technologies such as IoT meters, semantically aware reservoirs, and self-healing functionality, the smart grid is poised to transform the way we consume and manage energy. [5].

2.1.2 IoTMeters

IoT meters are utilized by distribution units as essential recording devices in the smart grid system. The two-way communication channel between the IoT meters and the smart grid enables the transfer of sensor data to internal RAM, which can hold up to 1.3 million records, and then transmit it in tabular form through the distribution node. These meters are designed to operate during both peak and off-peak hours, with peak hours representing the maximum utilization timeline.

Under normal workload and optimum conditions, the lifespan of an IoT meter is typically between 5 to 7 years. It is important to note that regular maintenance and monitoring are required to ensure the longevity of these meters and the overall functionality of the smart grid system. With the integration of intelligent technologies such as IoT meters, the smart grid aims to improve the conventional electrical infrastructure and provide self-healing functionality to deal with failures and blackouts. [5].

2.1.3 Semantic Web Technologies

The Semantic Web is an advancement from the current internet that focuses on providing meaningfully characterized data. It utilizes various elements such as ontology, schema, IRIs, and service discovery languages to enable the processing of datasets. There are several frameworks that support this processing, including the Resource Description Framework (RDF), RDF Schema (RDFS), Simple Knowledge Organization System (SKOS), SPARQL Protocol, and RDF Query Language (SPARQL), among others.

For the transfer and storage of semantic data, the RDF framework is critical, which enables the processing of data through different transport mechanisms and stores it in semantically aware repositories such as Allegro Graph, SESAME, Oracle 11g, and Jena-TDB. An RDF triple statement contains three parts: a subject, predicate, and object, and supports literal/IRI backings for all elements and their relationships. These advancements can also be leveraged in IoT meters to enable more efficient processing and analysis of data.[5].

2.2 Description Of The Smart Home Energy Management System

explains the numerous sensors and intelligent gadgets that are utilized in the system to control the flow of energy between sources and monitor energy consumption.[2]

explains how to maximize energy efficiency and cut costs by using renewable energy sources like solar and wind power.[2]

in order to maximize the utilization of renewable energy, emphasizes the significance of effective energy storage systems.[2]

2.3 The Smart Grid Architecture

The creation of new energy sources and the infrastructures needed to use and manage them must coexist. One of the topics that will be more popular in network-related research and beyond is smart grids. However, what language is and how it is spoken are factors in the ongoing effort to ensure the social, economic, and energy sectors are sustainable [7].

2.3.1 The Grid

First off, despite the fact that it may appear desired, it is important to keep in mind that energy must be managed, transported, and dispersed before it can be consumed after being produced. Considerations on electrical networks can be applied to networks of any kind and remain essentially identical, indicating that the discussion should focus on the "fundamental" characteristics of the network notion.

As a result, a network transports a good from one source of supply to another, taking into account that the two events do not occur simultaneously and the potential for temporarily storing or aggregating for more or less predictable times [7].

2.3.2 The Stakeholders Of The Grid

The efficient management of energy consumption requires a coordinated effort between various stakeholders. A centralized entity, such as a national network, is responsible for predicting consumption patterns and ensuring that demand is met in a timely manner. In addition, it must balance inputs and consumption while optimizing resource utilization. In Italy, TERNA oversees the primary transmission infrastructure, while the Energy Services Manager (ESM) is responsible for the electrical grid.

Production and consumption are then divided into various categories that interact with a single operator. These categories include large and small energy producers, end-users, intermediaries, institutional architects, and guarantors, such as the Single Buyer and the Electricity and Gas Authority. Regardless of their size, all participants play a role in the functioning of the Energy Market at different levels and in various ways. They can choose to either agree or refer to the market, either directly or through institutional guarantors, resulting in various Energy Account contract types. The deployment of IoT meters can help stakeholders monitor their energy consumption more efficiently and make informed decisions about their energy usage.[7].

