# Secure smart socket system for energy monitoring embedded with IoT

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**ABSTRACT** This study presents a smart socket system with wireless energy meter monitoring system through smartphone (utilizing the Blynk application). Furthermore, this system has optional feature such as the energy consumption alerts. Like a radical idea, it may also be utilized as a development of artificial intelligence to be applied to manual equipment in advance of the changeover to autonomous equipment. As example, to enable smart cities have effective energy management attributable to the combination of current technical breakthroughs and the Internet of Things (IoT). This system employed an ESP32 module to facilitate IoT connectivity with a cloud platform like the Blynk application. The proposed prototype model can monitor daily energy consumption and the other side it also providing consciousness to save electricity

**KEYWORDS** Smart Socket; IoT; Energey Monitoring

## I. INTRODUCTION

In today's world, electricity is the backbone of human civilization. Over the past century, the electricity demand has grown dramatically. As a result of the excessive electricity demand, the whole world is suffering from electric power deficiency [1].On the other side, most importantly nowadays the maximum generation of electricity is from fossil fuels or non-renewable resources. It is well known to everybody that these resources are also limited in nature [2]. So, if we will not take care of proper usage of electricity in our daily life maybe, we will also face an electricity outage in the near future. For example, in our household and industrial system, there are various electricity uses every day. In case of close observation of such uses, we can see, there are lots of electric equipment unnecessarily operated until getting a higher power tariff [3]. Moreover, besides this problem power theft is also a major problem in rural areas due to the lack of proper observation [4].Due to such kind of improper energy consumption most of the scenario's electricity generation corporations and users. The major solution to a such kind of problem is to improperly monitor electricity use. For that, the conventional manual energy meter is very inconvenient for users as well as electricity generation corporations [5]. The following drawbacks are commonly found in conventional annual energy meters:

- Lack of data transparency in daily and overall usage
- Consume lots of time for data collection
- Electricity theft problem
- Human observation errors during noting down the collected data
- Unorganized paperwork
- Must need extra manpower

Due to such kind of incorrect assessment sometimes consumers get a huge amount of power tariff at the same time the electricity generation corporation is also facing a huge revenue loss [6].

To overcome such kind of drawbacks we designed and implement a secured smart socket energy monitoring system (SSEMS) embedded with the internet of things. The primary goal of the study is to find out an alternative approach to traditional energy consumption metering. In recent years due to the benefit of cutting-edge technology, any system that is connected to the internet in order to be accessible from anywhere in the globe at any time is now referred to as being part of the Internet of [7]. By implicating, this proposed SSEMS the subsequent abilities will be attained:

- Capable of calculating the line voltage, over-voltage, under-voltage, power factor, energy consumption, and tariff calculation.
- Live energy consumption monitoring of each and overall appliance.
- Capable to deliver the consumed energy data to the user's mobile device after some time interval.
- Capable to process and transfer monitoring data to consumers and electricity generation corporations to make the system more transparent.

– Customized energy consumption alert notification on consumer's mobile notification.

In this proposed system we implemented two-way communication. As the advantages of this implementation, consumers will well know about their energy consumption and make decisions on energy expenditure. On the other side, suppliers do not need the manual reading collection.

The system that utilizes one-way communication is called Automated Meter Reading (AMR) [8]. and the system which utilizes two-way communication is called Advance Metering Infrastructure (AMI) [9]–[11]. AMR and this two-way communication will make our prototype more advanced and smarter, which creates differences from the conventional meter. AMR helps the consumer to get an accurate reading of energy consumption and also it reduces the cost of the conventional meter. This smart socket system consists of a voltage sensor, current sensor, ESP32 Wi-Fi module, microcontroller ATMega328, and a cloud-based database called Blynk. The main objectives of this research are to give information about real-time energy consumption to the consumer and provider. Whenever the maximum load demand of customers crosses its peak value, the consumer will be notified on their mobile devices with the help of smart socket system.

