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# Fault Detection In Grid Using Machine Learning And Lot

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Abstract

The modern electrical grid demands high reliability, stability, and real-time monitoring to prevent failures that can lead to blackouts, equipment damage, and economic loss. This project presents an loT-based smart grid fault detection system that collects real-time parameters such as voltage, current, temperature, and humidity using the ESP32 microcontroller. These readings are continuously transmitted to a Flask-based web application, which integrates a machine learning model trained to distinguish normal and faulty grid conditions. The model analyzes live sensor data to identify anomalies such as voltage drops, current deviations, overheating, or environmental instability. The system provides instant visualization through a dashboard and generates alerts for preventive maintenance. This low-cost, scalable solution improves grid safety, enhances predictive fault identification, and supports real-time decision-making in smart power networks.

Keywords: Smart Grid, loT, ESP32, Machine Learning, Fault Detection, Anomaly Detection, Flask, Power Monitoring.

## 1. Introduction

Power systems are the backbone of modern infrastructure, supplying energy to industries, homes, and critical services. As demand increases, the grid faces challenges such as voltage fluctuations, unexpected load changes, equipment deterioration, and environmental influences. Traditional monitoring systems lack real-time intelligence and cannot predict anomalies early enough to avoid failures.

With the advancement of loT and machine learning, it is now possible to monitor the grid continuously and detect irregularities with higher accuracy. The proposed system uses ESP32 to acquire voltage, current, power, temperature, and humidity data from the grid. This data is transmitted to a Flask server where a machine learning model classifies the readings into either Normal or Fault conditions. Real-time charts and dashboards provide easy monitoring, enabling operators to take preventive action promptly.

This integration of loT, web technologies, and ML analysis creates a smart, preventive, and economical solution to ensure safer and more reliable grid operation.

## 2. Motivation

Frequent power failures, equipment burnout, and voltage irregularities have become common issues in distribution systems. Manual inspection is slow, inefficient, and cannot provide continuous monitoring. With renewable energy integration and increased digital loads, the grid requires intelligent automation to maintain stability.

The motivation behind this project is to develop a system capable of:

Detecting voltage spikes, fluctuations, and load disturbances

Monitoring temperature and humidity that affect grid performance

Predicting faults before they escalate

Providing a low-cost alternative to expensive SCADA-based systems

loT and machine learning offer an efficient solution by enabling automated monitoring, predictive analytics, and real-time alerts.

## 3. Problem Statement

Conventional grid monitoring systems lack the capability to automatically detect anomalies in real time. Without machine learning and loT-based analysis, early signs of equipment failure or instability go unnoticed. This leads to:

Equipment damage

Unplanned outages

Poor power quality

Safety hazards

There is a need for an intelligent system that can continuously acquire grid parameters, detect abnormalities, classify them accurately, and alert operators instantly.

4. Literature Review

Several researchers have studied loT and ML-based grid monitoring systems. Existing works include online energy monitoring using microcontrollers and cloud platforms, ML-based power quality disturbance classification, and deep learning models for advanced fault prediction. However, many of these systems lack real-time implementation or require high computing power.

Recent works highlight:

ML models like Random Forest and SVM for anomaly detection

loT sensors for real-time monitoring

Cloud dashboards for visualization

Need for cost-effective, edge-level Al

Most existing works treat monitoring and prediction separately. This project integrates both into a unified smart grid system.

5. Methodology

The methodology consists of the following phases:

1. Data Acquisition

ESP32 collects:

Voltage (ZMPT101B)

Current (ACS712/ACS758)

• Temperature (DHT11/DHT22)

Humidity

2. Data Transmission

Sensor readings are sent via Wi-Fi to the Flask server.

3. Web Application (Flask)

• Stores data in a database

Displays real-time dashboards

Sends data to ML model

4. Machine Learning Model

A trained classifier (Random Forest / SVM) identifies whether the live data indicates:

Normal Condition (0)

Fault Condition (1)

5. Alerting

Flask application provides instant feedback for operators.