2.3.3 The Grid Management

With regard to power input in the network, the operator has several options:
buying electricity from national or non-national producers, acting on the energy markets or through bilateral agreements.

Fig 2 . The smart Grid.

Purchasing power from producers within or outside of the country, either through activity on the energy markets or through bilateral agreements.

manufacture electricity in processing plants from other sources, mainly hydrocarbonscontrol loads through resource optimization, or striving to waste nothing.

One of the major issues with managing the power grid is the peak in demand, when there suddenly needs to be a lot of energy available but the supplies are constant and do not have a varied form, and nobody makes money off of energy that is not used. In actuality, the energy manager must plan for the current energy offered by statistics, attempting to reduce the margins of surplus energy [7].

2.3.4 Development Points

Research and testing in the area of intelligent networks have led to the development of various ideas at the national level. One of the ideas involves the use of IoT meters to monitor and control domestic consumption trends as well as consumer input. This helps to provide important assistance inside the houses and facilities.

Another idea is to manage large-scale consumption through energy management by assigning internal or external staff to companies that can control and optimize energy use at all administrative levels. Additionally, implementing machinery that harmonizes discontinuities, such as inverter motors, gradual start-up, and local accumulation, can be useful for local governments, large manufacturing or small consumers, and consumption modes compatible with the availability of electricity grids. [7].

2.4 Power System Operations In Manufacturing Facilities That Rely On The Internet Of Things

Low power wide area networks (LPWAN) are utilized for implementing Narrowband Internet of Things (IoT) in smart grid applications, as it helps in avoiding the congestion of the unlicensed band. The benefits of incorporating IoT devices into energy management are numerous, including real-time data analysis, enhanced security, cloud computing reliance, and seamless offline-online cooperation. Smart sensors, switches, capacitor banks, reclosers, and actuators are some of the control devices that are part of an IOT-based smart grid constructed on IPV6 communication. The centralized data center is responsible for sending back control signals for decision-making.

The successful implementation and sustainability of an intelligent grid require strong technical expertise and leadership. Zigbee, ETSI, and IPSO are some of the organizations exploring the potential of these technologies for IoT applications. Advanced metering infrastructure (AMI) and supervisory control and data acquisition (SCADA) provide insights into the current implementation of IoT in grid technology. Fog computing, a cutting-edge technology that employs client machines or devices close to users as storage nodes, enables real-time decision-making in wide-area IoT deployments. A theoretical model predicting a 40.48 percent reduction in cost compared to cloud computing was constructed to facilitate comparison with the cloud computing platform. The potential and challenges of IoT are presented after reviewing the frequency of online physical data updates.[6].

2.5 Suitability The Smart Grid Architecture

The development of smart grids has been a game-changer in the energy sector, offering a range of benefits such as increased energy efficiency, better demand management, and reduced carbon emissions. One of the key components of a smart grid is the IoT meter, which plays a critical role in enabling real-time monitoring of energy consumption and facilitating communication between different parts of the grid. In this context, a range of interfaces and standards have been developed to enable seamless communication between the various components of the IoT meter system. [8].

At the heart of a typical IoT meter system is the data concentrator, which serves as a gateway for data exchange between the central server and the individual meters. In situations where direct communication between the server and the meter is not possible, data concentrators can be used to establish a connection. This is typically done through power line communication (PLC) systems, which use the existing electrical wiring in the building to transmit data. In cases where a handheld device is required for maintenance, a direct connection can be established between the device and the meter.[8].

Direct communication between the central server and the meter is also possible, and this is typically done through GPRS/UMTS/LTE or an existing broadband internet connection. This allows for real-time monitoring of energy consumption and other parameters, enabling utilities to better manage the grid and respond to changes in demand. [8].

In addition to these interfaces, IoT meters are also typically connected to nearby terminals for installation and configuration. This can be done wirelessly, enabling affordable "drive-by meter reading" without the need for physical access to the meter. [8].

Communication between primary and secondary meters is also important, particularly in the context of multi-utility meters that measure consumption of heat, water, or gas in addition to electricity. This enables better tracking of consumption across different utilities, enabling more accurate billing and more efficient management of the grid. [8].