## II. LITRATURE REVIEW

The area of smart energy management device-based smart meters has been extensively studied by earlier academics. This smart meter features an advanced feature auto billing system for energy savings and allows users to self-check their electricity usage utilizing an IoT platform from a smartphone application. Researchers have proposed a smart meter based on a system that is entirely trustworthy, efficient, and safe to use for efficient energy management because smart meters have not yet been fully implemented in many countries. Thousands of researchers from around the world have worked on many types of energy meter systems in the past to improve technological approaches and accuracy. However, effective efforts and resources for Smart Energy Meters are not keeping up with modern times. In 2021,present and implement AIoT technology to reduce the electric power consumption so it can deliver a easiest service to the end user [12].In 2020 introduced a solution based on preinstalled IoT on a manual meter, which provides wireless energy monitoring via smartphone using the Blynk application [13].Design an ANN mode for automated energy monitoring system for automating billing and handling acquired data remotely is presented in this work. [14].Authors implemented a Wi-Fi based energy meter with low-cost implementation for the internet of things [15].This research presents a wireless meter reading system that can monitor and analyze data at regular intervals, resulting in reliable and error-free results [16].Using IoT technology, they were able to control energy monitoring on solar and energy meters in this paper. Customers can utilize this system to control and operate IoT devices using a Esp8266 WIFI module for home automation. Mobile phones are used in this process of automation. In a cloud-based procedure, IoT technology is utilized to monitor data from solar panels and energy meters [17].

This paper they are presented, the Power Use Alert System is utilized to notify the customer of regular power consumption. This helps to conserve power while also allowing the ability to charge at critical points [18].Described a system for measuring residential energy use that also included the ability to monitor and record power use with a one-second resolution [19]. here they had presented a smart metering system which is capable for power theft detection [20]. Author in [21] proposed a DDoS Attacks [22] and Defense Mechanisms in Various Web-Enabled Computing Platforms: Issues, Challenges, and Future Research Directions. Author in [23] proposed a secure and energy efficient-based E-health care framework for green internet of things. Author in [24] proposed a novel coverless information hiding method based on the average pixel value of the sub-images. Author in [25] proposed a secure Machine Learning scenario from Big Data in Cloud Computing via Internet of Things network. Author in [26] proposed a context Aware Recommender Systems. Author in [27] proposed a cross-lingual transfer method and distributed MinIE algorithm on apache spark. Author in [28] proposed a smart defense against distributed Denial of service attack in IoT networks using supervised learning classifiers. Author in [29] proposed an adaptive Feature Selection and Construction for Day-Ahead Load Forecasting using Deep Learning Method. Author in [30] proposed and analysis of artificial intelligence-based technologies and approaches on sustainable entrepreneurship. Author in [31] proposed a digital Watermarking-Based Cryptosystem for Cloud Resource Provisioning. Author in [32] presents a Browser-Side Context-Aware Sanitization of Suspicious HTML5 Code for Halting the DOM-Based XSS Vulnerabilities in Cloud. Author in [33] proposed a lightweight mutual authentication protocol based on elliptic curve cryptography for IoT devices. Author in [34] proposed a secure Timestamp-Based Mutual Authentication Protocol for IoT Devices Using RFID Tags. Author in [35] proposed a novel framework for risk assessment and resilience of critical infrastructure towards climate change. Author in [36] presets a review on advances in security and privacy of multimedia big data in mobile and cloud computing. Author in [37] proposed myocardial infarction detection based on deep neural network on imbalanced data. Author in [38] proposed a reputation score policy and Bayesian game theory based incentivized mechanism for DDoS attacks mitigation and cyber defense.

## III. METHODOLOGY

There are several disadvantages exist in our conventional metering system due to the manual billing system. The power service company systems are also not good or flawless. And the result of this customers is also dissatisfied about the statistical errors in their monthly bills. To solve this issue, we are attempting to convey the concepts of fault minimization, and reducing the human system dependency. On the other hand, we are trying to make our proposed system cost effective.

