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APPLICATIONS OF IoT IN POWER SYSTEM ANALYSIS

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ABSTRACT

The rapid evolution of the Internet of Things (IoT) has transformed modern power systems by enabling real-time monitoring, automation, predictive analytics, and improved decision-making. The integration of IoT with smart sensors, cloud platforms, communication networks, and advanced data analytics supports more efficient power system analysis. This study explores the key applications of IoT in power system analysis, including load forecasting, fault detection, condition monitoring, grid stability assessment, and asset management. A structured methodology is adopted to examine IoT architectures, communication technologies, data acquisition procedures, and analytical frameworks. The findings indicate that IoT-driven systems significantly enhance the accuracy of power quality measurement, reduce outage duration, optimize energy distribution, and support real-time situational awareness. Results also show that IoT-based predictive maintenance reduces equipment failure rates and operational costs when compared to traditional supervisory systems. The paper concludes by discussing the importance of interoperability, cybersecurity, and scalable IoT frameworks in advancing next-generation intelligent power systems. This research offers a comprehensive view of how IoT technologies can strengthen power system analysis and provides recommendations for future smart grid development.

INTRODUCTION

The global energy infrastructure is undergoing a major transformation with the adoption of smart grid technologies and the integration of renewable energy sources. Traditional power systems, characterized by centralized monitoring and limited automation, face challenges such as voltage instability, unpredictable load variations, equipment failures, and inefficient fault handling (Gharavi & Ghafurian, 2011). The Internet of Things (IoT) has emerged as a key enabler in addressing these limitations by connecting physical electrical assets with sensors, communication networks, and intelligent decision-making systems (Amin, 2015).

IoT in power systems provides continuous data acquisition, real-time analytics, and enhanced visibility across transmission, distribution, and consumer-level infrastructure. As sensors and smart meters proliferate, utility operators gain deeper insights into system performance, enabling improved load forecasting, predictive maintenance, and power quality analysis (Sun et al., 2018). This paper explores the applications of IoT in power system analysis, presenting recent advancements and their role in evolving modern smart grids.

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LITERATURE REVIEW

IoT adoption in the energy sector has gained momentum in recent years. Several researchers have highlighted the transformative capabilities of IoT-enabled power grids.

Amin (2015) emphasized IoT as a foundation for smart grid modernization, enabling real-time monitoring and enhanced resilience. Sun et al. (2018) explored IoT applications in demand-side energy management, particularly in residential environments. Gharavi and Ghafurian (2011) investigated smart grid communication networks and identified the need for high-speed, reliable IoT infrastructures.

Kumar and Mallick (2018) examined IoT-based condition monitoring systems, demonstrating their ability to reduce maintenance and operational costs. Meanwhile, Gungor et al. (2013) analyzed IoT communication protocols and their role in improving smart grid security and scalability.

Collectively, past literature establishes that IoT has the potential to revolutionize power system analysis through enhanced connectivity, automation, and data-driven intelligence. However, research gaps remain in the areas of cybersecurity, interoperability, and large-scale system integration.

METHODOLOGY

The methodology adopted in this research includes:

Data Collection

A study of journals, conference papers, books, and online technical documents related to IoT applications in smart grids.

Analytical Framework

The analysis is structured around key IoT functional areas in power systems:

- Sensing and data acquisition
- Communication networks
- Cloud and edge computing
- Power system analytical applications

Evaluation Criteria

IoT applications were evaluated based on:

- Accuracy of system analysis
- Real-time performance
- Reliability and scalability
- Practicality and cost-effectiveness

FINDINGS

IoT in Load Forecasting

IoT sensors and smart meters provide real-time consumption data, improving forecasting accuracy. This results in better demand management and reduced peak load stress.

IoT in Fault Detection and Isolation

IoT-based sensors detect abnormal current, voltage, or temperature values, enabling:

- Fast fault localization
- Automated isolation
- Reduced system downtime

Studies show IoT-enabled fault management reduces outage time by up to 40% compared to traditional SCADA systems (Kumar & Mallick, 2018).

Condition Monitoring

Key equipment monitored with IoT:

- Transformers
- Circuit breakers
- Transmission lines
- Inverters

IoT-based condition monitoring supports predictive maintenance, reducing unexpected failures.

Power Quality Analysis

Continuous measurement of voltage sags, harmonics, and frequency variations enables proactive intervention.

Grid Stability and Renewable Integration

IoT supports:

- Monitoring output variability of solar/wind systems
- Grid frequency and voltage stability
- Distributed energy resource (DER) coordination

IoT improves system visibility, allowing utilities to handle fluctuations from renewable sources.

CONCLUSION

IoT plays a pivotal role in transforming power system analysis through enhanced monitoring, automation, predictive analytics, and improved operational efficiency. The integration of smart sensors, communication technologies, and cloud-based platforms enables accurate fault detection, improved load forecasting, and effective condition monitoring. The study demonstrates that IoT-driven systems outperform traditional supervisory methods in efficiency, reliability, and cost-effectiveness. To fully realize the benefits of IoT in power systems, issues such as cybersecurity, data interoperability, and large-scale deployment challenges must be addressed. IoT will continue to be a crucial component in developing next-generation intelligent and sustainable power grids.

Statements and Declarations

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Conflicts of Interest

The author declare no conflict of interest.

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