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Review TEE

Residential Sanctioned Load Monitoring and Controlling Using PLC and SCADA

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Abstract

Efficient load monitoring and control are crucial for managing energy resources in various industrial and commercial applications. Sanctioned load, which refers to the maximum permissible electrical load imposed by authorities or utilities, needs to be closely monitored and controlled to ensure compliance and optimize energy usage. Programmable Logic Controllers (PLC) and Supervisory Control and Data Acquisition (SCADA) systems offer reliable and efficient solutions for monitoring and control in industrial and utility applications. This study examines the integration of PLC and SCADA to regulate sanctioned electrical loads, ensuring optimal energy management. PLCs provide precise, automated control at the equipment level, while SCADA systems enable centralized supervision, real-time data acquisition, and visualization. Together, they facilitate continuous monitoring, rapid decision-making, and prompt corrective actions to prevent overloading and inefficiencies. By enabling automated responses based on live data, the integrated system enhances operational reliability, reduces manual intervention, and ensures compliance with load limits, ultimately contributing to improved energy efficiency and cost savings. The study covers the technical aspects of these systems, their interaction, and the benefits they provide in load control. Results suggest that the integration of these systems enhances energy efficiency, reduces penalties, and improves operational reliability in electrical systems.

Keywords: PLC, logic controllers, sanctioned load, efficiency, energy efficiency

INTRODUCTION

Logic Controllers (PLC) and Supervisory Control and Data Acquisition (SCADA) systems have become the backbone of automation and control in electrical systems. PLCs are widely used for real-time load control, while SCADA systems enable centralized monitoring and data analysis. By combining the two, industries can ensure that their electrical load stays within sanctioned limits, optimize energy usage, and minimize risks associated with overloads. This study aims to explore the integration of PLC and SCADA systems for load monitoring and control in the context of sanctioned load management. Sanctioned load is the maximum electrical load authorized by utility providers for industrial, commercial, or residential users [1]. Exceeding this limit often leads to penalties, excessive energy costs, and in some cases, disconnection from the grid. Managing this sanctioned load becomes imperative for industries to maintain compliance, optimize energy use, and prevent overloading of electrical infrastructure. The combination of Programmable Logic Controllers (PLC) and Supervisory Control and Data Acquisition (SCADA) systems provides a powerful solution for monitoring, controlling, and automating the load management process [2–4]. PLCs are integral in real-time control systems, acting as the primary device for managing equipment, sensors, and actuators. SCADA systems

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provide supervisory control, data acquisition, and remote monitoring, making them an essential tool for higher-level management and visualization of electrical loads. This study focuses on the use of PLCs and SCADA systems for sanctioned load monitoring and controlling. It covers the operational principles, components involved, and the benefits of implementing such a system, particularly in industrial and commercial applications.

LITERATURE REVIEW

A study examines the transformative role of Industry 4.0 in reshaping Supervisory Control and Data Acquisition (SCADA) systems, with a strong focus on the integration of Internet of Things (IoT) technologies. The incorporation of IoT significantly enhances SCADA capabilities, enabling more precise and responsive load monitoring and control, which in turn drives higher operational efficiency in industrial environments [5]. SCADA systems serve as a backbone for real-time management of industrial processes, collecting critical data from remote sites and providing centralized control over diverse operations. Traditionally, SCADA has been used to monitor and control infrastructure such as power grids, manufacturing lines, and water treatment systems. However, with Industry 4.0, SCADA systems evolve into intelligent, interconnected platforms capable of predictive analysis, automated decision-making, and seamless data exchange. IoT sensors and devices extend the reach of SCADA, allowing continuous monitoring of assets, early detection of anomalies, and rapid deployment of corrective measures [6]. This synergy fosters more resilient and adaptive industrial operations, reduces downtime, and optimizes resource utilization. By bridging operational technology with modern digital tools, the integration of IoT within SCADA not only modernizes traditional control systems but also lays the foundation for fully automated and data-driven industrial ecosystems.

