Real Time Load Flow Monitor in Distribution System

Bhong Bhagyashri Ashok[1]; Thombare Ankita Dilip[2];
Bandgar Namrata Manoj[3]; T. V. Deokar[4]

[1,2,3,4] Department of Electrical Engineering,
S. B. Patil College of Engineering, Indapur

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Abstract: The increasing demand for electrical energy in modern distribution systems necessitates efficient monitoring of load flow for reliable operation and energy management. This project focuses on the real-time load flow monitoring of a distribution system by analyzing the behavior of two representative loads: a purely resistive load (incandescent bulb) and a resistive–inductive (RL) load (single-phase table fan motor). The study aims to measure, monitor, and analyze key electrical parameters such as voltage, current, power factor, real power, reactive power, and apparent power under varying operating conditions. By comparing the characteristics of resistive and RL loads, the project highlights the impact of inductive components on power factor and energy consumption in the distribution network. The proposed system employs sensors and microcontroller-based data acquisition to provide accurate and real-time monitoring, enabling better decision-making for energy efficiency and power quality improvement. This work is expected to serve as a reference model for load behavior analysis, demand side management, and smart distribution system applications.

Keywords: *Real Time Load Flow Monitor (RTLFM); Distribution System; R Load; RL Load; Energy Efficiency; Power Quality.*

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I. INTRODUCTION

Electric power is used in our daily life for lighting, fans, motors, and many other appliances. These appliances create different types of loads on the distribution system. Some loads like bulbs are purely resistive, which means they only take real power. Other loads like table fan motors are resistive–inductive (RL loads), which means they take both real power and reactive power. Because of this, RL loads reduce the power factor and cause extra energy losses in the system.

To study this effect, load flow monitoring is very useful. It helps us to measure important parameters like voltage, current, power factor, real power, reactive power, and apparent power in real time. By comparing resistive and RL loads, we can understand how different appliances affect the distribution system.

This project focuses on monitoring the load flow of a bulb (R load) and a table fan motor (RL load) using sensors and a microcontroller. The results will show the difference in power consumption and power factor, which can help in improving energy efficiency and proper management of the distribution system.

II. OBJECTIVE

- Continuous Monitoring – To observe the real-time power flow, voltage, current, and power factor at different buses and lines of the distribution network.

- Efficient Power Flow – To ensure that power is distributed optimally with minimal losses and balanced load conditions.

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- Voltage Regulation – To maintain voltages within permissible limits across all nodes of the system.
- Improved Reliability – To enhance the stability, reliability, and quality of power supply to consumers.
- Decision Support – To provide operators with real-time data for effective control, planning, and optimization of the distribution network.

III. FEATURES OF TEG

- *Real-Time Measurement of Different Load Types*

- Resistive (R) Load: e.g., incandescent bulb, where current and voltage are in phase, so power factor ≈ 1.
- Resistive–Inductive (RL) Load: e.g., single-phase table fan motor, where current lags voltage, so reactive power (Q) must also be considered.
- System must monitor active power (P), reactive power (Q), and apparent power (S) in real time for both load categories.

- *Load Modeling Accuracy*

- R loads modeled as purely resistive (constant P).
- RL loads modeled as impedance with resistance + inductive reactance.
- Accurate modeling is important for phase angle, power factor, and current flow estimation.

- *Impact on Power Flow Calculation*

- Bulb (R load): contributes only to real power flow, simplifies calculations.
- Fan motor (RL load): affects both real and reactive power flow, influencing voltage drops, losses, and stability in feeders.
- Real-time monitoring should differentiate between R and RL contributions to improve load flow accuracy

- *Voltage and Current Monitoring*

- For R loads: Voltage and current magnitudes are sufficient for monitoring.
- For RL loads: Need to also capture phase shift (φ) to compute reactive power and power factor.

- *Visualization of Load Profiles*

- Display separate contribution of R and RL loads in dashboards
- Useful for identifying how much load is purely resistive vs inductive in real time.

