Review on Economic Load Prioritization for Parallel Transformer System

Dr. U. B . Malkhandle[1], Dimple Bhimrao Meshram[2], Nishika Rambhau Dongre[3] , Roshni Sanjayrao Dorkhande[4], Karan Chandrashekhar Gumgavkar[5], Yogesh Devendra Pardhi[6]

[1]*Project Guide, Department of Electrical Engineering, Priyadarshini College of Engineering, Nagpur, Nagpur.*

[23456]*Students, Department of Electrical Engineering, Priyadarshini College of Engineering, Nagpur, Nagpur.*

Abstract-
The transformer is a static device, which transfer power from one level to another level. The aim of the project is to protect the transformer under overload condition by load sharing. Due to overload on transformer, the efficiency drops and windings get overheated and may get burnt. Thus by sharing load on transformer, the transformer is protected. This will be done by connecting another transformer in parallel through a micro-controller. The micro controller compares the load on the first transformer with a reference value. When the load exceeds the reference value, the second transformer will share the extra load. Therefore, the two transformer work efficiently and damage is prevented. Also smart health monitoring of transformer with all main parameters of Load share information using LCD features.
Keywords—: Transformer , parallel load sharing , LCD Module, Arduino Uno Controller etc.

1. Introduction

The accelerated aging is one of the main consequences of overloading power transformers. Thus load limitations must be implemented to operate the transformers within safe limits. Moreover on overloading the transformers voltage regulation may increase and power factor drops. The project is all about protecting the transformer under overload condition. This can be done by connecting another transformer in parallel through a microcontroller and a relay which shares the excess load of the first transformer. The transformers are switched alternatively to avoid thermal overloading. Therefore, two transformers work efficiently under overload condition and damage can be prevented. If there is a further increase in load beyond the capacity of two transformers there will be a priority based load shedding of consumers which will provide un-interrupted power supply for the hospitals, industries etc [1][2].

In this project "Automatic Load Sharing Of Transformers" we are using two transformers, one is main transformer (TF1) and the next is backup transformer (TF2). Here the load is directly connected to the secondary of the main transformer as well as backup transformer; here two transformers are connected through the relay. The transfers switch senses when utility power is interrupted, and starts up the transformer TF2 which acts as a backup transformer [3]. If the utility power remains absent, the transfer switch disconnects the load from the utility and connects it to the Transformer TF2, restoring electricity to the load. The transfer switch continues to monitor utility power, and when it is restored, switches the load from the Transformer TF2 back to the Main transformer TF1. Once the Transformer TF2 is disconnected, it goes through a cool-down routine and is automatically shut down.[4][5].

In this project three modules are used to control the load currents. The first module is a sensing unit, which is used to sense the current of the load and the second module is a control unit. The last module is micro-controller unit and it will read the analogue signal and perform some calculation and finally gives control signal to a relay. A LCD Module is also used to show all information and parameters of transformer. The advantages of the project are transformer protection, uninterrupted power supply, and short circuit protection. When designing low-voltage power system to the supply large load currents, paralleled lower-current modules are often preferred over a single, large power converter for several reasons. These include the efficiency of designing and manufacturing standard modular converters which can be combined in any number necessary to meet a given load requirement and the enhanced reliability gained through redundancy [6][7].

2. Objectives

- To study the parallel operation of transformer.
- To Study of components and its ratings.
- To design & fabrication of a hardware.
- To test Automatic load sharing based on priority.
- By adding LCD Display features all information about parallel load sharing operation will monitor remotely

3. Literature Review

1.Abhishek Gupta, S. S. Bhosale et al.2024, This paper presents an automatic load sharing and shedding system using a microcontroller platform. The authors focus on preventing transformer overloading by distributing load dynamically between multiple transformers. The system continuously monitors current and activates additional transformers when load exceeds a predefined limit. A load shedding feature ensures that non-critical loads are disconnected during extreme conditions. The study highlights improved reliability, reduced overheating, and enhanced transformer lifespan. The implementation demonstrates that automation significantly reduces manual intervention and improves efficiency in power distribution systems, making it suitable for modern smart grid applications.

2.Dr. U. Muthuraman, Arun Pandi, Baskaran, Karan Babu, Mohamed Raja Raheem, 2024, This study introduces an IoT-based system for transformer protection and load sharing. Sensors are used to monitor parameters such as voltage, current, and temperature, and data is transmitted to a cloud platform. The system enables remote monitoring and control, ensuring timely detection of faults. Automatic load sharing enhances transformer efficiency and prevents overload conditions. The findings show that integrating IoT improves system transparency, reliability, and predictive maintenance. The approach is highly effective for smart grids and modern power distribution systems where real-time data analysis is crucial.