## IV. TWO-WAY COMMUNICATION SYSTEM

The smart energy socket is designed for both the consumer and the Provider. In This smart socket we integrate both the GSM And the Zigbee technology to send the data to user and the provider. After collecting the energy consumption reading, from the consumer side the smart socket transmits the result with the help of GSM And the Zigbee to the data storage system. The data storage system works in a three step, (i) gathers information, (ii)stores the information, and (iii) uploads the information to the internet. As a result, the customer can access respective information on the internet using an Android app or a website portal. The user can also receive consumption information by SMS over the GSM network from the receiver.

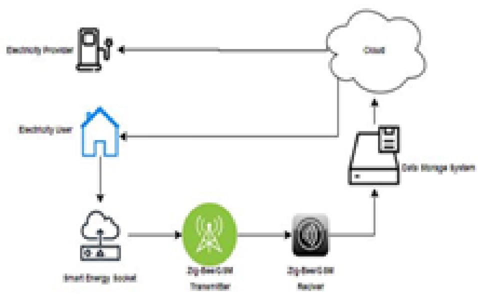

FIGURE 1: Two Way Communication System

## V. SMART SOCKET SYSTEM

To make smart socket system in this paper we have used AC Current sensor, Ac Voltage sensor, ESP32 micro-controller embedded with WIFI module ,110 V-12 V step down transformer, bread board, AC to DC rectifier, Display unit and Power supply units etc.

The Arduino platform is used to program the ESP32 microcontroller board. For the detection of current and voltage supply across the load, ESP32 is linked to the AC voltage sensor and current sensor. On the other hand phase line and neutral line are connected to the power supply board .To turn on the micro-controller board we need to give 9V DC power supply for that first we need to step down our main voltage using the help of 110v-12v AC step down transformer after then we are using AC-DC rectifier for the conversion of AC to DC power supply and at the last we are using (DC to DC) converter to get 12v DC to 9V DC. The whole process of voltage conversion has shown in Fig. 2.

In this fig. 3 we have shown the data flow of our smart socket system. At first our voltage sensor and current sensor sense the AC voltage and current readings and transfer the data to the ESP32 micro-controller. After, getting the data we transmitted it to the cloud by the help of embedded Wi-Fi module using IoT platform.

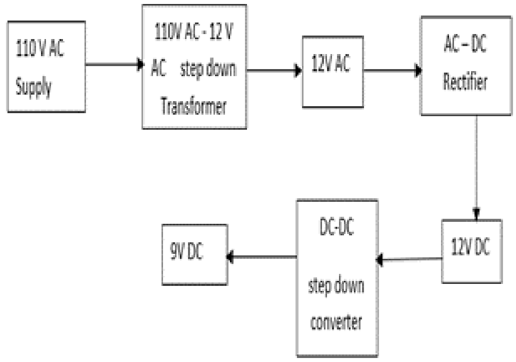


FIGURE 2: The step down of voltage 110V AC to 9V DC

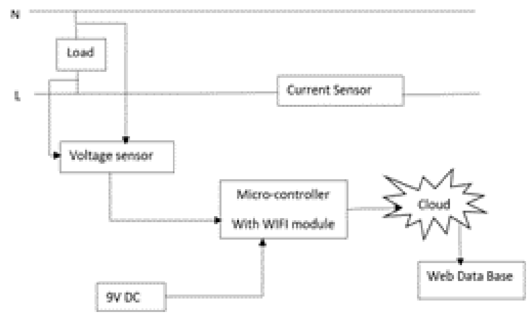


FIGURE 3: Schematic diagram of smart socket

## VI. MATHEMATICAL FORMULA

AC current is an electric current which changes its direction and magnitude over time. The nature of AC current is in sine wave, triangular wave and square wave. That's why we are needed for RMS value of voltage and current to calculate the power consumption.

$$V_{RMS} = \sqrt{\frac{sum\ of\ ordinate\ (voltages)^2}{number\ of\ mid\ ordinates}} \quad (1)$$

$$I_{RMS} = \sqrt{\frac{sum\ of\ ordinate\ (current)^2}{number\ of\ mid\ ordinates}} \quad (2)$$

Also, we can obtain the average power by only multiplying the RMS current with RMS voltage

$$P_{AVG} = V_{RMS} \times I_{RMS} \quad (3)$$

We got the result $P_{AVG}$(real power) in the unit of Watt or Kilowatt. To obtain the energy consumption measurement in our daily life We need to multiply this total average power with Time. So, the equation is

$$E_{kwh} = P_{AVG} \times \frac{t_{hours}}{1000} \quad (4)$$

## VII. BLYNK PLATFORM

The Blynk platform basically an application. It can be opened by taping the application icon on smartphone or tablet. This application allows the users to monitor power usage statistics.

