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Research

LOAD SHARING TRANSFORMER MANAGEMENT SYSTEM WITH GSM FAULT ALTERING

Bhatta Geyasri[1], Akku Aishwarya[2],Srimanthula Shivani [3], Kolkulapally Madhu[4], Sandhupatla Manish[5]

[1] UG Student, Department of EEE ,Malla Reddy Engineering College and Management Sciences, Hyderabad,Telangana,India.
Email: geyasribhatta@gmail.com

[2] UG Student, Department of EEE ,Malla Reddy Engineering College and Management Sciences, Hyderabad,Telangana,India.
Email: akkuaishwarya8@gmail.com

[3] UG Student, Department of EEE ,Malla Reddy Engineering College and Management Sciences, Hyderabad,Telangana,India.
Email: srimanthulashivani6@gmail.com

[4] UG Student, Department of EEE ,Malla Reddy Engineering College and Management Sciences, Hyderabad,Telangana,India.
Email: kolkulapallymadhu66@gmail.com

[5] Assistant Professor, ,Department of EEE ,Malla Reddy Engineering College and Management Sciences, Hyderabad,Telangana,India.
Email: sandhupatlamanish@gmail.com

ABSTRACT

The project titled “Load Sharing Transformer Management System with GSM Fault Alerting” aims to enhance the reliability and efficiency of power distribution systems by enabling intelligent load sharing between two transformers. The system utilizes an Arduino microcontroller to continuously monitor transformer conditions through sensors such as current transformers (CT) and fault detectors. When an overload or fault occurs in one transformer, the system automatically transfers the load to the standby transformer through a relay mechanism, ensuring uninterrupted power supply. Additionally, the GSM module sends real-time fault notifications to maintenance personnel, facilitating immediate response and minimizing downtime.

This automated transformer management system significantly improves fault tolerance and operational safety in electrical substations and distribution networks. The integration of LCD and buzzer modules provides local monitoring and alerting capabilities, while GSM communication ensures remote supervision. By automating the load transfer process and fault reporting, the system reduces manual intervention and enhances the overall reliability of transformer operations. The proposed model is a cost-effective, scalable solution suitable for smart grid applications and rural power management.

Keywords: Arduino, Transformer, Load Sharing, GSM, Fault Detection, Power Management, Current Transformer, Automation, Smart Grid, Relay Control.

1. INTRODUCTION

Transformers are critical components in electrical distribution networks, enabling the efficient transfer of electrical power across different voltage levels. They support residential, commercial, and industrial loads and ensure reliable energy delivery. As electrical demand increases due to rapid urbanization, expansion of industries, and the integration of modern electrical equipment, transformers are subjected to higher and often uneven load conditions. When transformers are overloaded or operate under faulty conditions for prolonged periods, they experience excessive heat, insulation degradation, reduced lifespan, and risk of catastrophic failure. These failures not only cause prolonged power outages but also result in costly repairs, safety hazards, and disruption of essential services. Therefore, effective transformer load monitoring, protection, and intelligent fault alerting mechanisms have become crucial in modern power distribution networks.

Traditionally, transformer monitoring has relied on periodic manual inspection and the use of basic protection devices such as circuit breakers, relays, and fuses. While these provide fundamental protection, they cannot deliver continuous, real-time monitoring of load conditions or detect early-stage faults. Moreover, manual inspection is time-consuming, prone to human error, and unable to respond immediately to sudden changes in load or emerging faults. As a result, important fault indicators—such as temperature rise, overloading, oil level changes, and short-circuit conditions—may remain unnoticed until significant damage occurs. The lack of an automated, intelligent monitoring system increases the risk of unexpected transformer failures, which directly impacts the stability and reliability of the power distribution infrastructure.

To address these challenges, modern power systems are increasingly adopting IoT-based monitoring, automated load sharing, and remote alerting technologies such as GSM (Global System for Mobile Communication). A Load Sharing Transformer Management System ensures that the connected transformers share the overall load intelligently and uniformly. When one transformer experiences a rise in load beyond its safe capacity, the system can transfer a portion of the load to another transformer, thereby preventing overloading. This not only enhances reliability but also optimizes the use of available transformers and reduces the operational stress on individual units. Load sharing mechanisms ultimately increase efficiency, extend equipment lifespan, and ensure stable power supply even under variable load conditions.

