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Automatic Load Sharing of Transformer: A Comprehensive Review

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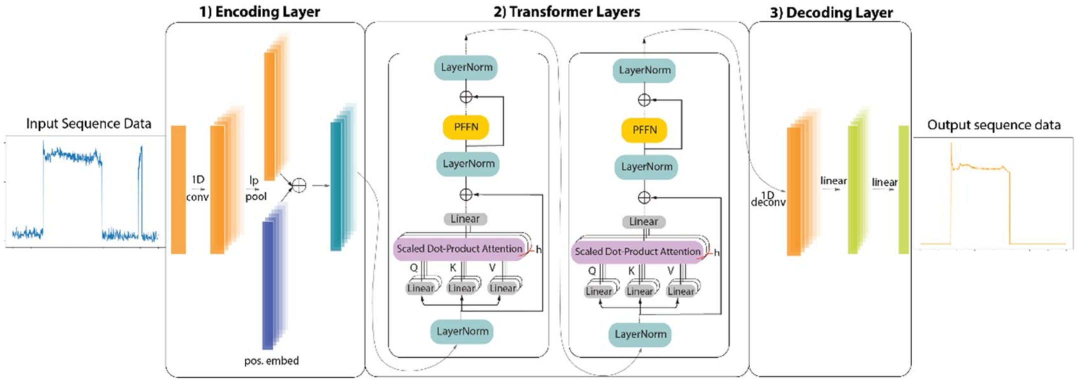
Abstract: The demand for efficient and reliable electrical power distribution systems has grown significantly with the increasing complexity of modern electrical grids. Transformers play a crucial role in these systems, serving as key components in the transmission and distribution of electrical energy. To enhance the performance and reliability of transformer hardware, automatic load sharing mechanisms have become essential. This review paper aims to provide an in-depth analysis of the various automatic load sharing methods employed in transformer hardware to optimize energy distribution, improve system reliability, and ensure efficient load management.

I. INTRODUCTION

Transformers is one of the most significant equipment in the electrical power system, hence transformer required protection. Apart from this the demand for electricity is increasing due to the increasing population and their unavoidable demands, with this increased power requirement, the existing systems have become overloaded. The overloading appears at the consumer end of the transformer terminals, which can affect its efficiency and protection systems. Due to overload on the transformer the efficiency drops and the windings gets over heated and may get burnt. It takes a lot of time to repair and lot of expenditure. Transformers are occasionally loaded beyond nameplate ratings because of existing possible contingencies on the transmission lines, any failure or fault in power systems, or economic considerations. One of the reported damage or tripping of the distribution transformer is due to thermal overload. To eliminate the damaging of transformers due to overloading from consumer end, it involves the control against over current tripping of distribution transformer. Rise in operating temperature of the transformer. The project is all about protecting the transformer under overload condition. 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. Transformers play a pivotal role in electrical distribution systems, facilitating power transmission over long distances and stepping down voltage for safe consumption. As the demand for electrical energy grows in today's technological landscape, transformers become even more essential, grappling with challenges like varying loads and disruptions. The uneven distribution of loads on transformers within modern grids poses a significant challenge. Manual load-sharing methods are inadequate for the complexities of today's grids, leading to inefficiency and equipment risks. Automatic load sharing of transformer hardware emerges as a solution, utilizing advanced technologies like microcontrollers and adaptive algorithms to optimize energy distribution, enhance reliability, and extend infrastructure lifespan. This comprehensive review delves into automatic load sharing of transformer hardware, exploring transformer types, load-sharing principles, historical limitations, and recent advances. The paper addresses challenges, cybersecurity considerations, and real-world case studies, aiming to be a valuable resource for researchers and decision-makers in the field. The significance of transformers in electrical distribution is undeniable, and the need for automatic load sharing is more critical than ever. This review provides insights into the past, present, and future of this technology, offering guidance for ensuring the reliability and efficiency of electrical power distribution systems.

