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Automatic Load Sharing of Distribution Transformer (IOT)

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Abstract: With the rapid advancement in artificial intelligence (AI), automation, and innovative infrastructure, the demand for electrical power has increased exponentially over the past century. Population growth is another major factor contributing to this continuous rise in energy consumption. To address the growing energy crisis—particularly the challenges related to excessive power demand and transformer protection—an Automatic Load Sharing System for Distribution Transformers using IoT is proposed.

The primary objective of this system is to prevent transformer overloading, which significantly affects transformer efficiency and reliability. Overloading causes frequent power failures, overheating of windings, and, in severe cases, transformer burnout. These failures not only increase maintenance costs but also demand considerable manpower for transformer replacement.

Ensuring the protection of distribution transformers from overloading and maintaining a stable, uninterrupted power supply to both industrial and domestic consumers are key challenges for modern power distribution networks. The proposed Automatic Load Sharing System offers an effective solution to these issues. The system employs a microcontroller-based control mechanism, where two distribution transformers are connected in parallel. The microcontroller continuously monitors the load on the primary transformer and compares it with a predefined reference value. When the load exceeds the threshold, the excess power demand is automatically transferred to the secondary transformer. This dynamic load sharing mechanism ensures optimal utilization of both transformers, enhances reliability, and prevents potential damage due to overloading.

I.INTRODUCTION

The primary objective of the Automatic Load Sharing of Distribution Transformer using IoT system is to protect the transformer from overloading and to ensure a reliable and uninterrupted power supply to industrial, commercial, and residential sectors.

In India, even in the era of AI and automation, the power distribution sector continues to face the persistent challenge of frequent power failures caused by transformer overloading. These failures lead to significant losses of both manpower and financial resources for distribution companies as well as end consumers.

The proposed IoT-based Automatic Load Sharing System aims to address these issues by enhancing the efficiency, reliability, and safety of power distribution networks. The system continuously monitors load parameters in real time and intelligently redistributes the load between transformers whenever necessary.

By integrating real-time monitoring, data analytics, and automated control mechanisms, the IoT-based system not only safeguards transformers from overload conditions but also optimizes power distribution operations. This approach contributes to modern energy management practices, improves infrastructure protection, and enhances the overall performance and reliability of the power grid.

II.SYSTEM DEVELOPMENT

our proposed IoT-based Automatic Load Sharing module for distribution transformers effectively integrates key components—transformer, microcontroller, sensors, and IoT connectivity—to achieve real-time energy monitoring, intelligent load management, and enhanced energy efficiency. This system empowers operators to remotely access transformer status via mobile applications or web portals, optimizing transformer lifespan, reducing repair costs, and contributing to national energy sustainability.

Fig 1 Transformer (230V AC)

