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Cloud Based Substation Monitoring and Controlling Unit

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***Abstract*— As complexity of distribution network has grown, automation of substation has become a need of every utility company. To Improve the quality of power it is necessary to be familiar with what sort of constraint has occurred. Additionally, if there is any inadequacy in the protection, monitoring and control of a power system. Therefore, it necessitates a monitoring system that will be able to automatically detect, monitor, and classify the existing constraints on electrical lines.**

***Keywords*---Distribution Network; Automation; Substation; Power quality; Constraints; Inadequacy; Protection; Monitoring; Control; Detection; Electrical lines.**

I. INTRODUCTION

The distance between the generators and load may be regarding hundreds of miles hence the amount of enormous power exchange over long distance has turned out as a result of the lack of quality of the electric power. During the earlier development stages, the issues on the quality of power were not frequently reported. Demanding thr quality of power being delivered to the user side has raised the alarm due to the increase in demand for electricity in the customer side. A massive amount of energy is lost during the transportation of the general power which prompts the decrease in the nature of intensity got the substation.

To improve the quality of power with a different solution, it is necessary to be familiar with what sort of constraint has occurred. Additionally, if there is any inadequancy in the protection, monitoring ad control of a power system. The system might become unstable. Therefore it is necessary a monitoring system that can automatically detect, monitor, and classify the existing constraints on electrical lines.

II. AIMS AND OBJECTIVES

1. Develop a cloud-based monitoring and controlling unit to streamline operations within substations, aiming to reduce manual intervention and optimize resource utilization.

2. Implement a system capable of identifying and addressing various constraints and disturbances within the distribution network to enhance the overall quality and reliability of power delivery.

3. Design algorithms and methodologies for the automatic detection, monitoring, and classification of constraints on electrical lines, enabling proactive management of power system issues.

4. Ensure the adequacy and effectiveness of protection mechanisms within the power system by integrating advanced monitoring capabilities with protective devices to promptly isolate faults and prevent equipment damage.

5. Develop user-friendly interfaces accessible via web or mobile applications, enabling remote monitoring and control of substations from anywhere, facilitating quicker response to grid events.

6. Implement data analytics tools and techniques to analyze historical and real-time data, providing insights for informed decision-making, such as predictive maintenance scheduling and load forecasting.

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III. HARDWARE COMPONENTS

1. Arduino Uno

The Uno with Cable is a micro-controller board base on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs); 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button.

It contains everything need to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

2. LCD

LCD (Liquid Crystal Display) is the innovation utilized in scratch pad shows and other littler PCs. Like innovation for light-producing diode (LED) and gas-plasma, LCDs permit presentations to be a lot more slender than innovation for cathode beam tube (CRT). LCDs expend considerably less power than LED shows and gas shows since they work as opposed to emanating it on the guideline of blocking light.

3. PZEM Module

This Peacefair PZEM-004T Multi-function AC Power Monitor is very popular in electrical consumption measurement projects. It is capable of measuring four interrelated electrical variables as voltage, current, power, and energy.

4. Dallas Temperature

The digital temperature sensor like DS18B20 follows single wire protocol and it can be used to measure temperature in the range of -67oF to +257oF or -55oC to +125oC with +-5% accuracy. The range of received data from the 1-wire can range from 9-bit to 12-bit. Because, this sensor follows the single wire protocol, and the controlling of this can be done through an only pin of Microcontroller.

5. Relay

A Relay is electromagnetic switch that used to turn on and turn off a circuit by lower power signal or where several circuits must be controlled by one signal.

6. Bulb

A bulb, commonly used in households, is a traditional incandescent lighting source that emits a warm and bright glow. However, with advancements in technology and the growing emphasis on energy efficiency, many households are transitioning to sensor-equipped bulbs. These smart bulbs incorporate various sensors, such as motion sensors, light sensors, or even color temperature sensors, to enhance convenience and energy conservation.

7. Node MCU

Node MCU is an open-source firmware and development kit that plays a vital role in designing your own IoT product using a few Lua script lines.Multiple GPIO pins on the board allow you to connect the board with other peripherals and are capable of generating PWM, I2C, SPI, and UART serial communications.