The key benefits of IoT meters is their ability to facilitate demand response and load shedding, which can help utilities manage peak demand and avoid blackouts. This is typically done through a Home Area Network (HAN) that connects the meter to in-home displays and controllers. This allows consumers to monitor their energy consumption in real-time and adjust their usage accordingly, while also enabling utilities to communicate with consumers and request load shedding when necessary. [8].

To enable seamless communication between these different components of the IoT meter system, a range of standards and protocols have been developed. These standards ensure that different components of the system are compatible with each other, and that data can be exchanged efficiently and securely. Importantly, these standards also enable upward compatibility, meaning that new technologies can be integrated into the system without disrupting existing infrastructure. [8].

In conclusion, the development ofIoT meters and associated interfaces and standards has revolutionized the energy sector, enabling real-time monitoring of energy consumption and better management of the grid. By facilitating communication between different components of the system, IoT meters enable utilities to respond to changes in demand, reduce carbon emissions, and provide better service to consumers. As the technology continues to evolve, it is likely that we will see even greater benefits in the years to come. [8].

III. Methodology

Configure the hardware parts: Connect the current sensor to the Arduino microcontroller and test the connection. Make sure the load status and unit count readings are accurately shown by connecting the LCD display to the microcontroller. Make sure the Node MCU is properly linked to the microcontroller before connecting it.

Create an account on Blynk Cloud: Link the Node MCU to a Blynk Cloud account you've created.

Create the code: Write the code to gather current sensor readings in real time, show them on the LCD, and transfer the information to the Blynk Cloud. Additionally, develop the code to allow remote control of the load using the Blynk app.

System evaluation: Check the system to make sure the current sensor is accurately recording data, presenting it on the LCD screen, and enabling remote control of the load via the Blynk app.

Adding the GSM module To enable the system to deliver SMS messages to the user when the Threshold is Meet , integrate the GSM module with the microcontroller.

making the Blynk app Develop the Blynk app that will allow the user to view the unit usage dependent on the load status. The load should be able to be controlled remotely via the app.

Run the Blynk app test: Check that the Blynk app is accurately receiving information from the microcontroller and enabling remote control of the load by the user.

Embedding the system: Create a completely functional smart energy metre by integrating every system component, including the microcontroller, current sensor, LCD display, relay module, Node MCU, GSM module, and Blynk app.

By using Blynk to remotely regulate the load and a Node MCU to link to the Blynk Cloud, we were able to create and test your smart energy metre project successfully. The load can be turned on and off using the relay module, and the LCD display will indicate unit count readings and the load's condition. The user can view the unit usage dependent on the load state using the Blynk app.

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IV. Implementation

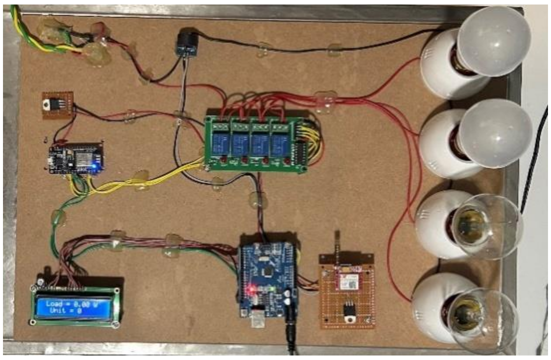

Fig 3

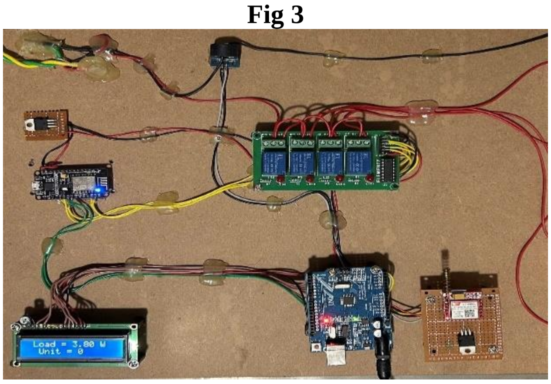

Fig 4

In Figure 3 and 4; Setup for connecting current sensor, LCD display, and Node MCU to Arduino microcontroller.

