IOT And GSM-Based Smart Grid Controlling and Monitoring System

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ABSTRACT

The IoT and GSM-based Smart Grid Monitoring and Control System is engineered to improve both the efficiency and safety of power distribution networks through real-time data tracking and automated notifications. At the heart of the system is an Arduino Mega 2560 microcontroller, which integrates with a PZEM004T sensor to monitor key electrical parameters such as voltage, current, frequency, and energy usage. To ensure safety, a Dallas temperature sensor and a fire detection sensor are employed—triggering a buzzer and sending a GSM alert if high temperatures or fire risks are detected. For load management, the system incorporates two relays to control 100W and 200W bulbs. A Node-MCU module enables continuous data transmission to the Ada-fruit IoT platform, offering remote monitoring and control. Powered by a 12V adapter and equipped with durable connectors and cables, this smart grid solution offers reliable performance, enhances energy efficiency, and ensures proactive safety responses.

Keywords: - IoT, GSM, Smart Grid, Buzzer, Node-MCU.

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I. INTRODUCTION

The increasing demand for electricity and growing impetus on efficient energy utilization have stimulated the growth of smart grid infrastructures. Traditional electric grids are experiencing a drastic revolution from being passive networks to intelligent grids that are spurred by the emergence of advanced communication, sensing, and automation technologies. IoT (Internet of Things) integrated with Global System for Mobile Communications (GSM) in smart grids allows effective monitoring and control of electrical objects in real time which increases system reliability, reduces energy losses and overall maximizes efficiency. In this project, we build a smart grid monitoring and controlling system with IOT and GSM technology. The system continuously monitors important parameters like voltage, current and energy consumption with the help of IOT sensors connected to it. This real time data is then sent via GSM to a central unit where the data is analyzed for improving energy distribution plans if needed as well as allows an operator to remotely control important circuit's breakers or switch which enabling quick response during faults or extraordinary demands.

The main aim of the system is to reduce energy consumption, losses and increase reliability in electrical grids. Utility companies can have an intelligent way of monitoring and controlling their grid infrastructure, thus reducing outage probability and increasing customer's satisfaction. With adaptive nature of application other industries along the energy which are generation, transmission and distribution can take benefit as well from such an application.

II. LITRRATURE

The development of electrical power systems in the smart grid marks a significant change towards the traditional infrastructure, intelligent, data-powered network. In the last decade, researchers and engineers have discovered the integration of large -scale advanced technologies such as IOT) and Global System for Mobile Communications (GSM), which is to increase the performance, efficiency and credibility of the power grid[1].

IOT has emerged as an important technique in modernization of electrical systems. Studies have shown that IOT-enabled equipment facilitates real-time monitoring and automatic data collection, allowing grid operators to make informed decisions and quickly respond to discrepancies. These smart sensors collect data related to consumer, constant voltage, current, temperature and energy consumption within various points of grid, which create a comprehensive picture of grid health and performance[2].

On the other hand, GSM, serves as a strong communication spine in areas where traditional internet connectivity is limited or incredible. The literature highlights the role of the GSM in ensuring remote access, ensuring remote access to the data and sending the control command from almost any place to the grid elements[3].

The fusion of GSM with IOT has proved to be effective for implementing remote switching operations and sending an alert message's during the situation of mistake or abnormal landscapes[4].