8. Buzzer

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke.

Software Requirements: -

Operating System: - Windows 8 and

above. Programming language: - C

Language and C++

Platform: - Arduino IDE

Supporting libraries: - PZEM004Tv30.h
OneWire.h

IV. LITERATURE SURVEY

A comprehensive literature survey reveals significant advancements and insights into the development and implementation of cloud-based solutions for substation monitoring and control in modern power systems. Zhu et al. (2017) present a pioneering study on cloud-based remote monitoring and management systems, emphasizing the integration of cloud computing and IoT technologies to enhance operational efficiency and reliability in power distribution networks. Mahmoud et al. (2015) provide a thorough overview of cloud-based substation automation systems, discussing architectural models and deployment strategies that offer scalability, flexibility, and cost-effectiveness. Nayak et al. (2019) explore the development of a cloud-based energy management and monitoring system tailored for smart grids, showcasing the integration of IoT devices, data analytics, and cloud computing for real-time control and optimization.

Siddiqui et al. (2018) investigate the implementation of cloud-based SCADA systems for power grid monitoring and control, emphasizing architectural considerations, security measures, and performance evaluation. Additionally, Zobaa et al. (2019) offer insights into the broader applications of cloud computing in smart grid environments, discussing benefits, challenges, and future research directions.

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1. "Cloud-based remote monitoring and management of power distribution networks" by J. Zhu et al. (2017): This paper discusses the design and implementation of a cloud-based remote monitoring and management system for power distribution networks, emphasizing the integration of cloud computing and IoT technologies for enhanced operational efficiency and reliability.

2. "Cloud-based substation automation system for smart grids" by M. M. Mahmoud et al. (2015): This study presents a comprehensive overview of cloud-based substation automation systems, highlighting their potential benefits in terms of scalability, flexibility, and cost-effectiveness. It discusses various architectural models and deployment strategies for integrating cloud computing in substation automation.

3. "Cloud-Based Energy Management and Monitoring System for Smart Grids" by K. Nayak et al. (2019): This paper explores the development of a cloud-based energy management and monitoring system specifically tailored for smart grids. It discusses the integration of IoT devices, data analytics, and cloud computing to enable real-time monitoring, control, and optimization of energy distribution processes.

4. "Cloud-Based SCADA System for Power Grid Monitoring and Control" by M. S. Siddiqui et al. (2018): This research investigates the implementation of a cloud-based SCADA (Supervisory Control and Data Acquisition) system for power grid monitoring and control. It discusses the architecture, security considerations, and performance evaluation of the proposed system, highlighting its potential advantages over traditional on-premises SCADA systems.

5. "Cloud computing for smart grid applications: A survey" by A. F. Zobaa et al. (2019): This survey paper provides an in-depth analysis of the applications of cloud computing in smart grid environments. It reviews various cloud-based solutions for grid monitoring, control, optimization, and energy management, with a focus on their benefits, challenges, and future research directions.

6. "IoT-based monitoring and control system for smart grid applications" by S. Ahmed et al. (2018): This study explores the integration of IoT technologies in monitoring and control systems for smart grids. It discusses the design and implementation of an IoT-based platform for real-time monitoring, fault detection, and remote control of power distribution networks, highlighting its potential for enhancing grid reliability and efficiency.

V. METHODOLOGY

In this model we have connected various components in streamlined manner to get better efficiency and work. Aligning the various components in a proper manner to generate precise output requires a lot of computation power and can be a complicated task also. The exact working of rover is explained below: -

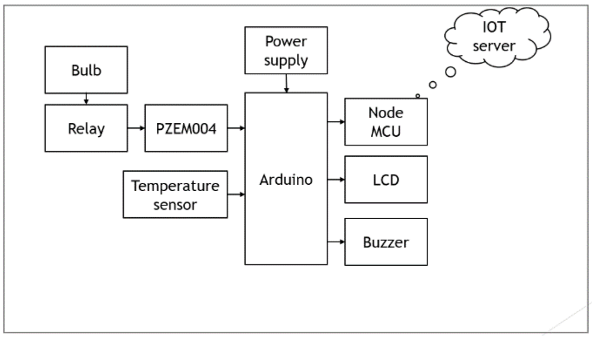

Fig 5.1 Overall working of Rover

1. Requirement Analysis:
Conduct a comprehensive analysis of the requirements and objectives of the cloud-based substation monitoring and controlling unit. This involves understanding the specific needs of utility companies, regulatory standards, and the technical capabilities required for effective monitoring and control of substations.

