APPLICATION OF IoT TECHNOLOGIES FOR MONITORING ELECTRICAL DISTRIBUTION NETWORKS

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Abstract. The modernization of electrical distribution networks requires reliable methods for collecting, transmitting, and analyzing information about network operating conditions. Conventional monitoring systems may not provide sufficient real-time information about equipment and electricity consumption, particularly in networks with aging infrastructure. The Internet of Things (IoT) provides an effective technological solution by connecting sensors, meters, communication devices, and information systems into a unified monitoring environment. This article examines the application of IoT technologies for monitoring electrical distribution networks. The main attention is given to IoT sensors, smart meters, data transmission, SCADA integration, fault detection, and real-time monitoring.

Keywords: Internet of Things, IoT, electrical distribution network, monitoring, smart meter, sensors, SCADA, fault detection, energy efficiency, digitalization.

Electrical distribution networks represent an important component of modern energy infrastructure. Their reliable operation is necessary for the stable functioning of residential, industrial, agricultural, commercial, and public facilities. However, many existing electrical networks operate with equipment that has been in service for several decades. As a result, technical losses, equipment deterioration, overloads, and difficulties in monitoring may occur.

Effective monitoring is therefore an important condition for improving the operation of electrical networks. Operators need timely information about voltage, current, power consumption, equipment temperature, load conditions, and other parameters. Traditional monitoring approaches may require manual measurements or periodic inspections, which can make it difficult to identify rapidly developing problems.

The Internet of Things offers new possibilities for solving this problem. IoT technology allows physical objects and equipment to be equipped with sensors and connected to communication networks. The collected information can be transmitted to a central system where it can be stored, processed, and analyzed.

IoT concept in electrical network monitoring. The Internet of Things refers to a technological environment in which physical devices can collect and exchange data through communication networks. In electrical power systems, IoT can connect sensors, smart meters, substations, transformers, circuit breakers, and other equipment to centralized monitoring platforms.

A simplified IoT-based electrical monitoring system consists of four main levels:

- **Measurement level** – sensors and smart meters collect technical data.
- **Communication level** – collected data are transmitted through communication networks.
- **Data processing level** – information is stored, processed, and analyzed.
- **Management level** – operators receive information and make appropriate decisions.

This structure allows electrical network conditions to be monitored continuously.

IoT sensors in electrical networks. IoT sensors are among the most important components of an intelligent monitoring system. Depending on the requirements of the network, sensors can measure voltage, current, temperature, power, frequency, and other parameters.

For example, temperature sensors can be used to monitor transformer operating conditions. Current and voltage sensors can provide information about load conditions. Sudden changes in measured parameters can indicate possible equipment faults or abnormal network operation.

The main advantage of IoT sensors is their ability to provide continuous information without requiring frequent manual measurements.

Smart meters as an IoT component. Smart meters can be integrated into IoT-based monitoring systems to provide information about electricity consumption. Unlike conventional meters, smart meters can transmit measurement data automatically. The data obtained from smart meters can be used to identify: changes in electricity consumption; peak load periods; abnormal consumption; possible technical losses; differences between expected and actual energy consumption.

Such information can improve both operational management and energy planning.

Integration of IoT with SCADA. SCADA systems provide centralized monitoring and control of electrical infrastructure. IoT technologies can complement existing SCADA systems by increasing the number and variety of data sources.

For example, IoT sensors installed at substations can continuously collect information about equipment conditions. This information can then be transferred to the SCADA platform.

The integration of IoT and SCADA creates a more comprehensive monitoring environment. Operators can receive information from different parts of the network through a centralized interface.

Such integration can be particularly useful in networks where complete replacement of existing monitoring infrastructure is not economically feasible.

IoT and reduction of energy losses. IoT technologies can also contribute to the reduction of energy losses. Continuous monitoring provides information that can be used to identify inefficient sections of the network.

For instance, information obtained from smart meters can be compared with data from substations. Significant differences between supplied and recorded electricity may indicate technical losses or other problems requiring investigation.

The analysis of such data can help network operators identify problematic areas and develop appropriate measures for reducing losses.

Conclusion. The application of IoT technologies provides significant opportunities for improving the monitoring of electrical distribution networks. IoT sensors and smart meters enable continuous collection of information about network parameters and equipment conditions. Integration with SCADA systems can create a unified monitoring environment and improve the speed of detecting abnormal conditions. The collected information can also be used to identify potential faults, support preventive maintenance, analyze electricity losses, and improve network reliability. For electrical networks with aging infrastructure, the gradual introduction of IoT technologies represents a practical approach to digital modernization. By combining existing electrical equipment with modern sensors, communication technologies, and data-processing systems, network operators can improve monitoring without completely replacing existing infrastructure. Thus, IoT-based monitoring can become an important component of the digital transformation of electrical distribution networks and can contribute to more efficient, reliable, and sustainable electricity supply.

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