

IOT Based Load Sharing Transformer with Real-Time Monitoring

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Abstract: *The transformer serves as a stationary apparatus; it transfers the electrical power between circuits, adjusting voltage and current to desired levels while maintaining a consistent frequency. A transformer can operate most efficiently from no load condition to full load capacity, but it will face issues when it is overloaded, which will lead to a serious problem for the health of the transformer. Therefore, it is essential to monitor their health and efficiently distribute the load among multiple transformers. To prevent a transformer from overloading, a backup transformer is employed to power the load when the main transformer is overloaded. The backup transformer is activated automatically by a microcontroller. This setup ensures optimal loading for both transformers. Additionally, both transformers can be turned on to provide the load alternately when the load is normal.*

Keywords: Real Time Monitoring, IOT, Sensor Integration, ESP8266, Load Sharing

I. INTRODUCTION

Electrical energy plays a vital role in the development of modern society. Almost every industrial, commercial, and residential activity depends on a continuous and reliable power supply. In electrical distribution systems, transformers are one of the most important components, as they are responsible for stepping down high transmission voltages to usable levels for end users. However, due to increasing power demand and uneven load distribution, transformers are frequently subjected to overloading conditions, which can lead to overheating, insulation failure, reduced efficiency, and permanent damage.

In traditional power distribution systems, transformer monitoring and load management are mostly manual or periodic in nature. These systems do not provide real-time information about transformer health or load conditions. As a result, overload situations often go unnoticed until a failure occurs, causing power interruptions and costly repairs. This problem highlights the need for an intelligent, automated, and remotely monitored transformer load management system.

The advancement of Internet of Things (IoT) technology has opened new possibilities for smart power system monitoring and control. IoT enables real-time data collection, wireless communication, and remote monitoring through cloud platforms. By integrating IoT with transformer load sharing, it is possible to develop a system that not only protects transformers from overload but also provides continuous monitoring and alerts to users. Electrical energy plays a vital role in the development of modern society. Almost every industrial, commercial, and residential activity depends on a continuous and reliable power supply. In electrical distribution systems, transformers are one of the most important components, as they are responsible for stepping down high transmission voltages to usable levels for end users. However, due to increasing power demand and uneven load distribution, transformers are frequently subjected to overloading conditions, which can lead to overheating, insulation failure, reduced efficiency, and permanent damage.

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II. LITERATURE SURVEY

For our project we are surveying some reports and references which are helping us to make it easy and simplest and they are as follows

1. The hardware required for this system includes; Controller: programmable logical controller, PC as a monitor device, Sensors: current transformer, potential transformer, and temperature sensor. In this type of monitoring, the system is connected to a distribution transformer and is able to record and send the abnormal values of the transformer parameters to a mobile device using a GSM network. This technology is used by many of the monitoring systems. Abdul Rahman Al-Ali [1] deals with the recording of transformer load currents, transformer oil, and ambient temperature by implementing a mobile embedded system. The large data about the transformer condition can be processed by using the devices like GSM modem, programmable logic controller and PC as a monitor device and sensors like a current transformer and potential transformer.

2. Viswanath [2] presented a paper uses a temperature sensor, pic microcontroller, LCD display, GSM board and Xbee which is used for send the message to the electricity board. This system is capable of detecting multiple faults in the three phase transmission lines. Mohamed Ahmed Eltayeb El Mustafa Hayatiet [3] have designed decision support system to grid operation engineers with information helps to estimate the loads, fix problems and identify weak points in the grid. Distribution transformer monitoring is very important in the grid in fact its abnormality adversely affects the smooth functioning of the smart grid. In this paper they suggested and implemented a method to remotely monitor a group of distribution transformers. Here the microcontroller is used for data acquisition and transmission.

3. Monika Agarwal et al. [3] This paper represents that they are designing a system where there exists communication between system and operator. For this we are using Transformer, microcontroller, logic level converter and GSM i.e. global system for mobile communication modem. This GSM modem helps to monitor transformer health by sending message to the system. Hongyan Mao, et al. [3] This paper represents a large number of power distribution transformer stations and they are far away from city, wireless GPRS transmission provides a good communication solution to supervise power distribution transformer stations. The scheme of remote wireless monitoring system for power distribution transformer station based on GPRS wireless network was designed in this paper. A control terminal system implement was mainly given, which adopted LPC2132 as main processor, GR47 as the data communication module. The monitor terminal software and flow chart were also designed. At last, the way of configuring the GPRS module to connect network is analyzed. condition.