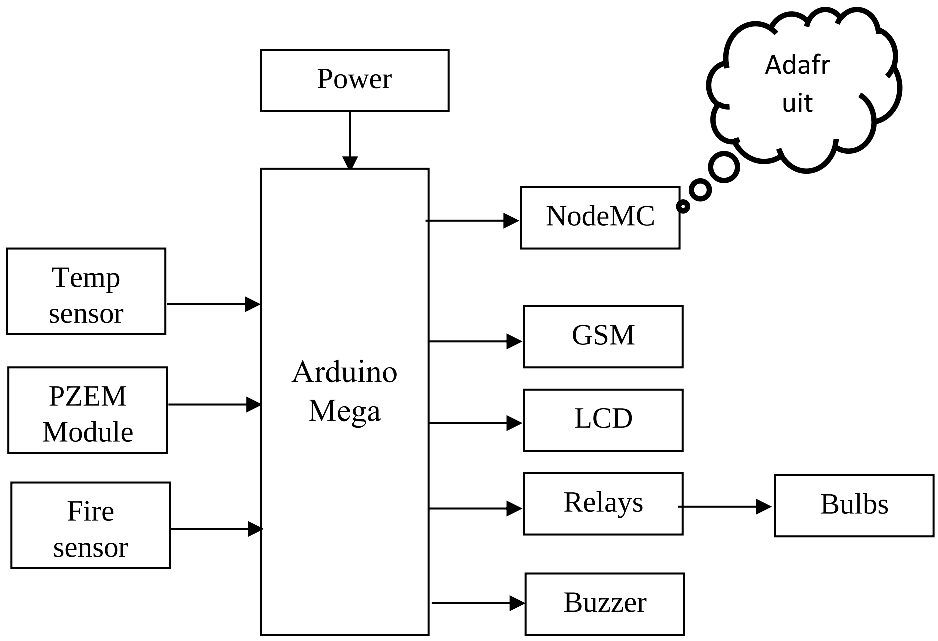
Various projects and research papers have displayed the implementation of Arduino-based systems in combination with IOT and GSM module for smart energy management. These systems are often supported by cloud platform or IOT dashboard (such as Adafruit IO or Blynk), which provide real-time visualization and analytics for end-users and utility companies [5].

III. Existing System

Traditional power grid setups mainly depend on manual processes for monitoring and maintenance, where technicians should physically inspect electrical parameters such as voltage, current and overall energy consumption. This approach not only lacks real -time accountability, but also increases the risk of detecting the delayed mistake in cases such as overheating, electrical surges or fire -in -charge. Traditional security mechanisms, often based on isolated sensors, are limited to local alarms and do not support distance warnings - timely interfering. Additionally, the absence of smart automation in energy distribution has disabilities and wasted resources.

Major issues with current grid systems include:

- Lack of real -time visibility: traditional grids often do not support continuous monitoring, detecting mistakes and delays resolution.
- Manual fault handling: Many systems depend on human intervention, which increases the chances of errors and long -term downtime.
- Poor data usage: Without strong analytics, it becomes difficult to identify the use pattern or optimize performance.
- Safety vulnerability: The older infrastructure is often susceptible to cyber-attack, risking the stability and data integrity of the grid.



BLOCK DIAGRAM

IV. PROBLEM IDENTIFICATION AND SOLUTION

PROBLEM: - Current power grid infrastructure is constrained by chronic techniques that limit operating efficiency, reliability and scalability. These systems suffer from real -time control and lack of monitoring, making it difficult to quickly detect and address the system defects. Consequently, energy loss, unexpected outage and high operating costs are common. In addition, the rigid nature of the existing grid integrates with renewable energy sources and is rapidly difficult to adapt to the rapid rash in the demand for energy. A smart, more adaptable solution is necessary to remove these limitations and meet modern energy management requirements.

SOLUTION: -IOT and GSM-based smart grid control and monitoring system brings a modern approach to managing energy distribution by incorporating automation and real-time data monitoring. The origin of the system is an Arduino Mega 2560, which is integrated with Pzem004T sensor, which continuously monitor major electrical parameters including voltage, current, power consumption and frequency. To ensure safety, a temperature sensor and a fire detection module are included - automatically activating a buzzer and sending an alert via GSM when unusual conditions are detected. Node-MCU module enables seamless data transmission on Adafruit IOT platform, allowing users to remove and control the system remotely. Load management is obtained through two relay that control 100W and 200W bulbs, which helps to adapt energy use. This setup greatly improves fault detection, reduces dependence on manual inspections, and overall grid increases reliability and efficiency.

4.2 Proposed solutions for existing challenges

Wise Energy Adaptation: Introduce a dynamic energy management structure capable of adjusting power distribution in real time based on system demands and performance data.

Integration of Smart Grid Infrastructure: Employ the smart grid components such as intelligent meters and automatic switches to streamline energy flow and increase overall grid accountability.