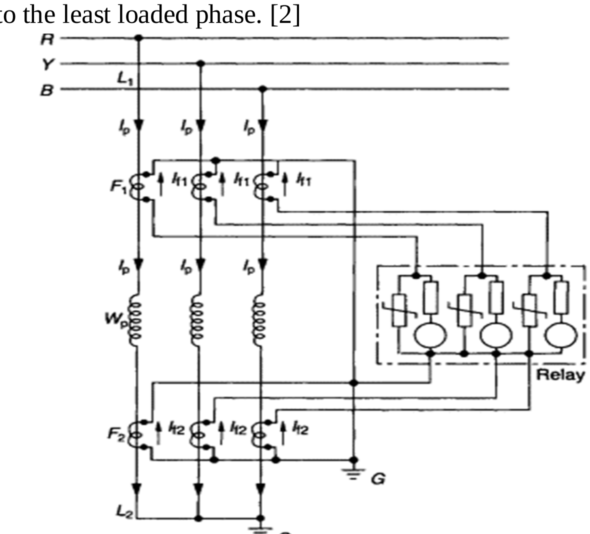
II. LITERATURE SURVEY

Develop an efficient and accurate approach for NILM, which involves inferring appliance consumption patterns solely from aggregated household signals. The project introduces Electricity, a transformer-based architecture for NILM, offering superior performance, efficiency, and reduced training time compared to existing methods. The outcomes suggest that Electricity is a promising approach for accurate and efficient Non-Intrusive Load Monitoring in household energy consumption scenarios. Discuss about methodology of Utilizes sequence-to-sequence deep learning models based on transformer layers. Transformer architecture relies on attention mechanisms to extract global dependencies between aggregated and appliance signals. model Electricity to reflect its focus on electricity consumption patterns. [1]

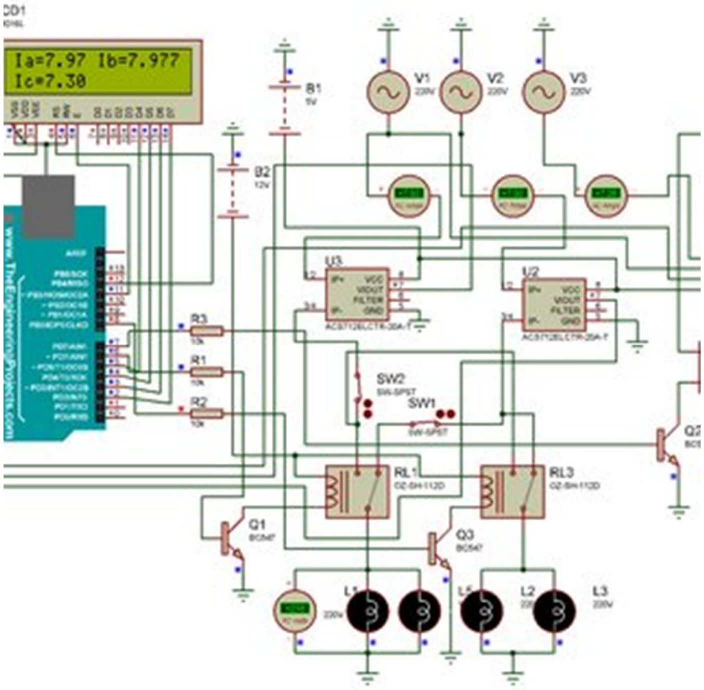


Training is split into an unsupervised pre-training mechanism and a supervised process. During pre-training, the aggregate signal is masked at random positions with fake samples and the generator tries to reconstruct the original signal. The discriminator has to distinguish which positions of the generator output were fake (replaced) and which correspond to the original signal. During training, the generator is discarded and the discriminator is fine-tuned to predict the individual appliance consumption from the aggregate signal.

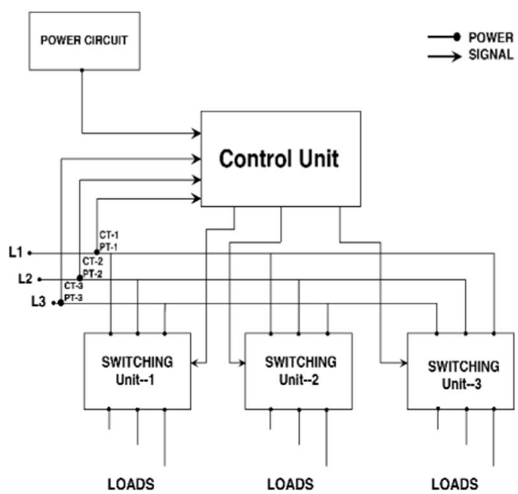
The proposed intelligent system effectively addresses the issue of load imbalance in a 3-phase 4-wire distribution system by employing an AI-based micro-controller and IoT-based data communication. The system ensures equitable load sharing among the phases, enhancing the overall performance and efficiency of the distribution network. The real-time monitoring capabilities contribute to the adaptability and responsiveness of the system to dynamic load changes. Problem is Imbalance in a 3-phase 4-wire distribution system due to disproportionate distribution of single-phase loads among the three phases. Now, we are over come to a system to sense the loading in each phase and distribute the load proportionately among the three phases. The proposed system automatically connects any new load to the least loaded phase. [2]



The development of an automated load management system at the domestic level to address issues related to load unbalancing and excessive energy consumption. The system incorporates current and potential sensing transformers, an Arduino Mega board, and utilizes the Internet of Things (IoT) for remote monitoring. To domestic load management by utilizing sensing transformers, an Arduino Mega board, and IoT technology. The integration of real-time monitoring and load shifting capabilities empowers users to make informed decisions and optimize their energy consumption. Both simulation and hardware results validate the effectiveness of the proposed system in achieving its objectives.