III. METHODOLOGY

The proposed system consists of two transformers: Transformer-1 (Main) and Transformer-2 (Backup). Transformer-1 supplies power to the loads during normal operation. Transformer-2 remains in standby mode and is activated only when an overload condition is detected.

An ESP8266 (NodeMCU) microcontroller acts as the central processing and control unit. It continuously receives electrical parameter data from the INA219 current and power sensor, processes the data, and makes control decisions based on predefined threshold values. The system controls the load distribution using a 4-channel relay module and provides user interaction through tactile push buttons.



Real-time monitoring and remote access are achieved through Wi-Fi communication between the ESP8266 and the Blynk cloud platform. The system also includes a 16×2 LCD display and a buzzer for local status indication and alert generation.

Automatic Load Sharing Transformer with IoT Monitoring

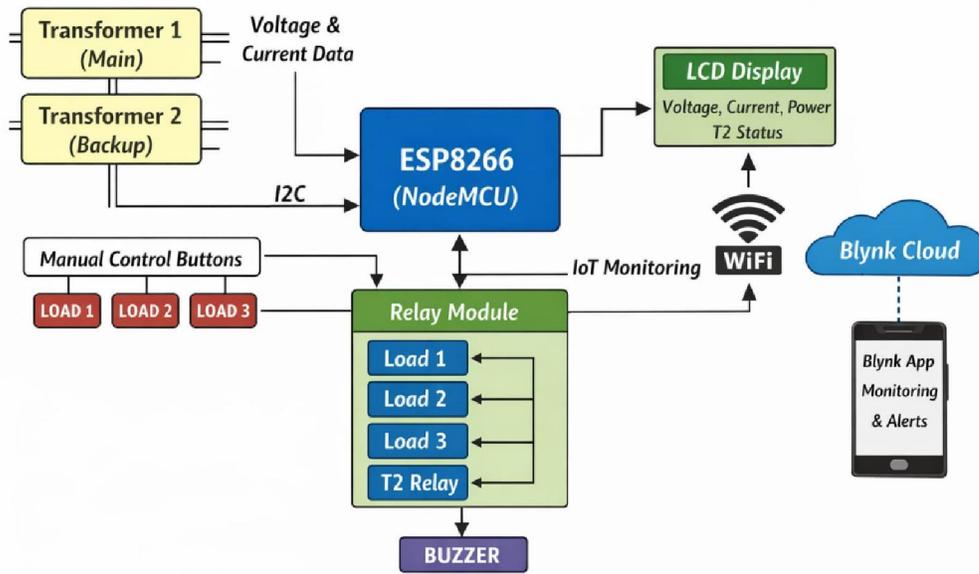


Fig. 1. Block Diagram

A. ESP8266 (NodeMCU):

The ESP8266 is a low-cost, Wi-Fi-enabled microcontroller used as the main controller of the system. It performs the following functions:

- Reads voltage, current, and power data from the INA219 sensor
- Processes load current data and compares it with the overload threshold
- Controls relay modules for load switching and transformer activation
- Communicates with the Blynk cloud using Wi-Fi
- Updates real-time data on LCD and mobile application

The ESP8266 is selected due to its built-in Wi-Fi capability, low power consumption, and compatibility with IoT platforms.



Fig. 2. ESP8266 Microcontroller



B. INA219 Current and Power Sensor:

The INA219 sensor is used to measure bus voltage, load current, and power consumption. It communicates with the ESP8266 using the I²C protocol, ensuring accurate and noise-free digital data transfer.

Key features include:

- High measurement accuracy
- Digital output via I²C
- Suitable for low- and medium-current applications
- Compact size and easy integration

The sensor continuously monitors the current drawn by the load and plays a critical role in detecting overload conditions.

