Optimal Solutions for Smart Load Sharing of Transformers

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Abstract — A transformer is a device that changes electrical power from one level to another. This project aims to protect the transformer from damage due to overload by sharing the load with another transformer. When a transformer is overloaded, its efficiency decreases, and its windings can overheat and burn. To prevent this, another transformer is connected in parallel using a microcontroller. The microcontroller monitors the load on the first transformer. If the load goes beyond a set limit, the second transformer automatically takes the extra load. In this way, both transformers work efficiently, and damage is avoided.

Keywords: Transformer, Overload, GSM, Arduino

I. INTRODUCTION

The transformer is a key part of the electrical power transmission and distribution system. Common issues include overloading, voltage fluctuations, and overheating. Repairing a damaged transformer is expensive and time-consuming. This project focuses on protecting the transformer from overload. When a transformer is overloaded, its secondary winding overheats and may burn out. To prevent this, the extra load is transferred to another transformer connected in parallel with the main transformer. This helps in maintaining efficiency and preventing damage. One way to handle this is through a manual approach, where another transformer is connected by hand during heavy load conditions. However, this method is not efficient in practice. To improve efficiency, we use Arduino, an automation-based microcontroller, to switch the transformer automatically. When the first transformer experiences an overload, the Arduino activates the second transformer, ensuring smooth load distribution.

Additionally, when the load remains constant, both transformers operate alternately. This prevents excessive heating of a single transformer, ensuring better performance and longevity.

The project consists of three main parts:

- Sensing Unit – Detects the load current.
- Control Unit – Manages the load-sharing process.
- Microcontroller Unit – Reads signals, performs calculations, and controls a relay. A GSM modem is also used to send information to the control station about switching operations.

When designing power systems for large loads, using multiple smaller transformers instead of a single large one is often better. This method improves efficiency, allows flexible power management, and provides backup in case of failure.

A. Automatic Transformer Load Sharing Using Arduino

A transformer plays a crucial role in power transmission, but overloading can cause efficiency loss and overheating, leading to damage. To prevent this, an Arduino-based automatic load-sharing system is implemented.

The Arduino continuously monitors the load on the first transformer and compares it with a set reference value. If the load exceeds this threshold, the second transformer is automatically connected in parallel to share the extra load. This ensures that multiple transformers operate efficiently under overload conditions, preventing damage.

In this system, the second transformer activates not only during overload but also under high temperature conditions. A sensor circuit, including a current sensor, current transformer, and Arduino, collects real-time data from the main transformer. If an overload is detected, the second transformer is immediately switched on to balance the load. Additionally, the Arduino monitors both load current and transformer temperature, displaying real-time values on an LCD screen. This allows for continuous performance tracking and ensures transformers operate efficiently without overheating. By automating transformer switching, this system eliminates the inefficiency of manual operation, ensures a stable power supply, and extends transformer life. Furthermore, alternating transformer operation under normal load conditions prevents excessive heating of a single unit, further improving reliability. This smart, cost-effective, and efficient approach enhances power distribution system stability, reducing maintenance costs and minimizing the risk of transformer failure. When additional loads are connected to the secondary side of a transformer, the secondary current increases. If the load current exceeds the transformer's rated capacity, the temperature of the secondary winding rises. To prevent damage, the Arduino detects this rise and sends a trip signal to the relay, which then activates the second transformer to share the load. Initially, when the system is powered on, the first transformer handles the entire load. However, if the load exceeds its rated capacity, the standby (second) transformer automatically switches on to balance the load. This setup ensures better maintenance and longer lifespan for both transformers by preventing continuous stress on a single unit. The automatic switching mechanism improves efficiency, protects the system from overload, and ensures reliable power distribution.

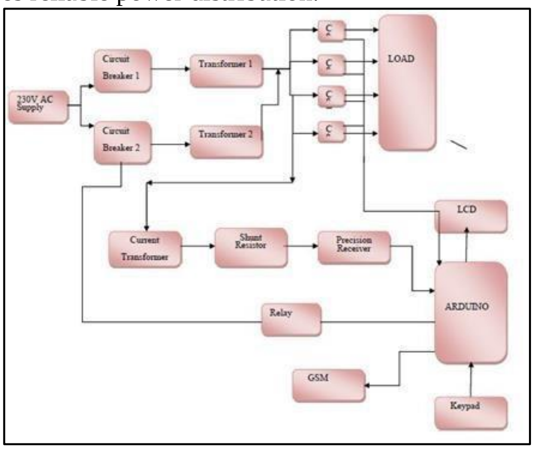


Fig. 1: Block diagram

II. PROPOSED ARDUINO BASED MODEL:

The main component is an Arduino board is a microcontroller-based platform that uses various microprocessors and controllers. It has digital and analog input/output (I/O) pins, which can be connected to expansion boards (shields), breadboards for prototyping, and other circuits. Arduino boards also support serial communication interfaces, including USB on some models, which allows programs to be uploaded from a computer.