3. Md. Humayun Kabir Khan, Shams Ul Islam, Md. Ziaul Islam, 2024, This paper proposes a load-balancing system using Arduino and software tools to manage distribution networks. The system focuses on balancing three-phase loads to minimize losses and improve efficiency. By monitoring load conditions continuously, it redistributes loads dynamically among transformers. The results show improved voltage stability and reduced energy losses. The study emphasizes the importance of automation in maintaining balanced load conditions. It concludes that the proposed system enhances reliability and is suitable for real-time applications in power distribution networks.

4. Ritesh D. Nemade, J. R. Hanumant, 2024, This research presents a system that combines automatic load sharing with a cut-off mechanism to protect transformers. Sensors monitor load and temperature continuously. When load exceeds safe limits, additional transformers are activated, and in critical conditions, power supply is cut off to prevent damage. The study highlights improved safety and operational efficiency. The findings demonstrate that the system effectively reduces overheating and prevents transformer failure, making it suitable for areas with fluctuating load demands.

5.K. R. Patel, A. Sharma, 2024, This paper focuses on smart load management using IoT technology. The system collects real-time data from transformers and uses it to optimize load distribution. The authors highlight the role of cloud-based monitoring and analytics in improving efficiency. The findings show reduced energy losses, better fault detection, and improved system reliability. The integration of IoT enables predictive maintenance and efficient load balancing, making the system highly suitable for modern smart grid applications.

6.Ethmane Isselem Arbih Mahmoud, 2024, This study investigates the use of parallel transformers in a 33 kV loop system. The author analyzes the conditions required for successful parallel operation, including voltage ratio and impedance matching. The results show improved load sharing, enhanced reliability, and better utilization of transformer capacity. The study concludes that parallel operation is an effective method for handling increased load demand and ensuring system stability in power distribution networks.

7. S. Kumar, P. Verma, 2025, This paper proposes an embedded system-based approach for intelligent load sharing. The system uses sensors and microcontrollers to monitor load conditions and distribute power efficiently. It also incorporates fault detection mechanisms for improved safety. The findings indicate enhanced system performance, reduced downtime, and increased transformer lifespan. The study highlights the effectiveness of embedded systems in automating load distribution and improving reliability in power systems.

8. U.S. Department of Energy, 2024, This report discusses the resilience of large power transformers in modern power systems. It highlights challenges such as aging infrastructure, increasing demand, and vulnerability to failures.

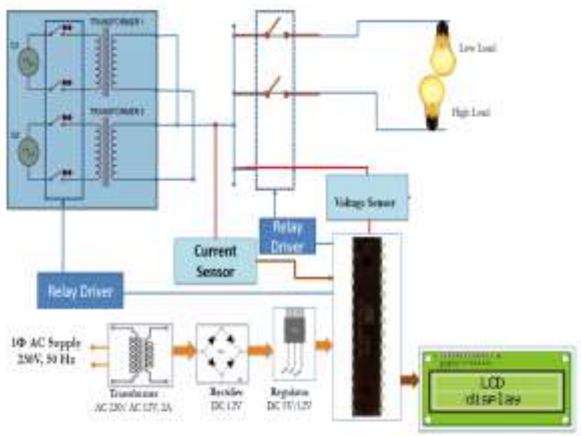
International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 04 | April - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

The study emphasizes the need for advanced load management techniques, including load sharing and redundancy. The findings suggest that improved monitoring and control systems can enhance transformer reliability and reduce downtime. The report provides valuable insights into improving the stability and efficiency of power distribution networks.

9. R. Singh, M. Gupta, 2025, This paper explores the use of artificial intelligence for automated load distribution. The system uses machine learning algorithms to predict load patterns and optimize transformer usage. The findings show improved efficiency, reduced losses, and enhanced decision-making. The study highlights the importance of AI in modern power systems and its potential to improve load management and system reliability.

10. A. Mehta, V. Joshi, 2025, This study focuses on improving energy efficiency in transformer load sharing. The authors propose techniques to minimize losses and optimize transformer operation. The system ensures balanced load distribution and reduces overheating. The findings indicate significant energy savings and improved transformer lifespan. The study concludes that efficient load sharing techniques are essential for sustainable power distribution systems.