The integration of a GSM fault alerting module further enhances the system's effectiveness by enabling real-time communication of abnormal conditions to maintenance personnel or control room operators. GSM alerts through SMS ensure that critical information—such as transformer overload, temperature rise, oil level drop, voltage fluctuations, or relay tripping—is delivered instantly, regardless of geographical distance. This remote fault alerting capability enables quick response, timely repair, and prevention of large-scale failures. GSM technology is particularly beneficial in rural or remote regions where transformers are spread across large distances and manual monitoring is difficult or delayed.

A Load Sharing Transformer Management System typically employs microcontrollers, current sensors, temperature sensors, relays, and communication modules to continuously analyze transformer health indicators. The microcontroller receives real-time data from connected sensors, compares it with predefined safety thresholds, and activates relevant control actions. For instance, if Transformer A is heavily loaded while Transformer B is lightly loaded, the system automatically redistributes the load by switching relays. If the load continues to rise despite corrective measures, or if any abnormal condition is detected, the GSM module sends immediate alerts. Such a combined approach not only ensures operational safety but also supports predictive maintenance practices—allowing faults to be diagnosed and addressed before they escalate.

In addition to improving reliability, this system also contributes to smart grid development, where automation, digital communication, and intelligence are used to improve the overall efficiency of the power network. Smart transformer management reduces power losses, minimizes downtime, and aligns with modern power system goals of resilience and sustainability. By automating load balancing, monitoring transformer parameters, and ensuring quick fault detection, the proposed system acts as a bridge between traditional electrical distribution methods and modern intelligent power management solutions.

Another important advantage of the system is its cost-effectiveness. Rather than replacing transformers or conducting frequent manual inspections, utilities can use this system to extend the operational life of existing equipment. Early detection of faults prevents severe damage and costly repairs. Load sharing further reduces stress on individual transformers, minimizing the need for replacement or overhaul. The inclusion of GSM provides a low-cost yet highly effective communication channel that does not require complex networking infrastructure. This makes the system especially suitable for small-scale substations, rural electrification setups, and developing regions where cost constraints limit the use of advanced SCADA systems.

Moreover, the proposed system enhances safety by preventing hazardous conditions associated with transformer failures, such as fire outbreaks, oil leakage, and electrical hazards. Fault alerts sent instantly help technicians take action without delay, significantly reducing risks. Since transformers often operate in outdoor or unattended environments, the ability to remotely supervise their health and performance becomes essential for ensuring safe and stable operations.

In summary, the Load Sharing Transformer Management System with GSM Fault Alerting addresses critical issues in power distribution such as overloading, unbalanced load distribution, delayed fault detection, and lack of real-time monitoring. By integrating sensors, microcontroller-based automation, intelligent load sharing algorithms, and GSM communication, the system ensures continuous supervision, quick fault communication, and efficient transformer operation. Through improved reliability, reduced downtime, enhanced safety, and cost savings, this system represents an important advancement in modern transformer management and contributes significantly to the development of smarter and more resilient power distribution networks

2. LITERATURE SURVEY

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30. Multiple open-source project reports & student implementations (2018–2025) — Arduino/ESP32 based transformermonitoring & automatic load sharing projects. These practical reports (IRJET / college journals / project PDFs) provide ready-to-adapt code snippets, wiring diagrams and component lists for prototyping GSM + load sharing hardware. They underscore how academic prototypes translate to field testbeds. (IRJMETS).

3. EXISTING SYSTEM

In the existing electrical distribution infrastructure, transformer monitoring is primarily carried out through manual inspection and basic protection mechanisms such as fuses, circuit breakers, and thermal relays. These conventional systems only respond after a fault has occurred and do not provide continuous, real-time monitoring of critical parameters like load current, winding temperature, oil condition, or voltage fluctuations. As a result, overload conditions often remain undetected until the transformer begins to overheat or fail. Moreover, the current system does not include automated load sharing between parallel transformers; therefore, one transformer may become heavily loaded while another remains underutilized, leading to inefficiency and increased risk of insulation damage. Fault information is not communicated automatically, and maintenance personnel often discover problems only after major failures or customer complaints. The absence of remote fault alerting technologies such as GSM further delays corrective actions, contributing to prolonged outages, higher maintenance costs, and reduced transformer lifespan.

4. PROPOSED SYSTEM

The proposed system introduces an intelligent, microcontroller-based transformer management architecture capable of performing real-time monitoring, automatic load sharing, and GSM-enabled fault alerting. Multiple sensors—including current sensors, temperature sensors, and voltage sensors—continuously measure the operational parameters of each transformer in the distribution network. These inputs are processed by a central microcontroller that compares real-time values with predefined safe thresholds. When an overload or abnormal condition is detected, the controller initiates relay-based switching to redistribute the load from the overloaded transformer to a secondary transformer. This automated load-sharing approach ensures balanced utilization, prevents overheating, and protects transformers from damage caused by excessive stress.