IV. CONCEPT AND METHODOLOGY

- *Block Diagram:*

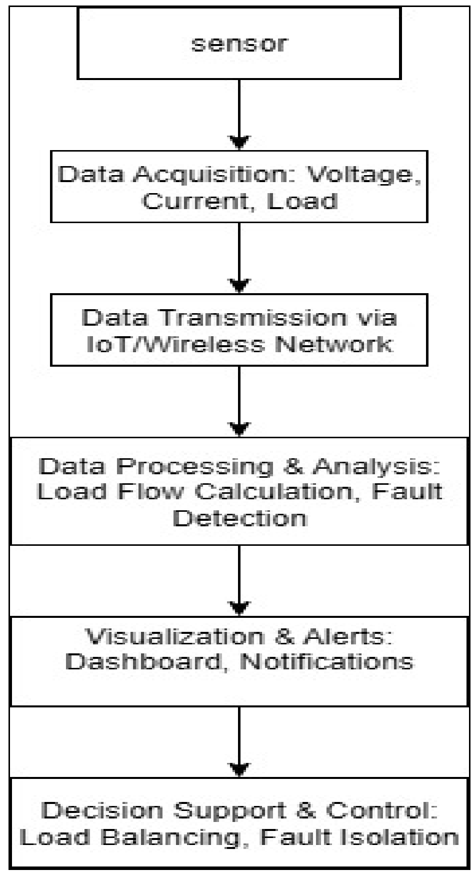

Fig 1 : Load Flow Monitor

- *Description of the System*

- Data Acquisition:- Install sensors and smart meters at various nodes in the distribution system. Measure real-time electrical parameters: voltage, current, and power.
- Data Transmission:- Transmit collected data to a central processing unit using IoT-enabled communication protocols like Wi-Fi, ZigBee, or PLC.
- Data Processing & Analysis:- Use a microcontroller/microprocessor or embedded system to process the incoming data. Compute real-time load flow, including active/reactive power, voltage drops, and line

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losses. Detect abnormal conditions such as overloads, voltage fluctuations, and unbalanced loads.

- Visualization & Alerts:- Display system status on a dashboard or GUI for operators. Generate alerts or notifications for abnormal conditions for prompt action.

- Decision Support & Control:- Recommend corrective actions like load balancing, fault isolation, or voltage regulation. Maintain historical data for trend analysis and planning future upgrades.

V. BENEFITS

- Enhanced Reliability: Real-time monitoring enables quick detection of voltage drops, overload conditions, and unbalanced loads, thereby improving supply reliability.

- Efficient Energy Management: Accurate observation of power flow minimizes technical losses and optimizes system performance.

- Fault Identification: Sudden deviations in load flow patterns assist in identifying faults and abnormal conditions in the network.

- Data-Driven Planning: Continuous monitoring provides engineers with valuable datasets for load forecasting, system expansion, and operational planning.

- Motor Protection: Detects unbalanced voltage, undervoltage, or overload conditions that can damage motor windings.

- Voltage Stability: Ensures bulbs operate at rated voltage, maintaining illumination quality and increasing lifespan.

VI. SCOPE OF THE STUDY

- Monitor and Analyze Load Behavior: Continuously measure voltage, current, real, and reactive power for different types of loads, including resistive bulbs and single-phase table fan motors.

- Assess System Efficiency: Evaluate the impact of R and RL loads on overall power losses, voltage stability, and power factor in distribution systems.

- Support Load Management: Provide real-time data to optimize load distribution, prevent overloads, and enhance reliability of power supply.

- Aid in Energy Planning: Generate datasets that can be used for forecasting, preventive maintenance, and improving the operational efficiency of distribution networks.

- Investigate Power Quality Issues: Analyze the effect of inductive loads on reactive power, voltage drops, and harmonic distortions, thereby suggesting mitigation techniques.

VII. ADVANTAGES

- Enhanced System Reliability: Real-time monitoring detects voltage drops, overloads, and unbalanced conditions quickly, ensuring stable operation of bulbs (R load) and motors (RL load).