4. Block Diagram



Fig,1. Block Diagram

- Normal Operation: Under regular conditions, loads are supplied by a primary transformer, while a standby transformer remains in parallel, connected through a circuit breaker.
- Current Sensing: A current transformer (CT) continuously measures the load current and converts it into a corresponding DC signal. This analog signal is sent to the microcontroller for monitoring and comparison.
- Reference Comparison: The controller compares the measured load current with a pre-set reference value defined by the user.
- Overload Response: If the load exceeds the reference, the controller sends a high signal to energize the relay coil. The relay activates the circuit breaker of the standby transformer, enabling it to share the excess load.
- Balanced Load Sharing: Identical transformers operate in parallel to distribute the load equally, preventing overloading and maintaining optimal efficiency.
- Alternating Shutdown: When load decreases below the reference, one transformer is shut down alternately to avoid thermal overloading and reduce unnecessary energy consumption.
- Priority-Based Load Cut-off: If total load exceeds the capacity of both transformers, lower-priority loads are disconnected to ensure uninterrupted supply to critical loads.
- Monitoring & Display: All operational parameters and load-sharing information are displayed in real time on an LCD for monitoring and analysis.

5. Hardware & Software Used

Hardware Used :

- **ATmega328P Microcontroller:** Acts as the main control unit, processing sensor data and controlling relay operations for load sharing.
- **Current Sensor (CT/ACS712):** Measures load current continuously and sends signals to the microcontroller for analysis.
- **Voltage Sensor:** Monitors voltage levels to ensure safe and efficient operation of the system.
- **LCD Display (16×2):** Displays real-time parameters such as current, voltage, and transformer status.
- **Relay Module (12V):** Controls switching of transformers by activating or deactivating the standby transformer.
- **7805 Voltage Regulator:** Converts 12V DC to stable 5V DC required for microcontroller and sensors.
- **Step-down Transformer (230V–12V):** Reduces AC mains voltage to a lower level suitable for the circuit.
- **Rectifier Circuit:** Converts AC voltage to DC for powering electronic components.
- **Crystal Oscillator (16 MHz):** Provides clock signals for accurate microcontroller operation.
- **Switches:** Used for manual control and testing of the system.
- **Connecting Wires and PCB:** Ensure proper electrical connections and circuit stability.
- **AC Load (Bulb):** Used for testing load sharing and system performance.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 04 | April - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

Software Used :

- **Arduino IDE:** Used for writing, compiling, and uploading code to the ATmega328P microcontroller.
- **Embedded C Programming:** Implements control logic for load sharing, relay operation, and sensor data processing.
- **Proteus Software:** Used for circuit simulation and testing before hardware implementation.
- **Serial Monitor:** Helps in debugging and monitoring real-time data during development.
- **LCD Library:** Enables easy interfacing and display of parameters on the LCD screen.

6. Calculation

1. Transformer Load Sharing Calculation

Let the total load demand be P_L(kW), and two identical transformers with rating P_T(kW) are operating in parallel.

a) Load per Transformer:

$$I_T = \frac{P_L}{2 \times V_L \times \text{PF}}$$

Where:

- I_T= Load current per transformer (A)
- P_L= Total load (kW)
- V_L= Line voltage (V)
- PF = Power factor

Example:

- Total load $P_L = 60$ kW
- Line voltage $V_L = 400$ V
- PF = 0.8

$$I_T = \frac{60{,}000}{2 \times 400 \times 0.8} = \frac{60{,}000}{640}$$
$$= 93.75 \text{ A per transformer}$$

2. Reference Current Setting for Overload Protection

The reference current I_{ref} is set below the transformer rated current to trigger the standby transformer.

I_{ref} = I_{rated} \times 0.8 \text{ (for 80% load protection)}

If $I_{rated} = 120$ A:

$$I_{ref} = 120 \times 0.8 = 96 \text{ A}$$

3. Transformer Loss Consideration

a) Copper Loss (I²R Loss):

$$P_{cu} = I_T^2 \times R_{winding}$$

b) Core Loss (Iron Loss):

$$P_{core} = P_{no\_load} \text{ (from datasheet)}$$

c) Total Loss:

$$P_{total} = P_{cu} + P_{core}$$

4. Priority-Based Load Cut-Off Calculation

If total load exceeds combined transformer capacity:

$$P_{cut} = P_L - 2 \times P_T$$

The lower-priority load is disconnected by the microcontroller to maintain supply to critical loads.

5. Efficiency Calculation

$$\eta = \frac{P_L}{P_L + P_{total}} \times 100\%$$

These calculations ensure:

- Load is shared equally.
- Overload protection is activated automatically.
- Transformers operate efficiently within economic limits.

