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Research on Smart Power Monitoring System Using IoT

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Abstract: The "Smart Power Monitoring System using IoT" constitutes a pioneering solution poised to revolutionize the landscape of power management in both residential and industrial settings. Anchored by the ESP8266 NODE MCU microcontroller, this system seamlessly integrates an array of state-of-the-art sensors and modules, all working in concert to deliver real-time monitoring and controlling capabilities. The predominant objective of this innovative system is multifaceted: to elevate energy efficiency, bolster security measures and enable remote monitoring through the dynamic fabric of the IoT. The ESP8266 NODE MCU, functioning as the system's central hub, orchestrates a symphony of components, including a current sensor for precise power consumption insights and a PIR sensor to intelligently detect human motion for enhanced automation. The inclusion of a GSM module ensures timely communication of critical alerts to users via SMS, underscoring the system's responsiveness. Additionally, a relay module facilitates the remote control of appliances, promoting user-friendly power management. A half horsepower induction motor acts as a tangible load indicator, providing users with a visual representation of power fluctuations. The system, powered by a stable 9V 1 Amp DC supply, culminates its capabilities by leveraging the “ThingSpeak” platform to graphically display power consumption trends, empowering users to make informed decisions for sustainable and efficient energy practices. In essence, the "Smart Power Monitoring System using IoT" emerges as a comprehensive and forward-thinking solution, poised to redefine the paradigm of intelligent power management.

Keywords: IoT technology, real-time monitoring, energy consumption analysis.

I. INTRODUCTION

The “Smart Vitality Administration System” is considered to be one of the most empowering advances, which makes a difference in leveraging the network that is postured by IOT, bringing back the estimation track and control that enhances the utilization of vitality through the building of certain complexes. The shrewd control checking framework is a multifaceted IoT-driven arrangement outlined to change vitality administration in private settings. The savvy control observing framework, a confirmation of IoT advancement, stands as a ground-breaking arrangement outlined to change vitality administration inside families. This paper presents a shrewd control-checking framework using IoT innovation for real-time monitoring and administration of family vitality utilization. Joining sensors like current and PIR, nearby GSM for cautions and hand-off control for machines, it offers inaccessible observing and control capabilities. The foundation of this framework lies in its capacity to incorporate and display information in a user-friendly way. The integration with “ThingSpeak” permits the consistent transfer of control utilization information, encouraging the creation of comprehensive charts and visual representations. This not only helps in understanding utilization designs but also engages clients in making educated choices that advance vitality preservation and cost-effectiveness. By uploading information to “ThingSpeak” for representation, this framework empowers clients to watch utilization patterns and take educated actions towards proficient vitality utilization, improving supportability and advancing keen domestic robotization.

IoT fulfilment in “Smart Home Energy Management Systems” developed quickly and also reacted to lots of issues, including power investments in stylish towns [1]. Multiple functions of SHEMS include electrical power monitoring [2], robotic power control [3], manual control and electricity power victimization. Earlier, various citizens used robotic meter recitation, progressive meters and energy meters [4–5]. Obsessive by the price devaluation of batteries for electric vehicles [6], the ‘internet of things’ instructs interacted connected daily gear in natural areas. All natural objects in the world are “ThingSpeak” in IoT [7, 8].

By amalgamating advanced innovation with user-friendly information representation, this framework also offers real-time checking, controlling and engaging clients to effectively lock in feasible vitality. This paper serves as an urgent step towards cultivating shrewd, energy-efficient homes and communities, advancing a greener, more feasible future.

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The fundamental commitments related to the survey are:

- Importance of the restrictions related to the flow-charged control organization.
- Talking about the function of an IoT is changing conventional charge control systems keen on shrewdly controlled networks.
- Giving a broad audit of IoT-based electric control framework applications.
- Giving a specialized evaluation of shrewd domestic applications of IoT sensors.
- The importance of the financial, social and natural effects of an IoT is charge control frameworks.
- Giving broad bits of knowledge is interacted with, organized and aimed at IoT-founded charge control organizations.
- Identifying limitations related to the IoT arrangement in electric control frameworks and suggesting arrangements to overcome them.