Another study presents an in-depth study on the application of Fuzzy Logic Control (FLC) for load management in smart grids. The proposed approach leverages the capabilities of fuzzy logic to enhance the efficiency, flexibility, and reliability of load management systems. With the growing adoption of renewable energy sources and the increasing variability in energy demand, smart grids require advanced control strategies capable of handling uncertainties and rapid fluctuations. Traditional load management techniques often rely on rigid control mechanisms, which struggle to adapt to the dynamic and complex nature of modern energy systems [7]. Fuzzy logic control offers a promising solution by emulating human decision-making processes, enabling systems to interpret imprecise data and make adaptive, context-sensitive adjustments. In the proposed method, FLC processes real-time input parameters such as load demand, generation capacity, and grid conditions to determine optimal load distribution and prioritize critical loads. This approach not only improves demand-supply balance but also reduces the risk of overloads and blackouts. Furthermore, the integration of FLC within smart grids enhances their ability to accommodate renewable energy sources, contributing to sustainable energy management. Overall, the study demonstrates that FLC is a robust, scalable, and intelligent tool for effective load management in next-generation power systems.

OVERVIEW OF SANCTIONED LOAD

The concept of sanctioned load has significant implications in energy management, especially in industries that rely on heavy electrical machinery. Sanctioned load refers to the maximum electricity consumption allowed based on a formal agreement with the utility provider. This value is based on an evaluation of the facility's requirements, and exceeding this sanctioned load can result in fines, load shedding, or disconnection of power supply [8]. Efficient monitoring of the sanctioned load is crucial to avoid these penalties and ensure that the electrical system operates within its safe limits. Monitoring involves measuring the load in real-time, comparing it with the sanctioned limit, and taking necessary corrective actions when the threshold is approached or exceeded.

METHODOLOGY

The proposed system consists of three main components: PLC for local load monitoring and control, SCADA for remote supervision and data logging, and sensors and meters for measuring real-time load values. The PLC receives load data from these meters and compares the current load with the sanctioned limit. If the load exceeds the authorized limit, the PLC will trigger control actions such as disconnecting non-essential loads or sending alerts to the operators via SCADA [9]. The SCADA system enables remote monitoring of the entire network, allowing operators to visualize load conditions, identify potential issues, and make informed decisions about load management. The system also integrates alarms and notifications that warn operators about load violations, facilitating prompt corrective actions.

WORKING MECHANISM

The sanctioned load monitoring system using PLC and SCADA operates in several key steps:

1. *Data Acquisition:* Current transformers (CTs) and potential transformers (PTs) continuously measure electrical parameters such as voltage, current, and power. These sensors send real-time data to the Programmable Logic Controller (PLC), which then processes and analyzes this information for further control and monitoring within the system.
2. *Load Calculation and Comparison:* The PLC calculates the total power consumption by processing data received from sensors. It then compares the calculated load with the pre-set sanctioned load value stored in the system to determine if the consumption is within allowed limits or if corrective actions are necessary [3].
3. *Threshold Detection and Action:* When the total load surpasses the sanctioned limit, the PLC automatically triggers corrective measures. This may involve sending alerts to the SCADA system, activating alarms, or starting automated load shedding to prevent system overload and maintain stable operation.
4. *SCADA Monitoring:* SCADA serves as a centralized platform to monitor real-time data from multiple PLCs at different locations. Upon detecting load violations, SCADA issues visual alarms and notifications, allowing operators to quickly assess the situation and make informed decisions or manual interventions [7].
5. *Load Management:* Together, SCADA and PLC coordinate to manage excess load by shedding non-essential loads, disconnecting certain devices, or redistributing power. This prevents exceeding the sanctioned limit, ensuring system stability and protecting infrastructure from damage due to overload.
6. *Remote Monitoring and Control:* SCADA enables operators to remotely monitor and control the electrical system. This capability allows centralized intervention in load management, especially useful for large-scale facilities or utility grids, improving responsiveness and operational efficiency.