In addition to intelligent load balancing, the system incorporates a GSM module to provide immediate fault notifications to maintenance personnel. When critical abnormalities such as high temperature, overcurrent, voltage drops, or sensor failures occur, the microcontroller triggers the GSM module to send SMS alerts containing detailed fault information. This real-time communication enables technicians to respond quickly, reducing downtime and preventing major failures. By combining automated load management, continuous monitoring, and wireless alerting, the proposed system enhances reliability, improves operational efficiency, extends transformer lifespan, and supports modern smart-grid-based power distribution.

Block diagram:

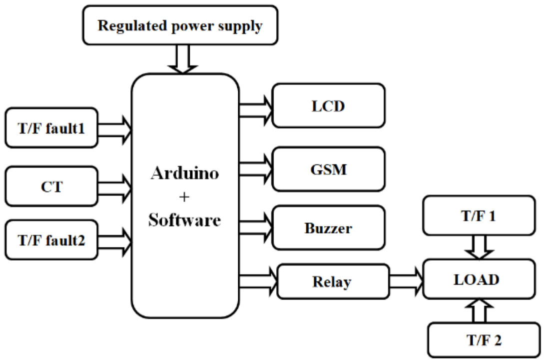

Fig.1: Block diagram of the proposed load sharing transformer management system

The block diagram represents a Load Sharing Transformer Management System with GSM Fault Alerting. It consists of the following main components:

1.Regulated Power Supply

Provides stable DC power to all modules, including the Arduino, sensors, relays, LCD, GSM module, and buzzer.

Ensures reliable operation and prevents voltage fluctuations that could affect the system's performance.

2.Arduino + Software

Acts as the central processing unit of the system.

Receives inputs from sensors and processes them based on pre-programmed logic.

Controls load sharing between transformers and triggers alerts if abnormal conditions are detected.

3.Input Modules

T/F Fault1 & T/F Fault2: Sensors that detect fault conditions (like overvoltage, short circuit, or overheating) in Transformer 1 and Transformer 2.

CT (Current Transformer): Measures the current flowing through the transformers and feeds real-time load data to the Arduino.

4.Output Modules

LCD: Displays real-time transformer parameters such as load current, fault status, and operational alerts.GSM Module: Sends SMS alerts to maintenance personnel when faults or overload conditions occur.

Buzzer: Provides an audible warning for immediate attention when a fault is detected.

Relay: Acts as a switch to redistribute the load between Transformer 1 (T/F 1) and Transformer 2 (T/F 2) to prevent overloading.

Load Distribution:

The relays control the connection between the transformers and the load.If one transformer is overloaded or faulty, the system automatically shifts a portion of the load to the other transformer, ensuring continuous and safe power supply.

5. RESULTS

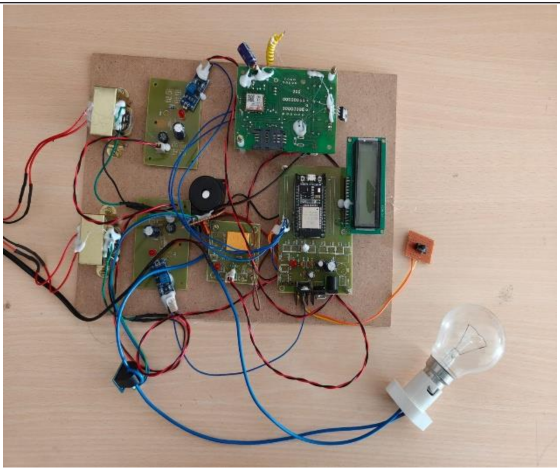

Fig. 2: Hardware prototype of the load sharing transformer system

The figure shows the complete hardware implementation including the Arduino controller, CT sensors, fault detection circuits, relay modules, GSM module, LCD, buzzer, and load arrangement, validating real-time load transfer between transformers.

Fig.3: LCD display indicating automatic transformer load sharing operation

The LCD displays system status during operation, showing automatic transformer (TF) load sharing, confirming correct fault detection and relay-based load transfer logic.