In smart electric power grids, implementing IoT has some benefits.

- Increase power effectiveness, adaptability, resilience and dependability [9].
- Fewer protocols for communication [10–11]
- Operation over networks and improved information operation capabilities [12]
- Better management of household appliances [13]
- Make end-to-end facility provision and on-demand information entry possible [13].
- Better ability to sense [14]
- Enhanced compatibility and scalability [15]
- Less damage is caused by natural calamities [16].
- Less physical attacks on EPS, such as substation break-ins [17], thanks to constant real-time physical asset monitoring of the of the electrical power network.

The order of the document is as follows: A critical analysis of previously implemented monitoring systems is presented in Section 2. The information on components use in power monitoring systems Section 3. Section 4: The workings of the system and the final portion contain the paper's conclusion.

II. LITERATURE REVIEW

A simplified overview of the relevant methods and readings discussed in this part. Including an IoT deployment, a control system, a monitoring system and other associated methods. Given the recent rise in power use, people's reliance on electricity is excessive these days [18]. In both domestic and commercial buildings, it is essential to think about computing and examine electrical techniques or purposes that are routine on an everyday basis. The inhabited regions, which are the specialty of this paper, are facts about modest power users and consumers, like homes and apartments. The inquiry recommended that for private vitality customers [19], domestic vitality can be accomplished by utilizing a domestic vitality checking framework [20, 21]. A few cases have shown that vitality utilization can be diminished by altering the way of life with legitimate habits and behaviours [22–23].

The regulatory framework is a framework that contains additional gears contingent on what is selected as regulated. Nearby and farther controls are comprised within regulated solicitation. Nearby regulate is an activity that the regulate thing will revenue on its claim and farther regulate is an instrument that in the least regulate the IoT base framework [24]. Electric gear functional prominence observation will diminish the toll of construct control utilization and grow constructed' electrical vitality to a sensible and effective proportion [25]. As they can be fully overseen, control frameworks can benefit shoppers' vitality more successfully and productively. The regulatory framework regulates the current in this ponder, which will be taken away if a complete current is discovered. This regulatory framework can increase awareness of the utilization of family machines among operators.

Innovation is one of the primary purposes for a nation to develop into a well-established nation. Advancements and innovation can possibly alter the commons and make the world more feasible and comprehensive. The web of things, known as the internet of things, is an unused and ever-growing arrangement that is getting to be a hot point in commons discussions in this period of advanced innovation. IoT is a wide, open and total arrangement of shrewd and brilliant substances that has the full ability and capacity to auto-organize, share data, facts and assets, act and respond to any circumstances or climate of the changing world [26–27]. IoT is developing and needs to be maintained so that it will be an extended, imaginative model in the IT world. IoT progression controllers are the genuine object that will change the web into a completely coordinated upcoming web [28]. Upcoming data announcement innovations are to be utilized with implanted detectors. The goal requests are savvy metering and Web-associated sensor gadgets for family apparatuses, highlighting the profits of farther real-time checking for family vitality utilization machines [29, 30–31].

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Related Works:

Anitha et al. proposed "Smart energy meter surveillance using IoT" about how 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 and the 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. [32] Devadhanishini et al., "Smart Power Monitoring Using IoT," find that energy consumption is a very important and challenging issue. An automatic electrical energy meter is used in large electric energy distribution systems. The integration of Arduino WIFI and SMS provides the system with a smart power monitoring system. A smart energy meter provides data for optimization and reduces power consumption. This system also includes a motion sensor so that if there is no human in the house, it will automatically turn off the power supply. [33] Mohammed Hosseiu et al. presented "Design and implementation of smart meters using IoT," describing the growth of IoT and digital technology. The future energy grid needs to be implemented in a distributed topology that can dynamically absorb different energy sources. [34] Himanshu K. Patel et al. demonstrated an "Arduino-based smart energy meter" that removes human intervention in meter readings and bill generation, thereby reducing the errors that usually occur in India. The system consists of the provision of sending an SMS to the user for an update on energy consumption, final bill generation and the freedom to reload via SMS. [35]