COMPONENTS AND TECHNOLOGIES USED

Programmable Logic Controllers (PLC)

Role in Load Monitoring: PLCs act as the brain of the monitoring and control system (Figure 1). These devices are capable of continuously monitoring electrical parameters such as voltage, current, and power. PLCs can be programmed to compare the actual load with the sanctioned load and trigger alarms or corrective actions if the load exceeds the threshold [10].

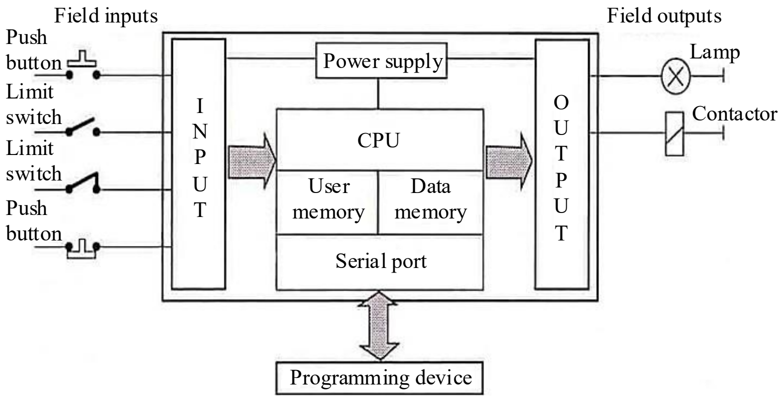

Figure 1. Block diagram of a programmable logic controller (PLC) system.

Data Acquisition: PLCs receive input data from sensors like Current Transformers (CTs) and Potential Transformers (PTs), which measure real-time current and voltage values. PLCs can then calculate total active power (kW) and power factor, helping determine if the load is within the sanctioned limit.

Supervisory Control and Data Acquisition (SCADA)

1. *Real-Time Data Visualization*: SCADA provides a comprehensive platform for visualizing real-time electrical consumption, making it easier for operators to monitor whether the sanctioned load is being exceeded. SCADA systems typically feature Graphical User Interfaces (GUIs) that display electrical parameters, alarms, and trends.
2. *Alerting and Control*: When the PLC detects that the load is approaching or exceeding the sanctioned limit, it sends a signal to SCADA, which generates an alert for the operator. SCADA allows operators to make informed decisions regarding load shedding, load distribution.
3. Current Transformers (CTs) (Figure 2) and Potential Transformers (PTs) are used to measure electrical parameters. These sensors provide the necessary data for the PLC to process and monitor power usage.

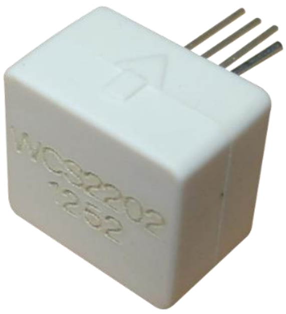

Figure 2. Current transformers.

RESULT AND DISCUSSION

The proposed system allows for real-time monitoring of sanctioned loads and provides an automated mechanism to prevent overload conditions. The PLC continuously checks the load status, and if a sanctioned load violation is detected, it immediately sends a signal to SCADA. The SCADA system then provides an interface for operators to take further actions, such as load shedding or adjusting the network configuration to balance the load. Data collected from the SCADA system can also be analyzed for performance optimization. In practice, this system offers a cost-effective, reliable solution for managing sanctioned load, ensuring grid stability, and optimizing energy distribution. The system also provides useful data for future predictive analysis and helps identify areas for improvement in the electrical network's operational efficiency.

CONCLUSION

Sanctioned load monitoring and control are essential for maintaining grid stability and ensuring energy compliance. The integration of PLC and SCADA technologies provides an automated solution that enhances load management efficiency. The combination of real-time monitoring, control, and remote supervision offers significant advantages in terms of operational reliability, energy conservation, and reduced human error. Further research can focus on enhancing the security of SCADA systems and improving load prediction models to optimize energy usage even further.

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