Fig 2 Microcontroller

Fig 3 Relay Module

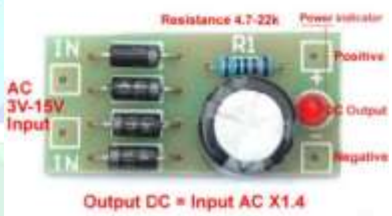


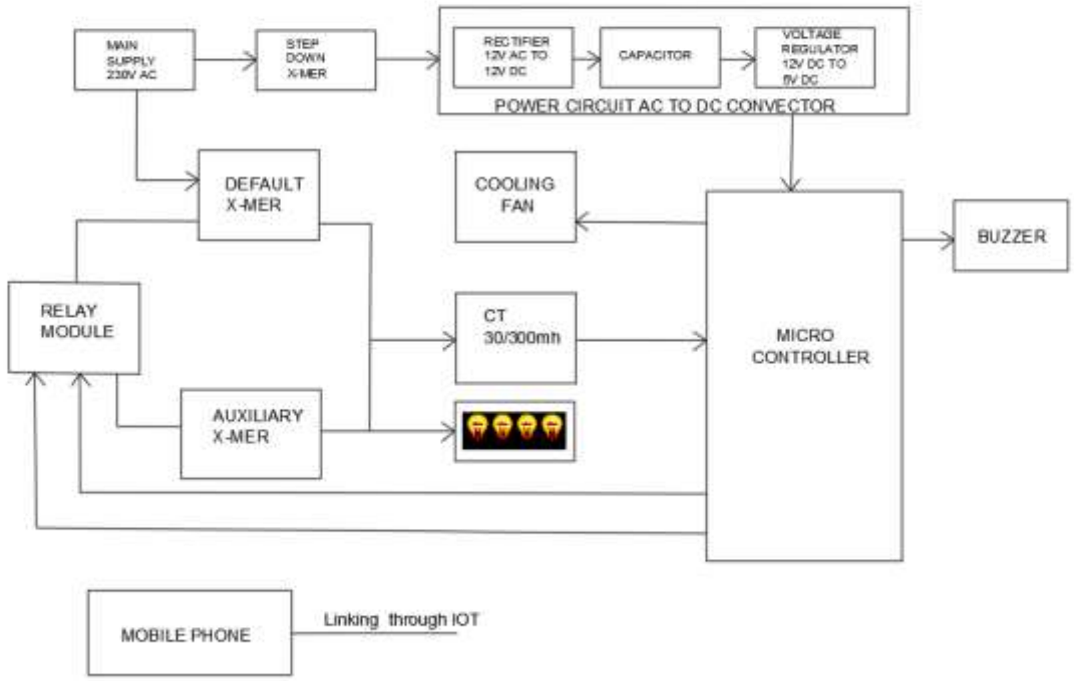
Fig 4 Rectifier

III.PROBLEM STATEMENT

In the current power distribution system, distribution transformers are frequently subjected to overloading conditions due to the continuous increase in power demand. Overloading leads to a reduction in transformer efficiency, overheating of windings, and eventually, transformer failure. The failure of a distribution transformer causes power outages, equipment damage, and increased maintenance and replacement costs. Moreover, manual monitoring and control of load distribution are time-consuming and inefficient.

Hence, there is a critical need for an automated system that can intelligently monitor transformer load conditions and dynamically balance the load among multiple transformers to prevent overloading and enhance system reliability

IV.BLOCK DIAGRAM



V.BLOCK DISCRIPTION

The purpose of the current module is to automatically share the load of a default transformer using an auxiliary transformer and a real-time monitoring system facilitated through IoT.

4.1 Hardware Components

The system module consists of the following hardware components:

- **Transformers:** Three in total — one Default Transformer and one Auxiliary Transformer (both 230V/110V), and one Step-down Transformer (230V/12V) for power supply.
- **Power Circuit:** Includes bridge rectifier (12V AC to 12V DC), capacitor, and voltage regulator (12V DC to 5V DC) to power the microcontroller and other electronic components.
- **Relay Module:** Two relays to switch the auxiliary transformer in parallel.
- **Current Sensing Unit:** Current transformer (30A/300mA) to measure load current.
- **Temperature Sensor:** DHT11 sensor to monitor transformer temperature and humidity.
- **Indication System:** LED indicators and buzzer for status alerts.
- **Cooling System:** Fan to prevent overheating of the default transformer.
- **IoT Components:** ESP8266 microcontroller with Wi-Fi capability and mobile app (Blynk) for real-time monitoring.
- **Load System:** Four 200W bulbs and four switches as load simulation.

4.2 Software Components

- **Arduino IDE:** Used to program the ESP8266 microcontroller with control logic.
- **Blynk Mobile App:** Provides a real-time IoT interface to monitor current, temperature, humidity, and load-sharing parameters.

4.3 System Configuration

For proper operation, all components must be installed in their designated positions. The system uses **parallel operation of transformers**:

1. **Primary Side:** The primary windings of the default and auxiliary transformers are connected in parallel, with a relay module in between to control the connection.
2. **Secondary Side:** The secondary windings are connected, and a current transformer is placed to measure the load.

The placement of the current transformer and relay module is critical to enable automatic load sharing. When the load on the default transformer exceeds a predefined value, the microcontroller sends signals to the relay module to switch the auxiliary transformer into operation, sharing the excess load.

The ESP8266 microcontroller operates on 5V DC, powered by the step-down and voltage-regulated circuit. It serves as the central control unit, receiving input signals from sensors and sending output commands to relays, cooling fans, and the IoT system.

4.4 Operational Workflow

1. On powering the system, the **default transformer** supplies the load.
2. As load is gradually increased (e.g., sequentially switching on bulbs), the **mobile app** indicates normal current, temperature, humidity, and load-sharing status.
3. When the **current exceeds a predefined threshold**, the current transformer detects overcurrent and the microcontroller activates the relay module to bring the **auxiliary transformer online**, thereby sharing the excess load.
4. Simultaneously, the **DHT11 sensor** monitors the temperature of the default transformer. If overheating occurs due to sustained high load, the sensor sends data to the microcontroller, which switches on the **cooling fan**, protecting the transformer from thermal damage.

The microcontroller is programmed via the **Arduino IDE**, a cross-platform software environment supporting C and C++ programming languages, to execute the control logic for automatic load sharing, temperature management, and real-time IoT monitoring.

VI.CONCLUSION

The **Automatic Load Sharing of Transformers using IoT** plays a vital role in ensuring balanced load distribution and enhancing the overall performance of power distribution systems. Performance analysis of such systems is essential to evaluate the **effectiveness, efficiency, and reliability** of the load-sharing mechanism.

By monitoring and assessing key parameters—such as load distribution accuracy, response time, voltage and frequency regulation, fault tolerance, and energy losses—engineers and operators can gain valuable insights into system performance. This analysis aids in identifying areas for improvement, optimizing system settings, and enhancing the operational efficiency of the power distribution network.

An efficient and reliable load-sharing system prevents both **overloading and underutilization of transformers**, thereby extending their lifespan and ensuring a consistent and reliable power supply. Additionally, it maintains stable voltage and frequency levels and allows the system to **adapt to faults or failures**, minimizing disruptions and supporting uninterrupted power distribution. Overall, the integration of IoT-based automatic load sharing contributes significantly to the **safety, reliability, and sustainability** of modern power distribution infrastructure.

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