Bibek Kanti Barman et al. proposed a smart meter using IoT for efficient energy utilization, which plays a very vital role in the development of smart grids in power systems. Hence, proper monitoring and control of power consumption is a main priority of the smart grid. [36] Garrab et al. proposed an AMR approach for energy savings in smart grids using smart meters and partial power line communication to meet the rising demand for energy. Smart meters are one of the proposed solutions for the smart grid. [37] Landi et al. presented an ARM-based energy management system using a smart meter and web server as a low-cost, real-time ARM-based energy management system. An integrated web server helps collect statistics on energy consumption, power quality and interface devices for load displacement. The device is used to access the information. [38] Koay et al. explained in "Design and Implementation of Bluetooth Energy Meters," described around the year 2004, that digital meters have started to replace electromechanical meters in Singapore. A wireless digital power meter would offer greater convenience for the meter reading task. Bluetooth technology is a possible wireless solution to this issue. [39]

Noor Nateq Alfaisaly et al. try to prove that a well-designed power monitoring system is quite effective and necessary in the current year. At the same time, the integration of IOT devices with this system increased its effectiveness and use in a variety of disciplines. [40] Diya Elizabeth Paul et al. presented implementing a fully automated electricity billing system. The aim is to measure and monitor the electricity consumed by consumers in a locality and transmit the consumed power to the station, as well as issuing the bill of consumed power automatically. [41] Sindhuja, Putta and M. S. Balamurugan. et al. presented internet of things technology to reduce the effort of humans by introducing machine-to-machine interaction. [42] Santos, Diogo and João C. Ferreira. describe the development and subsequent validation of EnerMon, a flexible, efficient, edge-computing-based Internet of Things (IoT) LoRa (LongRange) system to monitor power consumption. [43] Kurde, Arati and V. Kulkarni. focus on designing devices that have built-in capability to measure and report energy use or receive control input over the network. This study will help in creating energy-aware devices. [44].

Sulthana, Naziya and N. Rashmi introduce a smart energy monitoring system including Arduino, WI-FI and an and an energy meter. The system automatically reads the energy meter and provides home automation through an app developed and power management is done through this application. [45] Mohammad Kamrul Hasan, Musse Mohamud Ahmed, et al. present this ponder and propose a smart monitoring and control system (SMACS) for household appliances. The application's significance is to monitor household appliances' electricity usage using hardware and Internet of Things (IoT) methods. [46] Abhiraj Prashant Hiwale et al. describe the digitization of load energy usage readings over the internet. The proposed system design eliminates human involvement in electricity maintenance. The user can monitor energy consumption in watts from a webpage by providing a channel ID for the load. [47]

III. SYSTEM REQUIREMENT

HARDWARE REQUIREMENT

1. ESP8266 Node MCU
2. Current Sensor
3. PIR sensor

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4. GSM module
5. Relay module
6. Half HP induction motor

SOFTWARE REQUIREMENT

1. Arduino IDE
2. Proteus
3. "ThingSpeak" Application

ESP8266 Node MCU:

The Node MCU (Node Micro Controller Unit) is an open source software and hardware development environment that is built around a very inexpensive System-on-a-Chip (SoC) called the ESP8266 (Fig. 1).

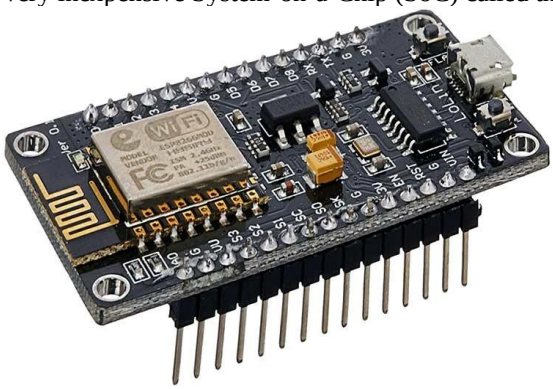

Fig. 1 ESP8266 Node MCU

Current Sensor:

Current flowing through a conductor causes a voltage drop (Fig. 2). The relationship 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.

