NATIONAL INSTITUTE OF TECHNOLOGY ANDHRA PRADESH
(An autonomous Institute under the aegis of Ministry of Education, Government of India)
DEPARTMENT OF ELECTRICAL ENGINEERING

GENESIS 2025 – A Student Project / Startup Idea Expo

Digital Twin for fault diagnosis and monitoring in smart electrical systems.

ABSTRACT

The increasing demand for reliable electricity necessitates real-time monitoring and predictive maintenance of power grids. Faults in electrical systems can lead to significant downtime and financial losses. This project aims to develop a small-scale smart power grid digital twin using affordable hardware such as Arduino and sensors, coupled with machine learning models for fault detection and system health prediction. By leveraging predictive analytics, this system enhances fault diagnosis, reduces maintenance costs, and improves grid reliability. The expected outcome is an intelligent monitoring system that provides early warnings of potential failures, ensuring a more resilient electrical infrastructure. This project benefits society by minimizing power disruptions, improving safety, and promoting efficient energy management.

Keywords: Digital Twin, Fault Detection, Power Grid, Smart Monitoring

INTRODUCTION

Power grids require efficient monitoring to prevent faults and power disruptions. Traditional methods are reactive, leading to delays and higher costs. This project develops a small-scale smart power grid digital twin using Arduino, sensors, and machine learning for real-time fault detection and health prediction. By integrating affordable hardware and open-source software, this system enhances grid reliability, reduces maintenance costs, and ensures efficient energy management.

PROPOSED METHODOLOGY

- Sensors monitor voltage, current, and power in the power grid.
- Data is transmitted to a PC through SPI communication.
- Machine learning models process the data to predict faults and health status.
- Graphical representations of voltage, current, temperature and power are generated for visualization.
- The system provides insights for health status of device by the formula: Health Index= 100 − (Degradation Factors/ Threshold)×100

Block Diagram:

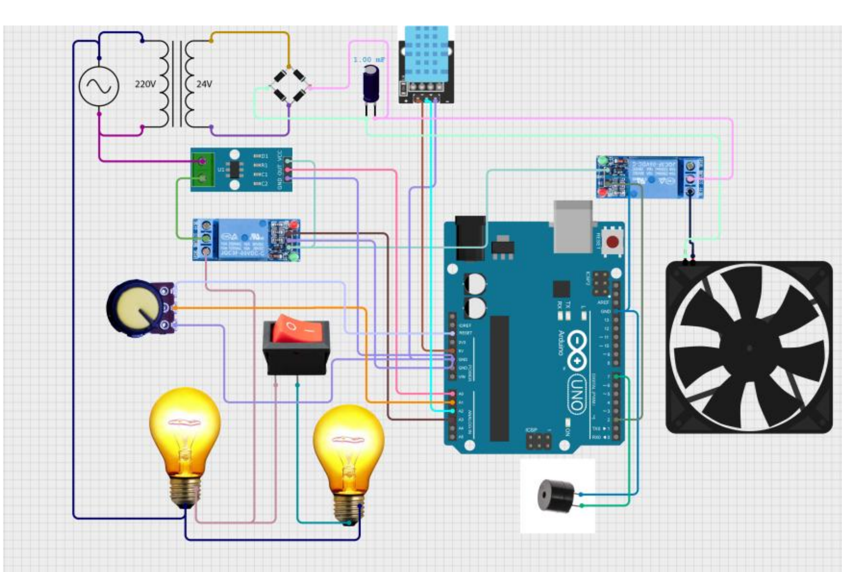

Fig. 1: Block diagram of the model.

References:

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RESULTS AND DISCUSSION

- The system successfully monitors real-time electrical parameters like voltage, current, temperature, and power.
- Machine learning models accurately detect faults and predict the health status of the grid.
- Graphical visualizations provide clear insights into parameter variations for better analysis.
- Early fault detection helps in preventive maintenance, reducing downtime and improving efficiency.
- The attached visualization validates the system's effectiveness in real-time monitoring and fault prediction.
- This cost-effective and scalable solution enhances grid reliability and optimizes energy management.

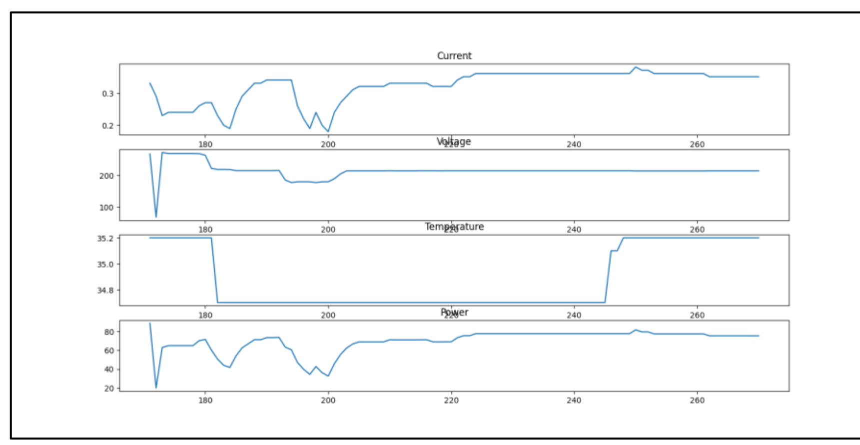

Fig. 2: Visualization of Electrical Parameters.

CONCLUSIONS

This project successfully develops a small-scale smart power grid digital twin for real-time monitoring, fault detection, and health prediction. By integrating sensors, Arduino, and machine learning, the system enhances grid reliability and efficiency. The graphical visualization of electrical parameters aids in early fault identification and preventive maintenance. This cost-effective, scalable solution minimizes power disruptions, reduces maintenance costs, and promotes efficient energy management for industries and households..

ACKNOWLEDGEMENT

This project work was supported by the Department of Electrical Engineering, NIT Andhra Pradesh.

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