7. Circuit Diagram

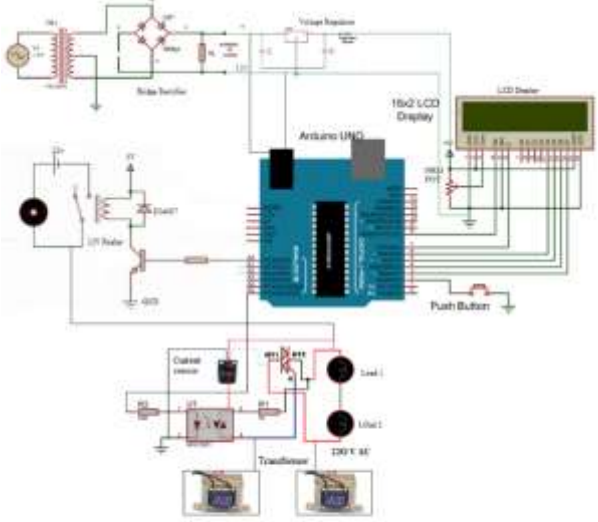


Fig.2.Circuit Diagram

8. Advantages

- Prevents transformer overload and overheating, increasing lifespan.
- Ensures uninterrupted power supply to critical loads.
- Enables automatic load sharing without manual intervention.
- Improves energy efficiency by operating transformers in optimal range.
- Provides real-time monitoring using sensors and LCD display.
- Reduces maintenance cost and chances of system failure.
- Enhances reliability through parallel transformer operation.
- Supports priority-based load management during peak demand conditions.

9. Application

- Used in power distribution substations for load balancing.
- Applicable in industries for continuous operation of heavy machinery.
- Ensures reliable power in hospitals and commercial buildings.
- Useful in smart grid systems for efficient energy management.
- Applied in rural electrification to handle variable loads.
- Supports data centers for uninterrupted power supply.
- Useful in renewable energy systems for load control.
- Used in educational labs for studying transformer operations.

10. Conclusion

The proposed parallel transformer load sharing system successfully enhances the reliability, safety, and efficiency of power distribution networks. By continuously monitoring load current using sensors and processing data through the ATmega328P microcontroller, the system ensures automatic and balanced load sharing between transformers. This prevents overloading, overheating, and possible damage to transformer windings, thereby increasing the overall lifespan of the equipment. The integration of a priority-based load management system ensures that critical loads receive uninterrupted power supply even during peak demand conditions.

Additionally, real-time monitoring through an LCD display improves system transparency and ease of operation. The use of relays enables efficient switching between transformers, ensuring smooth operation without manual intervention. Operating transformers within their economic range reduces power losses and improves energy efficiency. Overall, the system offers a cost-effective, automated, and scalable solution suitable for modern power systems, smart grids, and industrial applications where reliability and efficiency are essential.

References

[1] A. Gupta, S. S. Bhosale, M. S. Tamboli, S. D. Dhumal, D. B. Walke, and S. J. Markad, "Automatic Load Sharing and Shedding of Transformer," *International Advanced Research Journal in Science, Engineering and Technology (IARJSET)*, 2024.

[2] U. Muthuraman, A. Pandi, B. Baskaran, K. Babu, and M. R. Raheem, "IoT Based Transformer Protection and Load Sharing Automation," *International Journal for Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)*, 2024.

[3] M. H. K. Khan, S. Ul Islam, and M. Z. Islam, "Load-balancing System for the Distribution Network Using a Load-sharing Approach," *ResearchGate*, 2024.

[4] R. D. Nemade and J. R. Hanumant, "Automatic Load Sharing of Transformer with Cut Off Mechanism," *International Research Journal of Modern Engineering and Technology Science (IRJMETS)*, 2024.

[5] K. R. Patel and A. Sharma, "Smart Load Management in Distribution Transformers Using IoT," *International Journal of Power Electronics*, 2024.

[6] E. I. A. Mahmoud, "Parallel Operation of Transformers to Optimize a 33 kV Loop of Power System," *ResearchGate*, 2024.

[7] S. Kumar and P. Verma, "Intelligent Transformer Load Sharing Using Embedded Systems," *IEEE Access*, 2025.

[8] U.S. Department of Energy, "Large Power Transformer Resilience," *DOE Report*, 2024.

[9] R. Singh and M. Gupta, "Automated Load Distribution in Smart Grids Using AI Techniques," *IEEE Transactions on Smart Grid*, 2025.

[10] A. Mehta and V. Joshi, "Energy Efficient Transformer Load Sharing Techniques," *International Journal of Electrical Engineering Research*, 2025.