2. System Architecture Design:
Develop the architectural design of the monitoring and controlling unit, outlining the components, communication protocols, and data flow between substations and the cloud-based platform. Considerations include scalability, fault tolerance, security, and integration with existing infrastructure.

3. Sensor Selection and Integration:
Identify suitable sensors for measuring relevant parameters such as voltage, current, temperature, and equipment status within substations. Integrate these sensors with data acquisition systems to ensure accurate and reliable data collection.

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4. Communication Infrastructure**:**
Implement robust communication infrastructure to facilitate the transmission of real-time data from substations to the cloud-based platform. This may involve deploying communication protocols such as MQTT, OPC-UA, or RESTful APIs over wired or wireless networks.

5. Data Processing and Analytics**:**
Implement algorithms and data analytics techniques for processing and analyzing the incoming data streams. This includes real-time anomaly detection, fault classification, predictive maintenance, and trend analysis to derive actionable insights.

6. Validation and Evaluation:
Conduct thorough testing and validation of the monitoring and controlling unit in simulated and real-world environments. Evaluate performance, reliability, and scalability under various operating conditions to ensure compliance with requirements and standards.

7. Documentation and Deployment**:**
Deploy the cloud-based substation monitoring and controlling unit in operational environments, ensuring seamless integration with existing infrastructure and providing necessary training and support to operators and maintenance personnel.

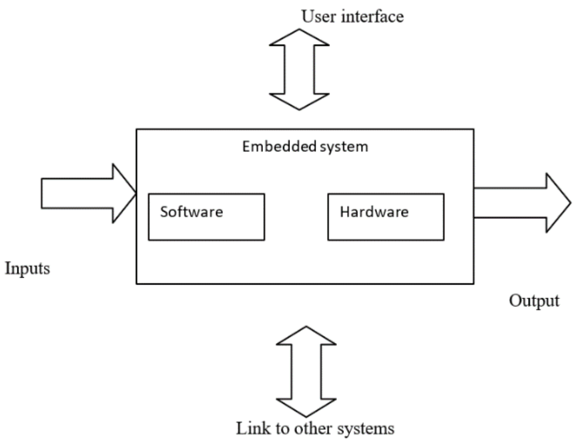
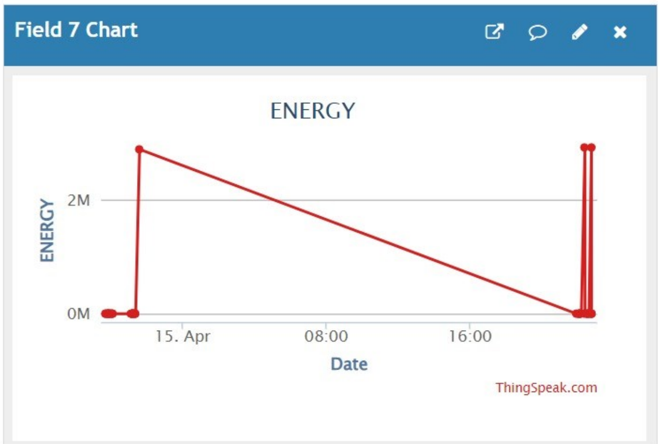
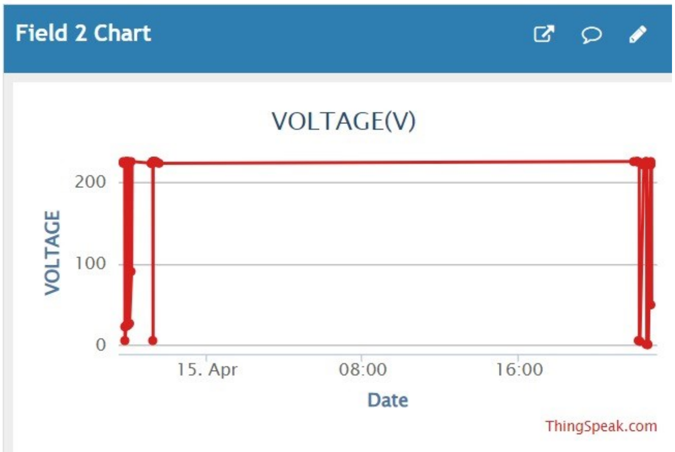