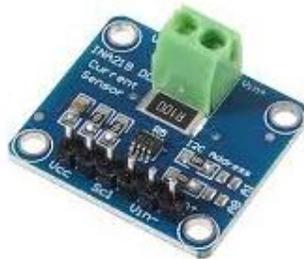


Fig. 4. Current & Power Sensor

C. 16x2 LCD Display:

A 16×2 LCD display is used to show real-time system information locally. The display presents:

- Voltage value
- Current value
- Power consumption
- Transformer-2 status (ON/OFF)

The LCD operates using the I²C interface, which reduces wiring complexity and improves system reliability.



Fig. 5. LCD Display

D. Relay Module(4-Channel):

A 4-channel relay module is used for electrical isolation and switching of loads and Transformer-2. The relay channels are assigned as follows:

- Relay 1 – Load 1
- Relay 2 – Load 2



- Relay 3 – Load 3
- Relay 4 – Transformer-2 activation

The relays are controlled by digital output pins of the ESP8266. When a relay is activated, it allows the corresponding load or transformer to be connected to the power supply.



Fig.6. Relay Module

E. Tactile Push Button:



Fig.7. Tactile Push Button

A Three tactile push buttons are provided for manual control of the connected loads. Each button corresponds to one load and allows the user to toggle the load ON or OFF manually.

The buttons are interfaced using internal pull-up resistors of the ESP8266 to ensure reliable operation and noise immunity.

F. Power Supply Unit:

- Control Power Supply:

A 12-0-12 V, 1 A step-down transformer with center-tap rectifier circuit is used to power the ESP8266 and control circuitry.

- Load Power Supply:

Two 12-0-12 V, 2 A transformers with rectifier circuits are used to supply the connected loads and support load sharing operation.

This separation ensures stable operation and reduces electrical interference between control and power sections.



Fig.8. Power Supply Unit



IV. RESULT

The IoT Based Load Sharing Transformer with Real-Time Monitoring system was successfully designed, implemented, and tested under various load conditions. During normal operation, the main transformer (Transformer-1) supplied power to the connected loads, and the system continuously monitored voltage, current, and power using the INA219 sensor. These parameters were accurately displayed on the 16×2 LCD and simultaneously updated on the Blynk mobile application in real time.

When the load current exceeded the predefined threshold value, the system correctly detected the overload condition. In response, the ESP8266 automatically activated the backup transformer (Transformer-2) through the relay module. This ensured effective load sharing between the two transformers and prevented excessive stress on the main transformer. At the same time, the buzzer was activated to provide an audible alert, and a notification was generated on the Blynk platform, confirming successful IoT-based monitoring and alert functionality.

Manual load control using tactile push buttons worked reliably without affecting the automatic protection mechanism. The relay switching was fast and stable, and the system returned to normal operation once the load current dropped below the safe limit. Overall, the results demonstrated that the system operates efficiently, provides real-time monitoring, and ensures reliable transformer protection.

V. CONCLUSION

This project successfully demonstrates the design and implementation of an IoT Based Load Sharing Transformer with Real-Time Monitoring. The system effectively addresses the problem of transformer overloading by automatically sharing the load between two transformers when excessive current is detected. The integration of the ESP8266 microcontroller, INA219 current sensor, relay modules, and Blynk IoT platform resulted in a smart, reliable, and cost-effective solution.

The proposed system enhances transformer safety, improves operational efficiency, and reduces the risk of power interruptions. Real-time monitoring and remote access through IoT technology provide better visibility and control compared to conventional transformer management systems. The combination of automatic control, manual flexibility, and alert mechanisms makes the system suitable for practical applications in small-scale power distribution environments.

Overall, the project meets its objectives and demonstrates the effective application of IoT and embedded systems in power system automation.

VI. FUTURE SCOPE

Although the proposed system performs effectively, there is significant scope for further enhancement and expansion. In the future, temperature sensors can be integrated to monitor transformer oil or winding temperature, providing more comprehensive protection. The system can also be extended to support multiple transformers and higher load capacities for larger distribution networks.

Advanced data analytics and cloud-based data logging can be implemented to enable predictive maintenance and fault analysis. The use of solid-state relays instead of mechanical relays can improve reliability and reduce switching wear. Additionally, enhanced security features and alternative communication technologies such as GSM or LoRa can be incorporated to improve system robustness in remote areas.

With these improvements, the system can evolve into a complete smart transformer monitoring and management solution suitable for modern smart grid applications.

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