In the proposed system, one transformer initially operates to supply power to the loads, while a standby transformer remains connected in parallel through a circuit breaker and relay. A current transformer continuously measures the load current and sends the data to the Arduino. The maximum load limit and priority levels of the loads are set by the user or the concerned authority. During peak hours, when the load demand exceeds the reference limit, a single transformer may not be sufficient. At this point, the Arduino activates the relay, switching on the standby transformer to share the load equally with the main transformer. Since both transformers have the same ratings, they distribute the load efficiently, ensuring an uninterrupted power supply. If the load further increases beyond the combined capacity of both transformers, the system implements priority-based load shedding. Low priority loads are disconnected by opening the respective circuit breakers, ensuring that critical loads remain powered. When the load decreases to normal levels, the first transformer is switched off to prevent thermal overloading. Since the first transformer operates for a longer duration, its temperature rises. By alternating the operation of the transformers, natural cooling is allowed, improving efficiency and longevity of the system.

To share the total load between two transformers connected in parallel, the following information is required: i) The power rating of transformer T1 (MVA1) and its percentage impedance (%Z1); ii) The power rating of transformer T2 (MVA2) and its percentage impedance (%Z2); iii) The total demand power (MVA); and iv) With these parameters, the load can be appropriately distributed between the two transformers. Load sharing by T1 is:

$$T1 = \frac{\frac{MVA1}{Z1}}{\frac{MVA1}{Z1}+\frac{MVA2}{Z2}} \times MVA \qquad (1)$$

Load sharing by T2 is:

$$T2 = \frac{\frac{MVA2}{Z2}}{\frac{MVA1}{Z1}+\frac{MVA2}{Z2}} \times MVA \qquad (2)$$

These equations will allow you to calculate the distribution of power between the transformers based on their ratings and impedances. Noting that one of the transformers is already existing in the system with a rating of T1, the load shared by the second transformer (T2) can be determined as the following:

- The total load demand (MVA) minus the power rating of the existing transformer (MVA1) gives the load that needs to be handled by the second transformer (MVA2).
- Mathematically: MVA2 = total load demand (MVA) − MVA1
- Where: MVA1 is the power rating of the existing transformer (10 MVA). MVA2 is the power rating required for the second transformer.

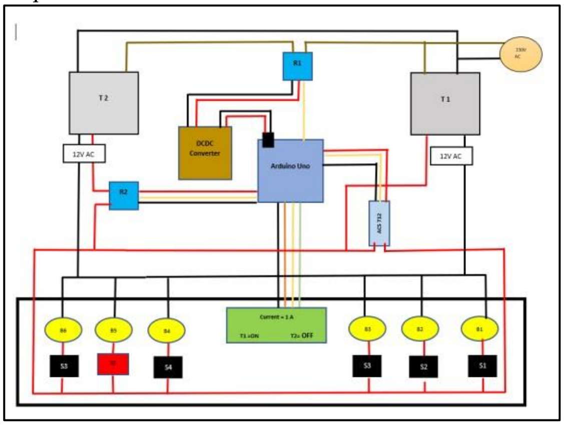
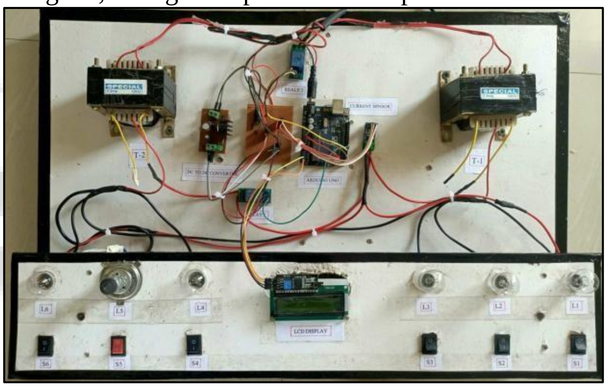


Fig. 2: Circuit Diagram

III. RESULTS AND DISCUSSION:

The main contribution of Load sharing transformers significantly improves the economic recovery, reliability, energy balance, no load shifting process, decentralised energy balance, reduce the peak flow rate, flexibility requirements in smart grids, voltage compliance rate improvement etc.



IV. CONCLUSION

This Paper has significant potential for application in substations, especially during peak hours, when an additional transformer is required to meet increased load demand. The system automatically connects the standby transformer when the load reaches a critical level, ensuring efficient power distribution. During off-peak hours, when the load is lower, both transformers do not need to operate simultaneously. This intelligent load-sharing mechanism optimizes power usage by running transformers in parallel only when necessary, improving overall efficiency and reliability.

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