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Three Phase Monitoring System

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Abstract: A reliable three-phase power supply is critical for industrial, commercial, and residential applications. However, issues such as phase loss, imbalance, undervoltage, overvoltage, and power theft can cause equipment damage and downtime. This paper surveys IoT-based three-phase power monitoring systems that provide real-time fault detection and SMS alerts for reporting and load protection. Typical architectures use an Arduino or ESP32 microcontroller with voltage and current sensors to monitor the R, Y, and B phases. When a fault is detected, the controller isolates the load via relays, triggers an alarm, and sends SMS alerts to the concerned authority. For enhanced monitoring, systems often integrate Wi-Fi/GSM communication, enabling remote access to voltage, current, and load conditions through IoT platforms with graphical visualization and data logging. Some implementations support automatic load transfer to healthy phases and optional GPS-based fault localization to minimize response time. The surveyed solutions improve reliability, reduce downtime, and offer cost-effective approaches suitable for smart grids, substations, factories, and residential complexes.

Keywords: IoT, Arduino, Three-Phase Power System, Fault Detection, GSM Module, Voltage Sensor, Current Sensor, SMS Alerts

I INTRODUCTION

Three-phase power systems are the backbone of modern power distribution in industrial, commercial, and residential sectors. Their reliability is critical, yet they remain vulnerable to issues such as phase loss, voltage imbalance, fluctuations, and line faults. These disruptions can cause equipment failures, downtime, safety risks, and financial losses. Conventional protection methods such as fuses and circuit breakers operate only after a fault occurs, providing little scope for proactive monitoring [1]. Recent advances in the Internet of Things (IoT) have enabled real-time monitoring and intelligent fault detection. Systems based on Arduino or ESP32 microcontrollers, combined with voltage and current sensors, can continuously track supply conditions and generate alerts. GSM-based solutions are widely adopted for SMS notifications [1, 2, 5, 4, 10], while Wi-Fi and cloud-based dashboards provide remote visualization and predictive maintenance capabilities [3, 9, 6, 11]. Researchers have proposed several IoT-based models for fault detection. Some works developed transmission-line monitoring systems capable of locating faults and estimating fault distance, while others introduced

automation-based load transfer systems to maintain supply during single-phasing. Beyond distribution-level applications, IoT has been applied to energy management. Egos et al. [6] designed a three-phase load monitoring system with cloud integration for data logging and preventive maintenance. Jamshed et al. [3, 11] demonstrated ESP32-based systems capable of phase-failure detection and online analysis [9]. Several authors also highlighted IoT-enabled SMS alerts applicable to both industrial and residential networks. To overcome these challenges, this survey discusses IoT-based three-phase power monitoring systems that integrate real-time fault detection, energy monitoring, and automated alerts. Using Arduino/ESP32 controllers, GSM/Wi-Fi modules, and cloud dashboards, such systems ensure continuous monitoring and enable predictive analytics. This approach is suitable for deployment across industrial, commercial, and residential infrastructures.

II LITERATURE SURVEY

Researchers have developed many IoT-based systems for three-phase power monitoring, mainly focusing on fault detection, phase monitoring, and automated alerts.

Dhilipkumar *et al.* [1] and Kumar *et al.* [2] designed GSM-based models that detect interruptions and voltage drops, sending SMS alerts within seconds. Mane *et al.* [5], Londhe *et al.* [10], and Shameera *et al.* [4] built practical systems and added GPS to improve location-based fault reporting. Wi-Fi and cloud-enabled systems extended these ideas by providing dashboards and predictive analysis. Jamshed *et al.* [3, 11], Kshirsagar and Jain [9], and Egos *et al.* [6] used ESP32 and ThingSpeak to display phase conditions online, record data, and manage transformer loads. Verma *et al.* [7] focused on transmission line faults, while Pravallika *et al.* [8] worked on automatic load transfer to maintain supply during failures. Across these studies, IoT-based monitoring showed clear benefits in detecting faults quickly, sending timely alerts, and improving system visibility. However, most systems remain prototypes. Challenges such as GSM network shutdowns, poor Wi-Fi coverage in rural areas, lack of predictive features, and limited large-scale testing still hinder full adoption.

III METHODOLOGY

This survey adopts a structured methodology to review existing IoT-based solutions for three-phase power monitoring and fault detection. The objective is to analyze current approaches, identify strengths and limitations, and highlight research opportunities.

1. Paper Selection Criteria

Twelve research papers published between 2021 and 2024 were selected as primary sources for this study. The selection considered the following criteria:

- Focus on IoT-enabled three-phase power monitoring or fault detection systems.
- Inclusion of real-time alerting mechanisms such as GSM, Wi-Fi, or cloud dashboards.
- Experimental validation or prototype-level implementation.
- Relevance to industrial, commercial, or residential applications.

2. Categorization of Studies

The selected works were grouped by technological orientation:

- **GSM-based systems:** SMS alerts for fault detection and power failure monitoring.
- **Wi-Fi/Cloud-based systems:** Online dashboards, data logging, and predictive maintenance.
- **Fault detection in transmission lines:** Line fault identification and localization.

- **Automation and load management:** Automated load transfer during phase failures.