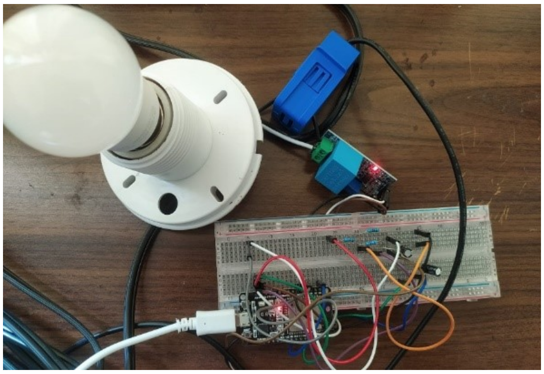

FIGURE 4: Prototype Model

It is showing data whish is collected by sensor and also has notification alert system, where users can avail a notification when the electricity usage has exceeded the energy usage level. The primary interface of the Blynk program is showing in Fig. 5. The center three boxes of the primary interface are used to receive the electrical data from the ESP32, which transmit the data signal to the Blynk cloud server. The ratting of RMS voltage in volts and RMS current in amperes are displayed on main interface page. More on , the average power in watts and total consumed energy in kilowatt-hours also displayed showing in same page .

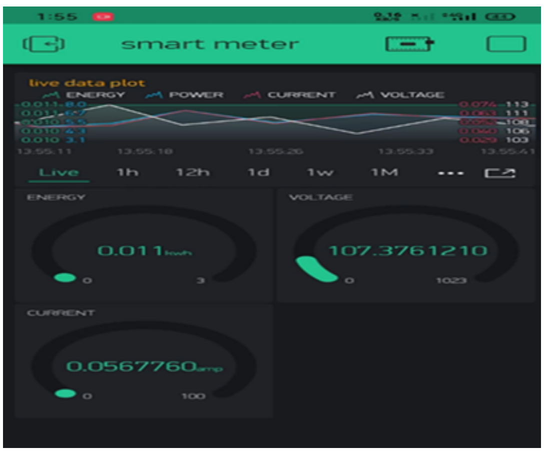


FIGURE 5: Blynk Application user interface

## VIII. EXPERIMENTAL RESULTS

The voltage and current sensors receive spontaneous data in a form of signal and send it to the ESP32, which calculate and evaluate the RMS ratting of voltage and current. Accordingly, the Blynk application displayed the RMS values voltage and current, and then using the help of RMS current and voltage data making a dot product calculation to getting the average power in watt and total energy consumption of the household in kilowatt-hours. In Fig. 6 the graph of average energy consumption in kilowatt-hours has been displayed. From this graph users can visualize energy consumption. The average energy usage is recorded in every 7 seconds for the live time reading. Users may choose when they want to know the consumption of energy reading with the time frame for up to one year.


FIGURE 6: Energy Consumption display in Blynk

More on, if the energy level exceeded Blynk will automatically send an email notification to the users email account. In Figure 7 shows an example of a Blynk warning when energy surpasses the energy consumption level.


FIGURE 7: : Energy Consumption Notification in email from Blynk

## IX. CONCLUSION

In this paper, a Smart Socket System introduced. This smart system includes energy monitoring in mode of wireless transmission of data, using the Blynk application platform. Which raises awareness for energy conservation and consumption reduction. This system also concludes with emerging IoT technologies, consumers may have more effective way to manage electric energy by monitoring the energy consumption. This research analyzed a suggestion for future work, to utilize an Artificial Neural Network prediction model for energy consumption tariff system forecasted based on the predictor variable.

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