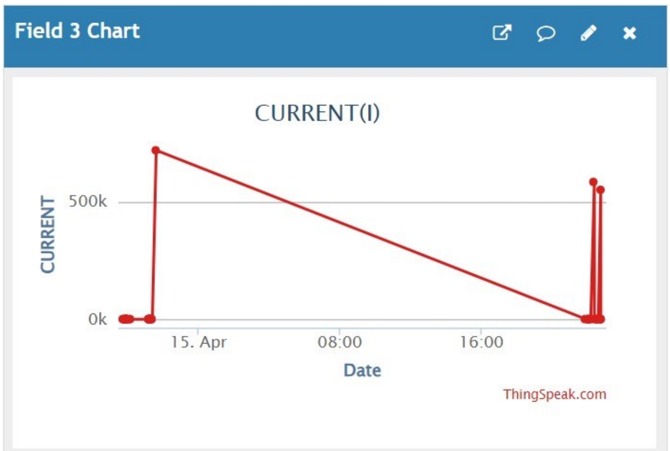
Fig 5.2 Block Diagram for Overview of embedded system

VI. TESTING RESULTS

Testing results for a Cloud-Based Substation Monitoring and Controlling Unit would typically involve evaluating various aspects of the system's performance, reliability, and functionality. Here are testing results we have conducted.







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VII. APPLICATIONS

1. Real-Time Monitoring

The system enables real-time monitoring of crucial parameters such as voltage, current, temperature, and equipment status within substations. This data is collected and transmitted to the cloud platform for analysis and visualization, providing operators with insights into the health and performance of the substation infrastructure

2. Fault Detection and Diagnosis

By continuously analyzing data from sensors within the substation, the monitoring unit can detect and diagnose faults or anomalies in the power distribution network. This includes identifying issues such as overloads, voltage fluctuations, insulation failures, and equipment malfunctions, allowing for timely intervention and preventive maintenance.

3. Remote Control and Automation

Cloud-based platforms facilitate remote control and automation of substation operations. Operators can remotely configure settings, adjust equipment parameters, and initiate control actions to optimize performance and respond to grid events without the need for physical presence at the site.

4. Predictive Maintenance

The system employs predictive maintenance techniques to anticipate equipment failures and degradation based on historical and real-time data analysis. By identifying potential issues in advance, maintenance activities can be scheduled proactively, minimizing downtime and reducing operational costs.

5. Load Management and Optimization

Cloud-based analytics enable efficient load management and optimization strategies within the distribution network. By analyzing load patterns and demand forecasts, the system can dynamically adjust power distribution, optimize feeder configurations, and implement demand response programs to ensure efficient use of resources and grid stability.

6. Energy Efficiency and Conservation

The monitoring unit supports initiatives for energy efficiency and conservation by providing insights into energy consumption patterns and inefficiencies within the distribution network. Operators can identify opportunities for load balancing, voltage optimization, and energy conservation measures to reduce overall energy consumption and carbon emissions.

7. Grid Resilience and Reliability

By continuously monitoring and controlling substation operations, the system contributes to enhancing grid resilience and reliability. It enables rapid response to grid disturbances, minimizes downtime, and facilitates quick restoration of service in the event of outages or disruptions, ensuring uninterrupted power supply to consumers.

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