Constant real -time monitoring: Install a strong system for continuous monitoring of important grid parameters to identify irregularities and apply immediate corrective measures.

IOT-deployment of based sensors: Use a network of IOT-competent sensors to capture real-time electrical data, improve system awareness and accountability.

GSM-competent data transmission: GSM takes advantage of technology for reliable.

V. MODELLING & METHODOLGY

In this project we can use different types of hardware components and arduino Software is used to build the project IOT AND GSM-BASED SMART GRID CONTROLLING AND MONITORING SYSTEM

HARDWARE COMPONENTS

- Temperature sensor
- Arduino UNO board
- PZEM Module
- LCD Display

SOFTWARWE USED

- Arduino IDE

Temperature sensor : - A temperature sensor used with Arduino Uno works by detecting the surrounding temperature and converting it into an electrical signal that can perform the Arduino process. For analog sensors like LM35, this signal is a voltage that changes with temperature, which Arduino reads through its analog input and converts to temperature value using the code. Digital sensors such as DHT11 or DS18B20 send temperature data directly through a pin, which requires specific libraries to explain data. Once obtained, Arduino can use this information to trigger alerts, control devices or performance readings.

FIG 1. Temperature Sensor

PZEM Module : - The PZEM module works by continuously covering the main electrical parameters similar as voltage, current, power, frequence and energy consumption- within an AC circuit. It uses internal detectors and circuitry to measure these values and transmits data to microcontroller similar as Arduino through periodical communication(Uart). The module operates in real time, allowing the system to dissect the trends of electrical use, descry disagreement and reply consequently. Its compact design and delicacy makes it ideal for smart energy monitoring operations where effectiveness and live data shadowing are necessary.

Fig 2. PZEM Module

LCD Display : - An LCD display acts like a high-tech window with a twist. Inside, small liquid bends crystal molecules and when an electric current flows through them. These crystals do not emit light - they play with it. Backlights shine through the layers, and the crystal lights only bend light enough to show images, colors and text. Each pixel is a small gatekeeper, which controls how many light passes, which makes a sharp view - we look like magic, but like science.

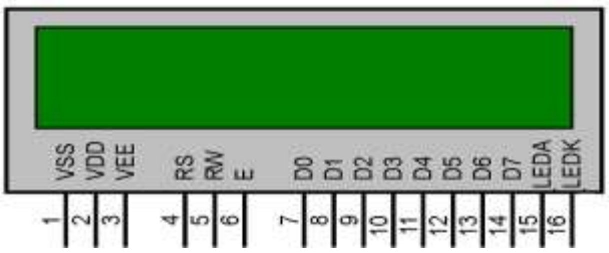


Fig 4. LCD Display

DS18B20 operates as a digital temperature sensor, which uses an exact mechanism for temperature detection and data conversion. Its resolution is configured between 9 and 12 bits, which has a default on 12-bit power-ups. This sensor is designed for low-power operation, which remains in a passive state until it becomes active. The temperature reading and analog-to-digital conversion is started using the "convert tea" command. Once the conversion is completed, the resulting temperature data is stored in a 2-bit internal register, after which the sensor returns to its-low-power-position.

When operated by external supply, the master device can read the time slot immediately after the convert tea command. During the conversion process, the sensor outputs a '0' to indicate that the measurement is still in progress and switches to '1' after the temperature data is ready, ensures efficient and synchronized communication.

Kit photo 	Kit photo 
Energy Monitoring	Working

VI. CONCLUSION

The IoT and GSM-based Smart Grid Control and Monitoring System offers a modern approach to power grid management by boosting energy efficiency, safety, and real-time oversight. Built around components like the Arduino Mega 2560, PZEM004T energy sensor, Dallas temperature sensor, fire sensor, GSM module, relays, and Node-MCU, the system precisely tracks power usage, identifies potential hazards, and enables automatic control actions. Through IoT-enabled data logging and instant GSM alerts, it empowers users with remote access and informed, timely decision-making. This intelligent, scalable system paves the way for safer operations, optimized energy use, and enhanced performance across smart grid infrastructures.

VII. REFERENCES

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