- Improved Power Quality: Continuous tracking of reactive power drawn by inductive loads (motors) helps maintain system voltage and minimize power factor issues.

- Energy Efficiency: Monitors real and reactive power, helping reduce losses in resistive loads and optimize motor performance.

- Data for Planning: Provides accurate datasets for distribution system analysis, future load forecasting, and expansion planning.

- Operational Optimization: Ensures stable voltage for resistive loads (bulbs) and optimal torque-speed performance for RL loads (motors).

VIII. DISADVANTAGES

- Data Overload: Continuous data collection generates large datasets, requiring robust storage, processing, and analysis tools.

- Maintenance Requirements: Monitoring devices and communication modules require periodic maintenance for accurate operation.

- Cybersecurity Risks: IoT devices are more exposed to hacking, malware, and unauthorized access compared to traditional SCADA, potentially compromising the distribution system.

- Network Dependency: IoT monitoring relies on stable internet or wireless connectivity; any network failure can disrupt real-time data acquisition.

IX. APPLICATIONS

➢ *Remote Load Monitoring*

- IoT devices allow utilities to monitor R and RL loads in real-time from any location via the internet or cloud platforms.

- Ensures accurate measurement of active and reactive power consumption for bulbs and table fan motors.

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➢ *Energy Management and Optimization:*

- Real-time data enables demand-side management, helping to reduce unnecessary energy usage.

- IoT can provide alerts when reactive power from RL loads is high, enabling corrective action such as capacitor switching.

➢ *Power Quality Monitoring:*

- IoT devices can continuously monitor voltage dips, swells, and harmonics caused by RL loads.

- Helps in improving power quality for sensitive resistive and inductive appliances.

➢ *Consumer Awareness and Energy Billing:*

- Provides end-users with real-time consumption data for bulbs and fans, encouraging energy-efficient behavior.

- Enables accurate time-of-use billing and load-based tariff implementation.

X. CONCLUSION

The implementation of a real-time load flow monitoring system in the distribution network using IoT technology provides an efficient and intelligent solution for modern power systems. This approach enables continuous monitoring of both resistive (R) and inductive (RL) loads, such as bulbs and single-phase table fan motors, allowing utilities to accurately track power consumption, detect anomalies, and optimize load distribution. The system enhances operational efficiency, reduces energy losses, and supports proactive maintenance, thereby improving reliability and stability of the distribution network. Furthermore, the use of IoT facilitates remote monitoring, real-time data acquisition, and smart decision-making, making it a cost-effective and scalable solution for smart grid applications. Future work can focus on integrating advanced analytics, AI-based predictive load management, and expanding the system to multi-node distribution networks.

REFERENCES

[1]. S. Niloy, F. H. Sumona, M. H. Khan, M. Z. Islam, S. Ahmad, and S. Howlader, “Solar Powered Smart Irrigation System Based on Internet of Things (IoT) Using Microcontroller,” in Proc. 3rd International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST), IEEE, 2023, pp. 259–263

[2]. J. F. Riya, Md. T. H. Chowdhury, S. A. Usha, S. Howlader, S. Ahmad, and M. Z. Islam, “A Smart Helmet: Ensuring Safety of Bike Riders,” in Proc. 3rd International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST), IEEE, 2023, pp. 305–31O.

[3]. S. Ahmad, W. Chek Leong, M. Saad, S. Arghya, and A. Tariful, “IoTbased scalable Smart Home Automation System Design using Raspberry Pi,” in Proc. 11th AUN/SEED-Net Regional Conference on Computer and Information Engineering, Indonesia, 2018, pp. 1–6.

[4]. S. Ahmad et al., “Smart home automation and security system design based on IoT applications,” ASEAN Engineering Journal, vol. 9, no. 2, pp. 57–71, Dec. 2019.

[5]. Z. Tang and Y. Zou, “Condition Monitoring System for Circuit Breaker Based on Substation Automation System,” in Proc. 41st International Universities Power Engineering Conference, 2006.