

Smart Grid Fault Detection and Restoration Using Artificial Intelligence and Edge Computing

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Abstract: *The increasing complexity of modern power distribution networks and the integration of renewable energy sources require intelligent and reliable fault management systems. This paper presents , a smart grid framework that integrates Artificial Intelligence (AI) and edge computing for real-time fault detection, prediction, and restoration. The proposed system continuously monitors electrical parameters such as voltage, current, and power using sensors. Edge-based processing enables rapid identification of abnormal conditions and facilitates automated fault isolation and power rerouting through relay-based switching. Machine learning techniques are incorporated to analyze historical and real-time data for fault classification and predictive maintenance. A NodeMCU (ESP8266) module enables remote monitoring and real-time fault notifications through Telegram, while an LCD provides local visualization of grid parameters and system status. The proposed approach aims to reduce fault detection time, minimize power interruptions, improve maintenance efficiency, and enhance the reliability and resilience of smart grid networks.*

Keywords: Smart Grid, Artificial Intelligence, Edge Computing, Fault Detection, Predictive Maintenance, Self-Healing Grid.

I. INTRODUCTION

The increasing demand for electricity and the integration of renewable energy sources require power grids to become more reliable, efficient, and intelligent. Conventional power systems face challenges in detecting faults quickly, minimizing power interruptions, and restoring electricity supply. Smart Grid technology addresses these challenges through intelligent monitoring, automation, and advanced control systems.

This paper presents a smart grid system using Artificial Intelligence (AI) and edge computing for fault detection and restoration. The system continuously monitors electrical parameters such as voltage, current, and power to identify abnormal conditions. Machine Learning (ML) techniques support fault classification and predictive maintenance, while edge computing enables faster data processing and reduces response time.

The proposed system also incorporates automatic fault isolation, power rerouting, and real-time notifications through Telegram. These features help improve power supply continuity, reduce downtime, and enhance the reliability of electrical distribution networks. The integration of AI and edge computing provides an intelligent approach to developing a more efficient, reliable, and self-healing smart grid.

II. OVERVIEW OF PROJECT WORK:

1. System Design: Develop a smart grid system using Arduino Mega 2560, voltage and current sensors, relays, and NodeMCU (ESP8266).
2. Real-Time Monitoring: Measure voltage and current continuously and display electrical parameters and grid status on an LCD.
3. Fault Detection: Use switches to simulate faults and identify affected sections of the power distribution network.

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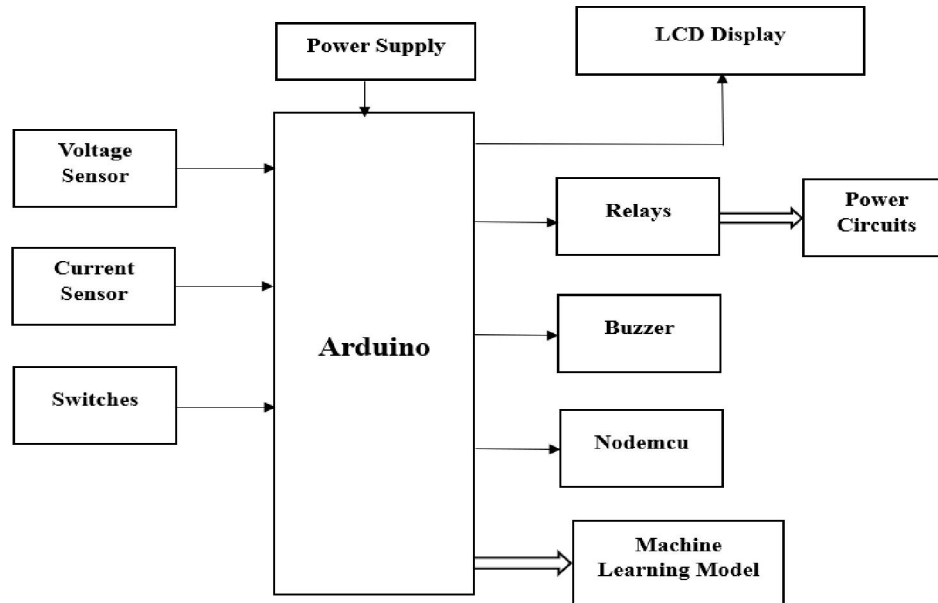
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4. **Fault Isolation and Restoration:** Control relays to isolate faulty sections and reroute power through alternative paths where applicable.
5. **Remote Monitoring:** Integrate NodeMCU with Telegram to send real-time fault notifications and system status updates.
6. **Artificial Intelligence and Machine Learning:** Analyze collected electrical data to support fault identification and predictive maintenance.