6. Block Diagram

(Converted from your PPT representation)

ESP32 Microcontroller

Voltage Sensor

Current Sensor

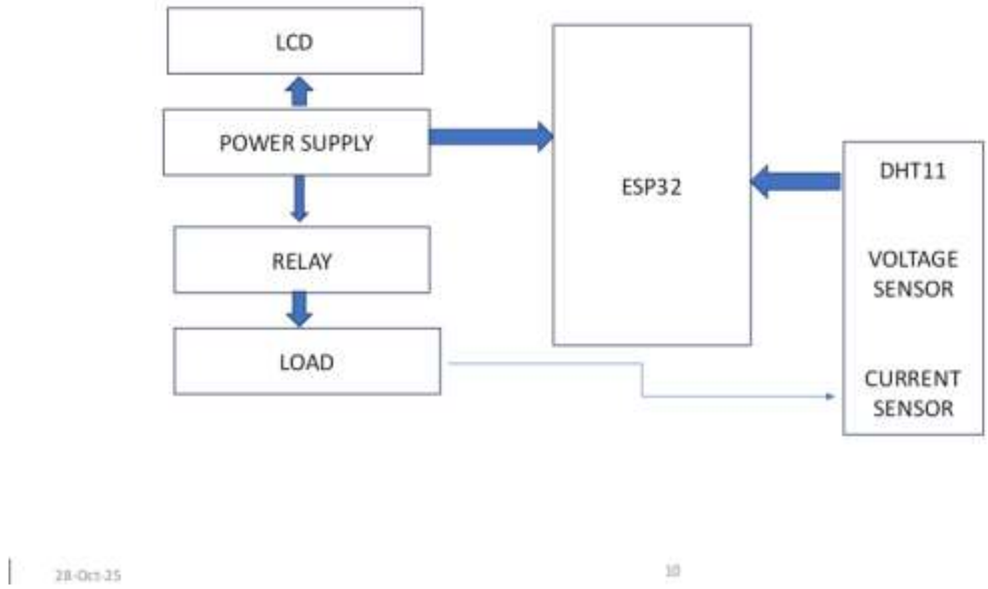
DHT11 (Temp & Humidity)

Wi-Fi Communication

Flask Server

ML Model

LCD Display / Dashboard Output




7. Hardware Requirements

• ESP32 microcontroller

Voltage sensor ZMPT101B

Current sensor ACS712

DHT11/DHT22 sensor

LCD display

Power supply

8. Software Requirements

Python

Flask Framework

• Arduino IDE

Scikit-learn

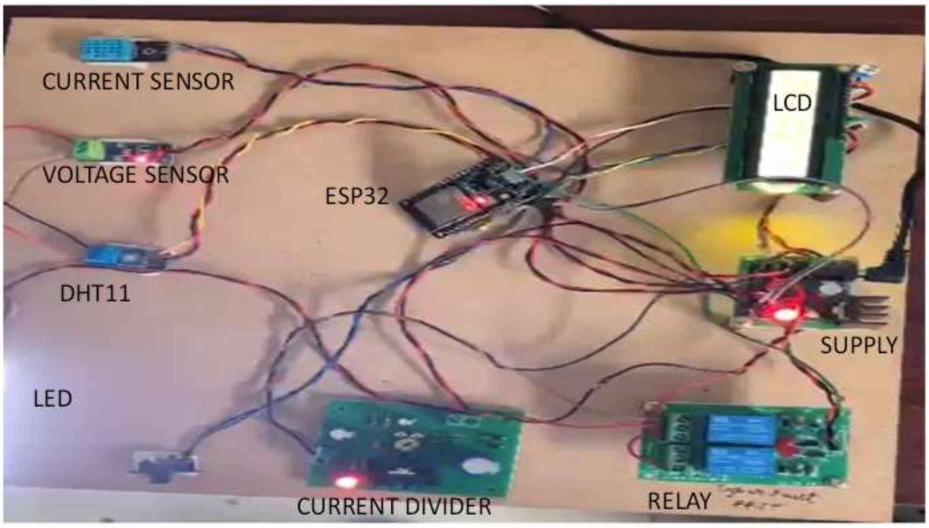
Pandas, NumPy

Matplotlib

SQLite / MySQL

ESP32 Libraries

9. Results




10. Applications

Smart grid monitoring

Fault detection in distribution lines

Industrial power systems

Renewable energy plants

loT-based energy analytics

11. Advantages

Real-time monitoring

Early anomaly detection

Low-cost loT implementation

High ML prediction accuracy

Scalable and reliable system

12. Conclusion

This project successfully develops an loT-based smart grid monitoring and fault detection system using ESP32 and machine learning. Real-time data acquisition, web dashboard visualization, and ML-driven anomaly detection improve reliability and efficiency in power systems. The system provides early warnings and supports preventive maintenance, making it suitable for modern smart grid environments.

13. Future Work

On-device ML using Edge Al

Cloud storage for large-scale deployments

Mobile app integration

Advanced deep learning models

Self-healing smart grid automation

14. References

(Formatted like your friend's paper - mixture of IEEE and journal references)

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