The measurement of current is necessary for the proper working of devices. The measurement of voltage is a passive task and it can be done without affecting the system. Whereas measurement of current is an intrusive task that cannot be detected directly as voltage.

Fig. 2 Current Sensor

PIR Sensor:

A passive infrared sensor (Fig. 3) is an electronic sensor that measures infrared light radiating from objects. PIR sensors are mostly used in PIR-based motion detectors. Also, it is used in security alarms and automatic lighting applications. The below image shows a typical pin configuration of the PIR sensor, which is quite simple to understand from the pinouts. The PIR sensor consists of three pins.

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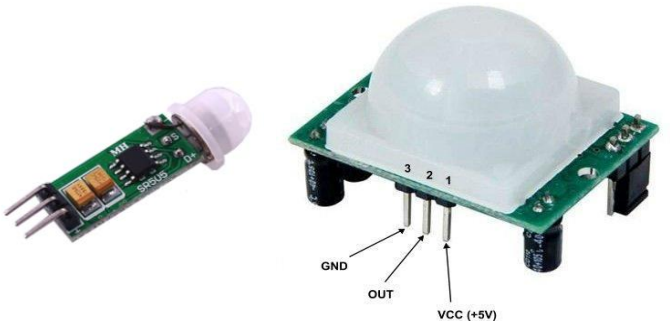

Fig. 3 PIR Sensor

GSM Module SIM800L:

The SIM800L is a GSM module (Fig. 4) from SIMcom that gives any microcontroller GSM functionality, meaning it can connect to the mobile network to receive calls, send and receive text messages and also connect to the internet using General Packet Radio Service (GPRS), Transmission Control Protocol (TCP), or Internet Protocol (IP). Another advantage is that the board makes use of existing mobile frequencies, which means it can be used anywhere in the world.

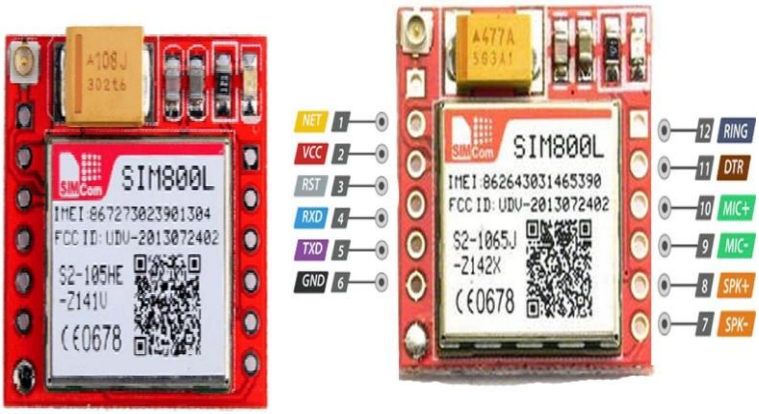

Fig. 4 GSM Module

Relays:

Relays (Fig. 5) are the essential components for the protection and switching of a number of the control circuits and other electrical components. All the relays react to voltage or current, with the end goal of opening or closing the contacts or circuits. This article briefly discusses the basics of relays and the different types of relays that are utilized for a variety of applications. A switch is a component that opens (turns off) and closes (turns on) an electrical circuit. whereas a relay is an electrical switch that controls (switches on and off) a high-voltage circuit using a low-voltage source. A relay completely isolates the low-voltage circuit from the high-voltage circuit.