III. BLOCK DIAGRAM AND WORKING PRINCIPLE



Working Principle

1. **Power Supply:** The system receives power to operate the control unit, sensors, communication module, and other components.
2. **Voltage and Current Sensing:** Voltage and current sensors continuously monitor the electrical parameters of the distribution system and provide the measured signals to the Arduino Mega 2560.
3. **Data Processing:** The Arduino Mega 2560 processes the sensor readings and checks the electrical conditions to identify abnormal operating conditions.
4. **Fault Detection:** Faults are simulated using switches. When an abnormal condition is detected, the controller identifies the affected section based on the sensor readings and system configuration.
5. **Fault Isolation:** The controller operates the corresponding relays to disconnect the faulty section, helping prevent the fault from affecting the remaining network.
6. **Power Restoration:** Where an alternative supply path is available, the controller operates the relays to reroute power and restore supply to the healthy sections.
7. **Display and Alert System:** The LCD displays electrical parameters and system status, while a buzzer provides a local alert when a fault occurs.

IV. COMPONENTS USED AND THERE WORKING

1. **Arduino Mega 2560:** Acts as the main control unit, processing sensor data and controlling the relays.
2. **Voltage Sensor (ZMPT101B):** Measures the voltage in the electrical system for real-time monitoring.



3. **Current Sensor (ACS712):** Measures the current flowing through the circuit and provides data for monitoring and fault detection.
4. **NodeMCU (ESP8266):** Provides Wi-Fi connectivity and sends fault alerts and system updates through Telegram.
5. **Relay Module:** Disconnects faulty sections and enables switching operations for power restoration.
6. **LCD Display:** Displays real-time electrical parameters and the operating status of the system.
7. **Switches:** Simulate faults during testing to demonstrate fault detection and isolation.
8. **Buzzer:** Provides an audible alert when a fault is detected.
9. **DHT11 Sensor:** Measures temperature and humidity for environmental monitoring, as described in the project report.
10. **Power Supply Unit:** Supplies the required operating power to the control and sensing components.
11. **Connecting Wires and Circuit Components:** Provide electrical connections between the sensors, controller, relay module, display, and communication module.
12. **Telegram Application:** Receives remote fault notifications and system status updates through the NodeMCU Wi-Fi connection.

V. APPLICATIONS

1. **Smart Power Distribution:** Improves monitoring and management of electrical power distribution networks.
2. **Fault Detection and Isolation:** Identifies abnormal electrical conditions and isolates faulty sections to limit disruptions.
3. **Automatic Power Restoration:** Supports the restoration of power to healthy sections through relay-based switching and alternative supply paths.
4. **Smart Grid Monitoring:** Enables real-time monitoring of voltage, current, and system status.
5. **Industrial Power Systems:** Helps improve the reliability of electrical distribution systems in industries and manufacturing facilities.
6. **Remote Fault Monitoring:** Sends fault alerts and system updates through Telegram, allowing operators to monitor the system remotely.
7. **Predictive Maintenance:** Uses historical and real-time electrical data with machine-learning techniques to help identify potential equipment failures.
8. **Power Distribution Substations:** Can support monitoring and fault-management functions in distribution substations.

VI. CONCLUSION

The VIDYUT project presents a smart grid system designed to improve the reliability, efficiency, and resilience of electrical power distribution. By integrating Arduino-based control, voltage and current sensors, relay-based fault isolation, and NodeMCU-based communication, the system supports real-time monitoring, fault detection, and power restoration. The integration of edge computing enables local data processing for faster responses, while artificial intelligence and machine learning techniques can support fault classification and predictive maintenance. Furthermore, Telegram-based notifications provide remote updates on fault conditions and system status. Overall, the proposed system offers a promising approach to reducing power interruptions, improving fault management, and supporting the development of intelligent and self-healing power distribution networks. Future work may focus on optimizing machine-learning models, improving predictive accuracy, and testing the system in larger and more complex distribution networks.

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