3. Comparative Parameters

Each system was evaluated on:

- Type of microcontroller used (Arduino, ESP32, etc.).
- Communication technology (GSM, Wi-Fi, ESP8266, GPS).
- Monitoring scope (phase failure, load monitoring, transmission faults).
- Alerting mechanism (SMS, dashboard, hybrid).
- Practical deployment limitations (connectivity issues, scalability, obsolescence).

4. Mathematical Modeling

The proposed model evaluates the health of each phase by comparing its instantaneous RMS voltage with a threshold V_{th} . The overall system status $S(t)$ is derived from the product of individual phase states, and an alert signal $A(t)$ is generated whenever a failure is detected.

- Each phase voltage is considered as $V_R(t), V_Y(t), V_B(t)$.
- A phase is healthy if $V_i(t) \geq V_{th}$, $i \in \{R, Y, B\}$, where V_{th} is typically 180V.
- A failure occurs if $V_i(t) < V_{th}$.
- Network latency for SMS is considered negligible compared to detection time in this model.

Limitations of Existing Work

Although IoT-based three-phase monitoring systems have shown promise, several important limitations remain.

1. Network Dependency

Most systems rely on GSM or Wi-Fi for communication. GSM-based solutions depend on 2G/2.5G networks that are being phased out in some regions, threatening long-term usability. Wi-Fi and cloud-based approaches provide richer dashboards but suffer from poor coverage in rural areas.

2. Prototype-Level Validation

Many works were tested only at prototype level in laboratories or small residential setups. Large-scale industrial validation is largely missing.

3. Energy Efficiency and Optimization

While load monitoring and transformer management have been addressed in some works [6], most systems focus narrowly on fault detection. Broader goals such as energy efficiency, demand-side management, and smart grid integration remain underexplored.

4. Hardware and Cost Constraints

Low-cost microcontrollers such as Arduino and ESP32 are effective for prototypes, but industrial deployments require ruggedized hardware, redundancy, and cybersecurity features [7].

5. Data Security and Privacy

Few reviewed systems explicitly addressed secure data handling. Cloud-based dashboards and IoT communication raise risks of unauthorized access and tampering; encryption and authentication protocols are necessary for safe large-scale deployment.

Implementation and Results

IoT-based three-phase monitoring systems have been validated through prototypes, simulations, and experimental setups.

A. Hardware and System Design

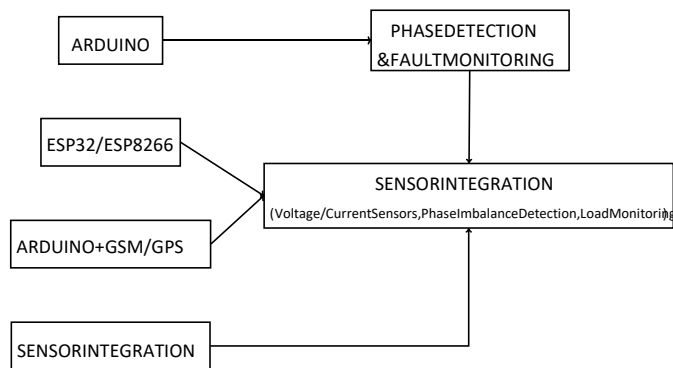


Figure 1: Hardware and System Design for IoT-Based Three-Phase Power Monitoring

B. Communication and Alert Mechanisms Communication and Alert Mechanisms

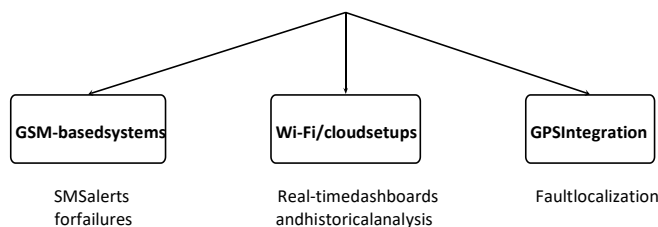


Figure 2: Communication and alert mechanisms in IoT-based three-phase monitoring

C. Reported Results

Reviewed systems consistently showed fast detection, reliable alerts, and improved monitoring accuracy. GSM-based prototypes were able to send SMS notifications within seconds of a failure, while other systems accurately detected real-time phase disconnections. Wi-Fi and cloud-enabled models provided effective data logging and visualization, supporting predictive maintenance. Load monitoring helped improve transformer management, and fault detection systems enabled automated recovery, ensuring continuity of supply.

IV .CONCLUSION

This survey reviewed twelve recent studies on IoT-based three-phase power monitoring systems, covering fault detection, automated alerts, load management, and energy optimization. IoT technologies combined with microcontrollers (Arduino, ESP32), sensors, and communication modules (GSM, Wi-Fi, GPS) can greatly improve real-time monitoring and fault response in power distribution. GSM-based models proved effective for sending quick SMS alerts, while Wi-Fi and cloud-based systems enabled remote dashboards and basic predictive analysis. Advanced applications such as transmission-line fault detection and automatic load transfer demonstrate the versatility of IoT in this field. However, gaps remain: reliance on possibly obsolete networks, prototype-level validation, limited predictive features, hardware constraints, and sparse attention to data security. Future research should focus on hybrid communication methods, AI for predictive maintenance, smart-grid integration, stronger cybersecurity, and cost-effective durable hardware.

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