Fig. 5 Relay

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Half HP Motor:

A half horsepower (HP) motor is an electric motor (Fig. 6) with a power rating of approximately 0.5 HP, which is equivalent to 373 watts. These motors are commonly used in various applications, such as small machinery, appliances, pumps and fans. A half HP motor provides a moderate level of power, making it suitable for tasks that require a balance between energy efficiency and performance. They are often found in home appliances like washing machines and air conditioners, as well as in industrial equipment for tasks such as driving small conveyor belts or powering ventilation systems. Half HP motors are known for their reliability and durability, making them a popular choice for a wide range of applications where a modest amount of mechanical power is required.

Fig. 6 Half HP Induction Motor

Arduino IDE Software Intro:

Arduino.cc (Fig. 7) is an official software introduced by Arduino that is mainly used for writing, compiling and uploading the code to almost all arduino modules and boards. Arduino IDE is open-source software and is easily available to download and install.

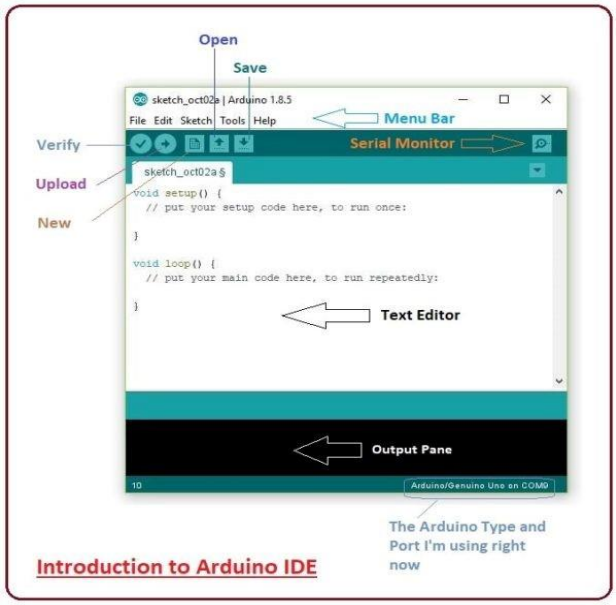

Fig. 7 Arduino IDE Software

Proteus:

It is a software suite containing schematics, simulations and PCB design.

- ISIS is the software used to draw schematics and simulate the circuits in real-time. The simulation allows human access during run time, thus providing real-time simulation.
- ARES is used for PCB design. It has the feature of viewing the output in a 3D view of the designed PCB along with the components.
- The designer can also develop 2D drawings for the product.

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ThingSpeak Application:

ThingSpeak is an IoT analytics platform service that allows you to aggregate, visualize and analyse live data streams in the cloud (Fig. 8). You can send data to ThingSpeak from your devices, create instant visualizations of live data and send alerts using web services like Twitter® and Twilio®. With MATLAB® analytics inside ThingSpeak, you can write and execute MATLAB code to perform pre-processing, visualizations and analyses. ThingSpeak enables engineers and scientists to prototype and build IoT systems without setting up servers or developing web software.

ThingSpeak is a platform providing various services exclusively targeted for building IoT applications. It offers the capabilities of real-time data collection, visualizing the collected data in the form of charts and the and the ability to create plugins and apps for collaborating with web services, social networks and other APIs. We will consider each of these features in detail below.