The figure depicts the setup for connecting a current sensor, an LCD display, and a Node MCU to an Arduino microcontroller. The current sensor is connected to an analog input pin on the microcontroller, with its signal pin attached to the pin and its ground pin attached to the microcontroller's ground pin. The LCD display is connected to the microcontroller's digital pins for data transfer, with its power and ground pins connected to the microcontroller's power and ground pins, respectively.

Before connecting the Node MCU, it's important to ensure it's properly linked to the microcontroller. Once everything is connected, a sample code can be uploaded to the microcontroller to test the connection and make sure that the load status and unit count readings are accurately displayed on the LCD display.

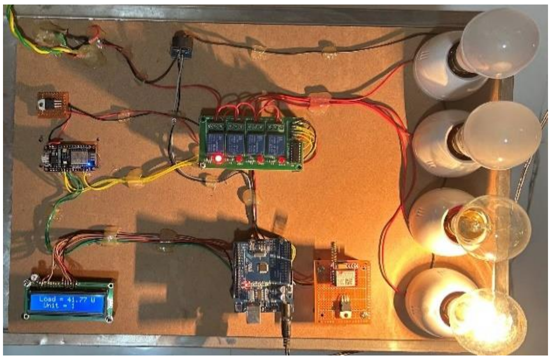

Fig 5

Fig 6

In figure 5 and 6 depicts the process of setting up a Blynk Cloud account and writing code to gather current sensor readings in real time, display them on an LCD, and transfer the information to the Blynk Cloud for remote monitoring and control.

Fig 7

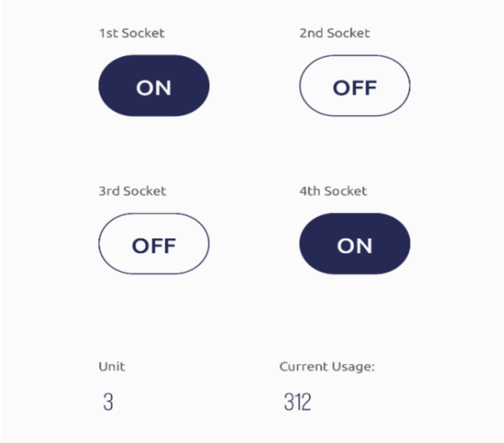

Fig 8

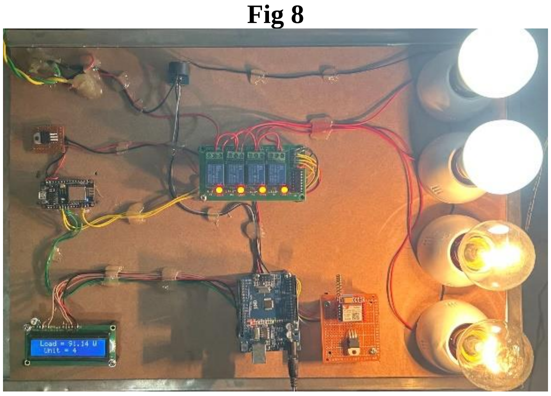

Fig 9

Fig 10

In figure 7,8,9 And 10 Illustrates the process of evaluating the smart energy meter system to ensure that the current sensor accurately records data, displays it on the LCD screen, and enables remote control of the load via the Blynk app.

Figure 7 and 9 shows the testing of the current sensor, where different loads are connected to the smart energy meter to ensure that the current sensor accurately records data. The readings are compared with a reference meter to check for any discrepancies.

The figure 8 and 10 shows the testing of the remote control feature, where the Blynk app is used to remotely control the load. Different loads are tested to ensure that the Blynk app can successfully control the load remotely.