The control unit consists of Arduino mega 2560 microcontroller that analyzes the load and power on each incoming line. Moreover, the controller also measures the current consumption of the load with the help of CTs and PTs. The Arduino tries to balance the load on each line by sending switching signals to the relay unit, which will shift the load on different lines. According to the algorithm, the load on each line will be calculated separately and if the load increases than the threshold value then the controller finds the less loaded line. On finding the less loaded line, the controller shifts the high power consuming electrical appliances to that line. It is pertinent to state here that all the lines are not perfectly balanced.



The implementation of a microcontroller fault detection and monitoring system for power transformers. The system utilizes various sensors and devices, such as Arduino microcontrollers, voltage transformers and current transformers to enhance the reliability and safety of power transformers. The microconroller-based fault detection and monitoring system described in the passage contributes to the efficient and safe operation of power transformers. It combines fault detection, real-time parameter monitoring, and control capabilities to address issues promptly and enhance the overall reliability of the power distribution network. The utilization of microcontroller allows for remote monitoring, enabling timely decision-making and maintenance interventions.

III. PROPOSED SYSTEM DEVELOPMENT

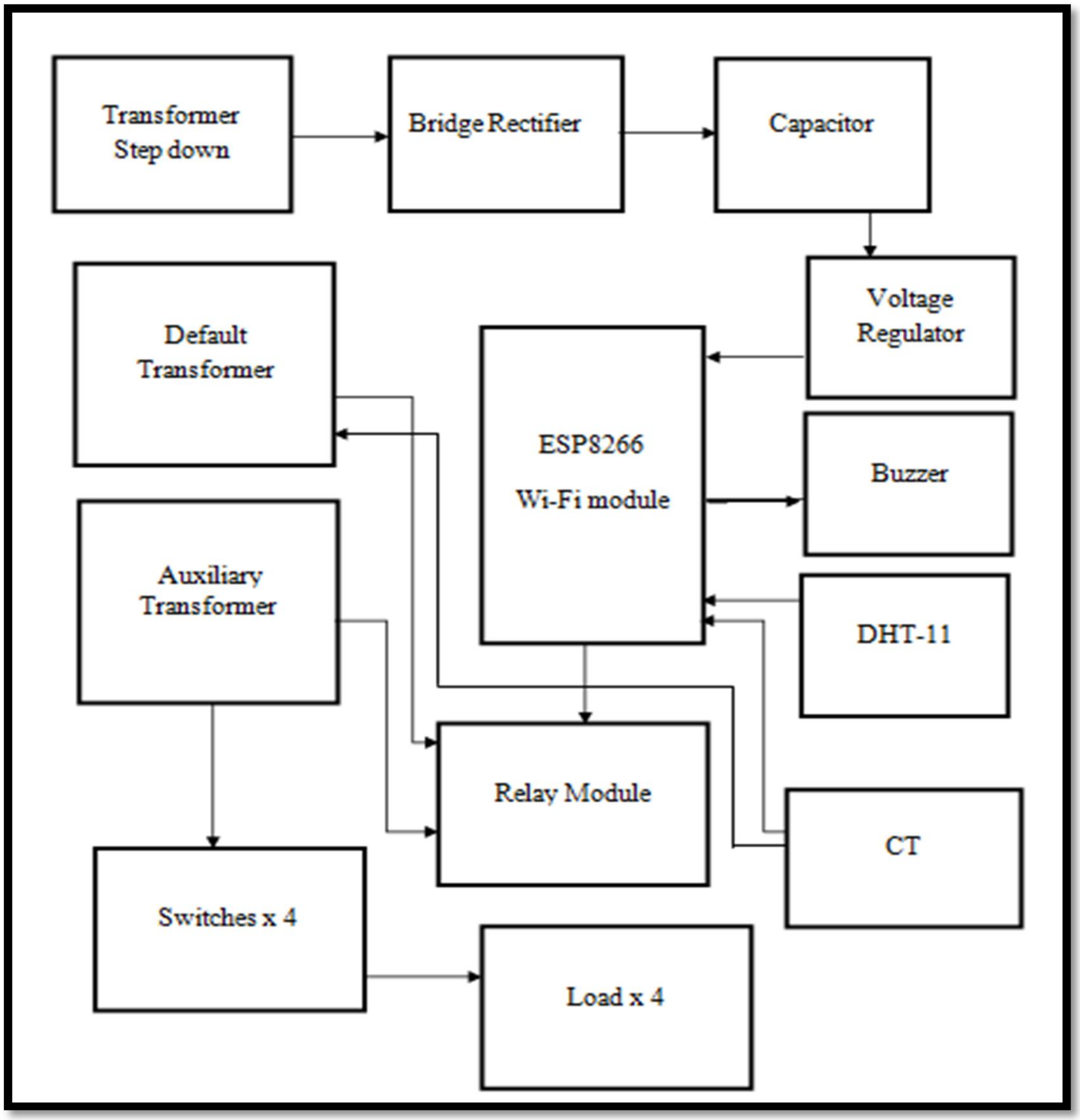


Figure 1 Block Diagram

A. *Types Of Transformers*

1) *Distribution Transformers*

Distribution transformers are commonly found at the tail-end of the electrical grid, where they reduce the voltage for safe use in homes and commercial buildings. These transformers typically have lower power ratings and are often located near consumers, ensuring a consistent and reliable power supply. Commonly used in residential, commercial, and industrial areas. Multiple distribution transformers can be connected in parallel to share the load. Adjust the turns ratio to maintain a constant output voltage.

2) *Power Transformers*

Power transformers are situated at the heart of the electrical grid, serving as crucial elements in high-voltage transmission networks. These transformers handle substantial power capacities and are responsible for stepping up or stepping down voltage levels to facilitate long-distance power transmission. Higher voltage ratings compared to distribution transformers. Connect different parts of the power grid, such as generators, transmission lines, and distribution networks. Used for transmitting electrical power over long distances. Connect multiple power transformers in parallel to share the load. Adjust the tap settings to control the output voltage. adjust taps even during operation to accommodate load changes.

3) Special Purpose Transformers