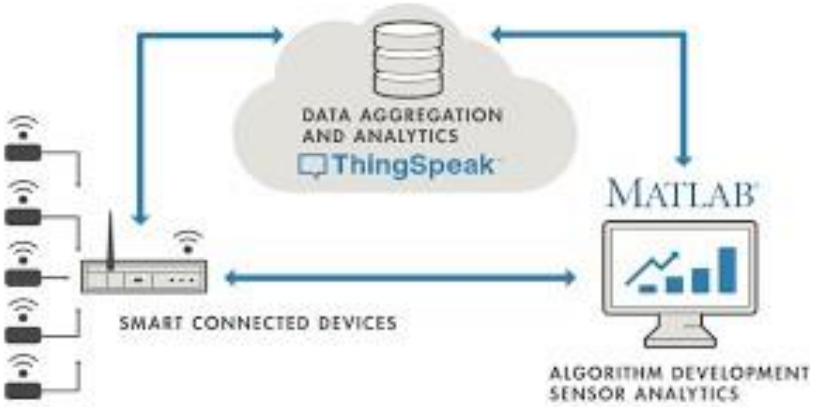

Fig. 8 ThingSpeak Application

IV. METHODOLOGY

The proposed keen control observing framework utilizing IoT involves a step-by-step workflow planned to consistently coordinate different components for comprehensive control observing and control. At first, the framework utilizes an ESP8266 NODEMCU as the center, which coordinates the collection and handling of information from different sensors. Firstly, the current sensor, which coordinates with the framework, precisely measures control utilization. Concurrently, a PIR (inactive infrared) sensor is utilized to distinguish human movement, permitting the framework to observe inhabitancy status inside the checked region. Along these lines, this data is utilized to powerfully alter machine operation based on inhabitancy designs, optimizing vitality utilization. The incorporation of a GSM module empowers the framework to trigger SMS automatic meter readings on the occasion of bizarre control utilization events, giving opportune notices to clients. Besides, a transfer module, controlled by the NODE MCU, encourages the administration of the on/off states of domestic apparatuses, including an extra layer of control and productivity. To precisely re-enact real-world scenarios, an acceptance engine is utilized to speak to the stack, giving real-time criticism on control utilization. The whole framework is fuelled by a 9V, 1 Amp DC control supply, guaranteeing dependable operation. Also, integration with “ThingSpeak” encourages the consistent uploading of control utilization information to the cloud, empowering clients to visualize patterns and designs through natural charts and, in this manner, enabling educated decision-making with respect to vitality administration methodologies. Through this comprehensive workflow, the framework offers a strong and user-friendly arrangement for shrewd control checking and control.

Working

The Smart Power Monitoring System operates seamlessly through a coordinated network of components (Fig. 9). The ESP8266 NODE MCU, acting as the system's central processor, continuously gathers data from the current sensor and PIR sensor. The current sensor meticulously measures power consumption, while the PIR sensor detects human motion, indicating occupancy status. Upon detecting significant changes in power consumption or occupancy, the GSM module swiftly triggers SMS alerts to notify users, ensuring timely awareness of any irregularities. Additionally, the relay module, under the NODE MCU control, efficiently manages the on/off states of home appliances, optimizing energy usage based on occupancy patterns (Fig. 10). A simulated load, facilitated by the induction motor, offers real-time feedback on power consumption, aiding users in understanding their energy utilization habits. Powered by a reliable 9V 1 Amp DC power supply, the system seamlessly integrates with "Thingspeak," uploading consumption data for users to analyse via intuitive graphs, empowering them to make informed decisions towards effective energy management.