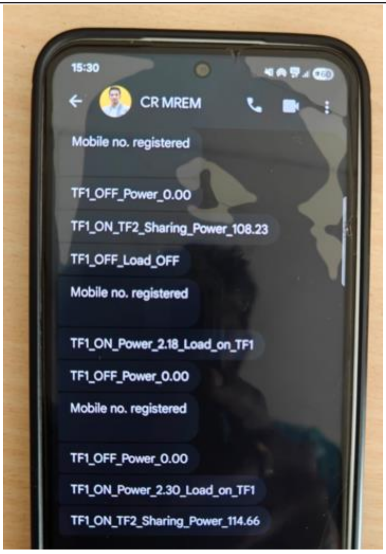

Fig.4: GSM-based fault and load status alerts on registered mobile device

SMS notifications generated by the GSM module report transformer ON/OFF status, load sharing conditions, and power levels, demonstrating reliable remote fault alerting.

S.No	Voltage	Current	Power	TF_Status	Date
1	230.00	67.72	116.81	TF1_OFF_Load_OFF	2026-02-02 15:26:31
2	230.00	66.47	114.66	TF1_ON_TF2_Sharing_Power_114.66	2026-02-02 15:25:27
3	230.00	1.34	2.30	TF1_ON_Power_2.30_Load_on_TF1	2026-02-02 15:24:29
4	0.00	0.00	0.00	TF1_OFF_Power_0.00	2026-02-02 15:23:50
5	0.00	0.00	0.00	TF1_OFF_Power_0.00	2026-02-02 15:21:44
6	230.00	1.27	2.18	TF1_ON_Power_2.18_Load_on_TF1	2026-02-02 15:20:36
7	230.00	67.42	116.29	TF1_OFF_Load_OFF	2026-02-02 15:15:34
8	230.00	62.74	108.23	TF1_ON_TF2_Sharing_Power_108.23	2026-02-02 15:14:10
9	0.00	0.00	0.00	TF1_OFF_Power_0.00	2026-02-02 15:13:29
10	230.00	59.68	102.95	TF1_ON_TF2_OFF_102.95_Load_OFF_Because_of_High_Pow	2026-01-28 21:11:27
11	230.00	59.68	102.95	TF1_ON_TF2_Sharing_Power_102.95	2026-01-28 21:10:49
12	230.00	21.97	37.89	TF1_OFF_Power_37.89	2026-01-28 21:10:08
13	230.00	60.09	103.66	TF1_ON_TF2_Sharing_Power_103.66	2026-01-28 21:09:26
14	230.00	60.49	104.34	TF1_ON_TF2_Sharing_Power_104.34	2026-01-18 13:52:35
15	0.00	0.00	0.00	TF1_OFF_Power_0.00	2026-01-18 13:51:45

Fig.5:Logged transformer voltage, current, and power data on IoT/server platform

The table displays recorded voltage, current, power, and transformer status with timestamps, confirming accurate data logging and monitoring of load sharing events.

6. CONCLUSION

The “Load Sharing Transformer Management System with GSM Fault Alerting” provides an effective and reliable solution for improving the performance and fault tolerance of electrical power distribution networks. The proposed system successfully demonstrates automated load sharing between two transformers to prevent overloading and ensure continuous power supply during fault conditions. By continuously monitoring transformer parameters through current transformers and fault detection sensors, the system is capable of identifying abnormal operating conditions in real time.

The Arduino microcontroller serves as the central control unit, coordinating sensor data acquisition, relay-based load transfer, and communication functions. When an overload or fault is detected in the primary transformer, the system automatically shifts the load to the standby transformer without human intervention. This fast and intelligent response minimizes power interruptions, protects transformer equipment from damage, and improves overall system reliability. The relay control mechanism ensures safe and efficient switching, while the LCD display provides real-time status information for on-site monitoring.

The integration of the GSM module adds a critical layer of remote communication by sending instant fault alerts to maintenance personnel. This feature enables quick fault diagnosis and timely corrective action, significantly reducing downtime and maintenance delays. The buzzer and visual indicators further enhance safety by providing immediate local alerts during abnormal conditions. By reducing dependence on manual supervision, the system increases operational efficiency and lowers maintenance costs.

Overall, the proposed load sharing transformer management system offers a cost-effective, scalable, and intelligent solution for modern power distribution challenges. It is particularly suitable for substations, industrial plants, and rural distribution networks where uninterrupted power supply and rapid fault response are essential. Future improvements may include integration with IoT platforms for cloud-based monitoring, predictive fault analysis using data analytics, and expansion to multi-transformer systems for large-scale smart grid applications. This project demonstrates a practical step toward automation and reliability in power system management, aligning with the goals of smart grid development.

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