Special purpose transformers serve specific functions in the electrical system. They can include instrument transformers, rectifier transformers, furnace transformers, and others. These transformers cater to niche requirements, and their load-sharing techniques vary based on the particular application. For instance, rectifier transformers used in industrial settings may utilize complex control algorithms to manage load sharing in response to changing manufacturing processes. Some special purpose transformers are designed to synchronize their operation with process variables, ensuring that the load-sharing mechanism aligns with specific industrial requirements.

B. Comparison Table

In this table, we explore various approaches and technologies applied to the domain of electrical systems and load management. The following table presents a comparative analysis of different studies.

Literature Survey Topic	Methodology	Key Technologies	Conclusion
Electricity: Efficient Transformer for NILM	Non-Intrusive Load Monitoring (NILM)	Machine Learning, Signal Processing	Efficient NILM system using machine learning for load monitoring. High accuracy in identifying individual appliance consumption. Enables energy disaggregation without the need for intrusive sensors.
Smart Load Balancing in 3-phase 4-wire System	Dynamic Load Balancing	3-phase 4-wire distribution system	Effective load balancing in 3-phase 4-wire systems for optimal energy distribution. Minimizes phase imbalances and reduces losses. Utilizes real-time monitoring and control to enhance the efficiency of the distribution network.
Dynamic Load Sharing at Domestic Level using IoT	Dynamic Load Management.	Smart Appliances, Sensors.	Optimal load distribution in a household using controller. Utilizes real-time data from sensors and smart appliances for dynamic load management. Improves energy efficiency, reduces costs, and provides user-friendly interfaces.
Load Sharing of Transformers by Arduino with GSM	Load Sharing Control, Arduino, GSM	Transformers, Relays, Current Transformers (CTs)	Automation of load sharing among transformers using Arduino and GSM modules. Provides a cost-effective solution for preventing overloads and optimizing transformer utilization in power distribution systems.
IoT-based Distribution Transformer Monitoring System	Distribution Transformer Monitoring, IoT	IoT Devices, Cloud Computing, Communication Protocols	Real-time monitoring and protection of distribution transformers using IoT. Enhances transformer operational status monitoring, reduces downtime, and improves the overall reliability and efficiency of power distribution networks.

IV. CONCLUSION

In today's advanced power systems, having a dependable and effective way to distribute electrical energy is more important than ever. As our electrical grids become more complex, it's crucial to make sure that energy is distributed efficiently and reliably. Automatic load sharing is really important because it helps us manage energy effectively. By sharing the load among different transformers, we can make sure that the energy is distributed optimally, making the system more reliable and efficient. Researchers are exploring new and smart ways to improve our electrical systems. Integrating IoT technology, which connects devices and systems over the internet, is making our power transformers safer and more efficient. This helps in detecting faults early and ensures that our power systems work smoothly.

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