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Circuit Diagram

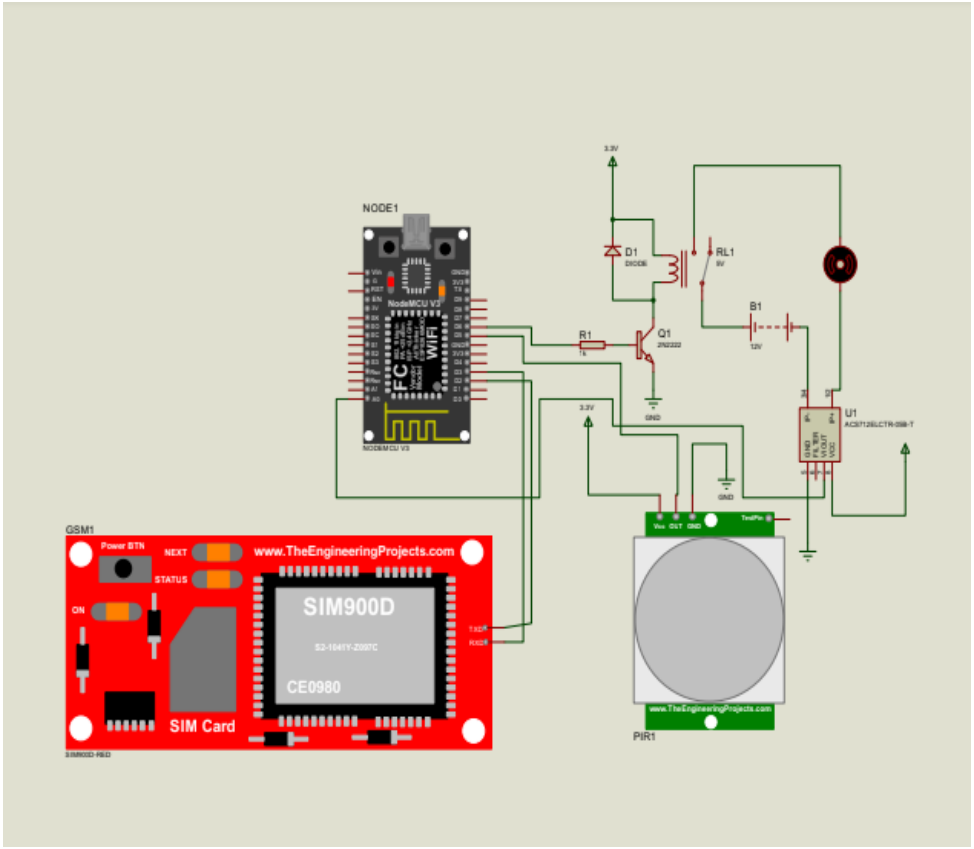

Fig. 9 Circuit Diagram

Experimental Setup & Result Experimental Setup

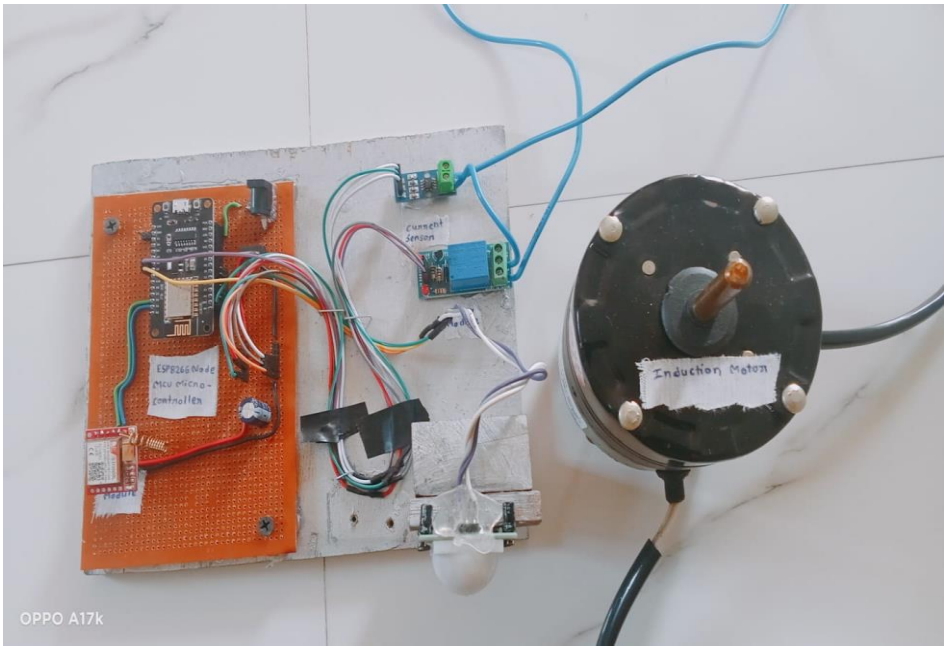

Fig. 10 Shows the Experimental Setup of the system

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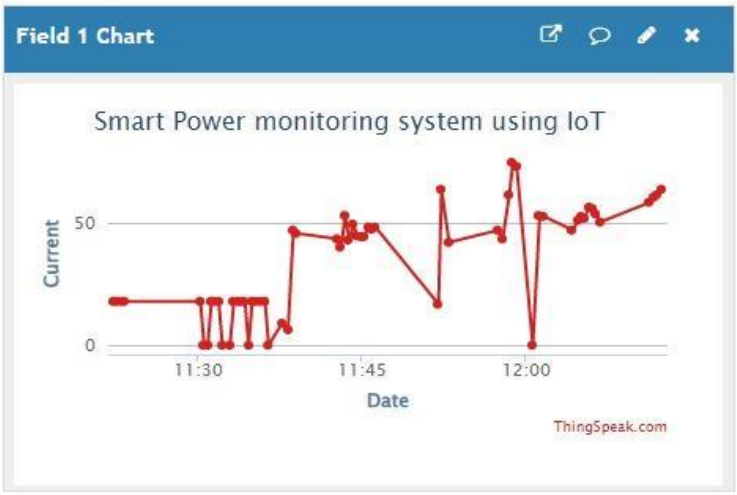
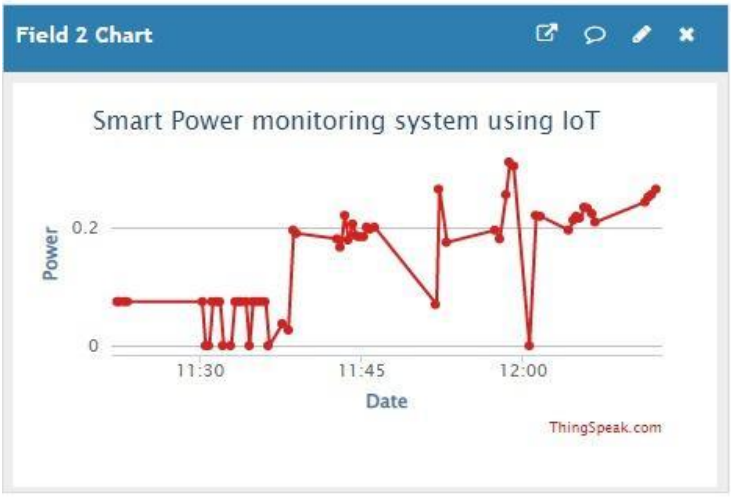
V. RESULT

The results of this smart power monitoring system using IoT showcase a sophisticated approach to energy management and control. By integrating various components such as current and motion sensors, a GSM module for alerts, a relay module for appliance control and integration with "Thingspeak" for data visualization, the system offers real-time monitoring and adaptive functionality based on occupancy. The use of an induction motor as a load provides practical insights into power consumption (Figs. (a) and (b)). Overall, the system enables users to monitor, analyse and optimize energy usage effectively, leading to potential savings and improved efficiency in residential or commercial settings.



(a)



(b)

Fig. (a) and (b) show the graph of power consumption output on the ThingSpeak App

VI. CONCLUSION

In the realm of modern residential energy management, the Smart Power Monitoring System stands as a light of technological innovation. Its fusion of IoT-driven real-time monitoring, remote control functionalities and proactive alert systems heralds a new era in household energy efficiency. By seamlessly integrating an array of sensors, communication modules and data visualization tools, this system not only enables users to observe and regulate their power consumption during the real-time period but also instils a sense of awareness and responsibility towards sustainable living practices. The Smart Power Monitoring System harnesses the potential of IoT technology to revolutionize energy management in residential spaces. By amalgamating real-time monitoring, remote control capabilities and proactive alerts, this system gives users the power to make updated decisions concerning energy consumption.

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The integration of sensors, communication modules and data visualization not only facilitates efficient energy usage but also fosters a culture of sustainability and smart living. Ultimately, this paper signifies a pivotal step towards creating energy-conscious communities and a more sustainable future.

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