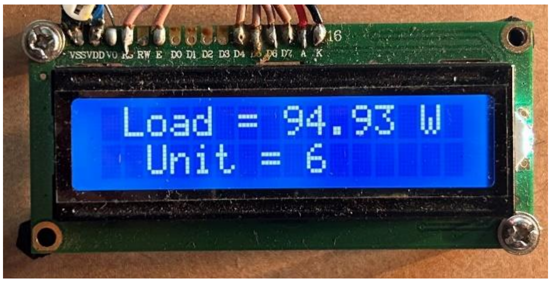

Fig 11

In figure 11 this verify that the load status and unit count readings are accurately displayed on the LCD in real-time.

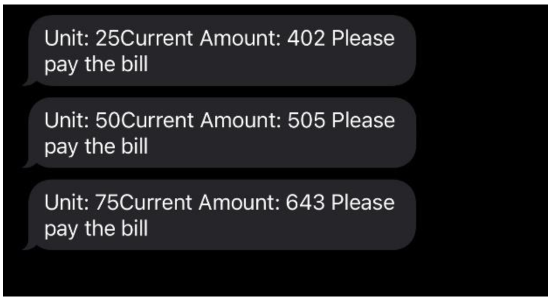

Fig 12

In figure 12 it shows the integration of the GSM module with the microcontroller to enable the system to deliver SMS messages to the user when the threshold is met. The GSM module is connected to the microcontroller, allowing it to send and receive data through the cellular network. The microcontroller is programmed to monitor the load status and unit count, and when the threshold is reached, it sends a signal to the GSM module to trigger the SMS message. The integration of the GSM module with the microcontroller ensures that the user receives timely notifications about the load status, enabling them to take appropriate action.

V. Results And Discussion

By combining an LCD screen, the Blynk app, and a GSM module, a "smart" energy meter was built, and its readings of energy consumption, load status, and unit count have proven to be highly reliable. Additionally, the system enabled remote load control and sent an SMS alert to the user when the unit limit was surpassed. The hardware utilized in the project was trustworthy and provided accurate readings for the course of its lifespan.

The project's findings indicate that using a smart energy meter to monitor and manage electricity consumption may result in significant savings and reduced emissions. The Blynk app enabled remote control of loads and extra monitoring functions, while the LCD panel presented an intuitive interface for viewing energy consumption and load condition. Users were more cognizant of their energy consumption thanks to the GSM module alerting system.

The integrity of the hardware and the precision of the programming were critical to the completion of the project. A user's habits and routines regarding energy use also had an impact. Therefore, it is crucial to take into account the user's requirements and objectives throughout the design, development, and testing phases of a smart energy meter project.

Ultimately, a smart energy meter can be a helpful tool for homes and companies that want to monitor and manage their energy consumption. Accurate measurements, remote control, and notifications when the unit threshold is achieved are all provided by the LCD display, Blynk app, and GSM module. The success of a smart energy meterproject depends on a number of elements, such as the quality of the hardware and the actions of the end users, yet such a project is achievable with proper design and execution.

VI. Conclusion

In this research paper, we have presented a IoT energy meter system that utilizes Internet of Things (IoT) technology to remotely monitor and control the energy consumption of a load. The system uses a NodeMCU with an Arduino microcontroller, a current sensor, an LCD display, a GSM module, and the Blynk app to measure and display the energy consumption of the load in real-time, as well as to remotely control the load using a smartphone.

Our testing results demonstrate that the system is capable of precisely measuring and displaying the load's energy consumption as well as enabling remote control of the load from a smartphone. As an additional layer of monitoring and control, the GSM module enables the system to notify the user through SMS when the load is turned on or off.

Overall, the ability of IoT technology to enable more sustainable and effective energy usage is demonstrated by this smart energy meter system. Users may better manage their energy usage and make more educated decisions about their energy consumption habits by offering real-time data on energy consumption and enabling remote management of loads. As a result, this technology is a significant step in the direction of more intelligent and sustainable energy management techniques.

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