

Application Research on Online Monitoring and Intelligent Detection System for Lightning Protection Devices Based on Internet of Things

Ruijia Zhang

Shenzhen Branch of Guangdong Putian Lightning Protection Testing Co., Ltd., Shenzhen 518073, Guangdong, China

Abstract: Lightning disasters pose a continuous safety threat to various building electrical equipment and automated facilities. The traditional manual inspection mode has inherent shortcomings such as insufficient timeliness and limited coverage. The Internet of Things (IoT) technology can achieve real-time transmission of on-site perception data and remote centralized control. The lightning protection online monitoring system built based on this technology can continuously collect key operational information such as grounding resistance, discharge current, and component aging status, and automatically complete the identification of abnormal states and risk warnings. Sort out the theoretical content related to lightning protection monitoring, analyze the various limitations of the traditional detection and operation and maintenance mode, and combine the Internet of Things architecture to sort out the system construction ideas and application methods, providing feasible practical ideas for the regular safety control of lightning protection facilities in various industries.

Keywords: Internet of Things; lightning protection device; online monitoring; intelligent detection

1. Introduction

In modern production and living scenarios, the popularity of electrical and intelligent devices continues to increase. However, various precision electronic components have relatively weak tolerance to lightning overvoltage and induced lightning strikes. The stable operation of lightning protection facilities has become an indispensable part of site safety management. For a long time, the lightning protection safety of the site has relied on regular on-site manual inspections to maintain the operational status determination. Staff members need to arrive at the site to complete the entire process of instrument wiring, data reading, and on-site record-keeping. In scenarios where the site is scattered and there are numerous points, the overall operation and maintenance efficiency is relatively low. Some hidden areas are difficult to achieve high-frequency inspections, and the accumulation of hidden dangers can easily lead to equipment damage or even safety accidents. The popularization of digital technology has continuously driven the innovation of security operation and maintenance models. Internet of Things perception, wireless transmission, and cloud data processing technologies have gradually been integrated into the field of infrastructure protection and management. The real-time operating parameters of the lightning protection device are collected by means of distributed perception terminals, and the data is summarized to the unified control platform through network links. The system independently completes the status judgment and abnormal push.

2. Theories related to lightning protection safety monitoring and Internet of Things technology

A complete lightning protection system for buildings and sites is composed of a lightning arrester system, a down-conductor conduction system, grounding devices, and overvoltage protection devices. The entire protection system forms a complete discharge channel, which can quickly conduct the instantaneous high-energy current when lightning occurs, preventing the building structure and internal electrical equipment from being damaged by impact. The conduction performance of the grounding system directly determines the efficiency of lightning energy discharge and is also the most crucial assessment index in lightning protection detection work. Seasonal hardening, long-term dryness, acid-base corrosion and other changes in the site soil will cause continuous alterations in grounding conduction conditions, leading to irregular fluctuations in grounding parameters. Oxidation and rusting of the metal surface of lightning protection components, loosening of connection points, aging and detachment of fastening accessories, and performance degradation of protective device components will all directly lead to structural performance defects in the overall protection system.

The front-end sensing devices can automatically collect the core parameters of the lightning protection system, enabling continuous operation around the clock without human intervention and completely getting rid of the time limit of manual inspection. Wireless transmission technology can break free from the site limitations of wired cabling, and is suitable for the renovation and upgrading of old sites, open-air areas, and complex building structures, significantly reducing the con-

struction difficulty and renovation cost of intelligent transformation. The cloud-based data processing platform is equipped with massive data storage, multi-dimensional trend analysis, precise status discrimination, and multi-level intelligent early warning capabilities. It can transform scattered physical monitoring data into standardized digital management resources, providing stable, accurate, and continuous data support for lightning protection safety control. Truly achieve a technological upgrade in lightning protection monitoring from manual spot checks and post-event remediation to real-time monitoring across the entire region and pre-event prediction [1].

3. The existing limitations of the traditional lightning protection device detection and operation and maintenance mode

Traditional lightning protection detection work all adopts a periodic fixed-point detection mode. The detection cycle is fixed and the interval time is relatively long. Problems such as performance degradation, component damage, and abnormal parameters of the device that occur between two detection cycles cannot be detected in time, and the hidden danger window period is relatively long. With the continuous increase in the density of modern site equipment, the lag and limitations of the traditional manual detection mode have been continuously magnified, making it difficult to meet the basic requirements of modern site dynamic safety management [2].

The hidden damage to components caused by lightning strikes does not immediately manifest in appearance and conventional parameters. The performance loss caused by a single lightning strike is relatively weak and is difficult to be detected in a timely manner by annual manual inspection. After multiple lightning strikes accumulate, the overall protection capability will gradually weaken, eventually leading to the failure of the protection system. The manually archived data is rather scattered. The test data from different years and different regions are independent of each other and cannot form a continuous life cycle data chain. It is difficult for operation and maintenance personnel to sort out the aging patterns of equipment and the characteristics of lightning protection losses on the site based on fragmented historical data. The formulation of annual operation and maintenance plans and equipment replacement plans is completely dependent on experience-based judgment, lacking scientific data support, and the operation and maintenance work is not targeted enough [3].

4. Application Path of the intelligent detection system for Online lightning protection monitoring Based on the Internet of Things

4.1 Front-end Perception Terminal Layout and Installation Configuration

The front-end perception terminal of the system is the core hardware carrier for achieving intelligent monitoring. The terminal layout must strictly conform to the actual distribution of lightning protection devices on the site, and be standardized based on the building structure, down conductor position, grounding point position, and the distribution of protection equipment. The terminal equipment integrates multiple types of sensor modules, which can simultaneously complete the real-time collection of multiple core parameters such as grounding resistance, lightning discharge current, equipment temperature, and line status, comprehensively covering the key monitoring indicators of the lightning protection system. Each terminal is set with an independent identification code. The platform can precisely distinguish the point information, ensuring that the monitoring data accurately corresponds to the lightning protection equipment in each area and eliminating the problems of data confusion and point disorder [4].

4.2 Hierarchical Data Transmission Link Construction Plan

The system data transmission adopts a hierarchical distributed architecture. After the front-end terminal collects data, it is connected to the regional aggregation node nearby. After the aggregation device completes the data integration and verification of the area, it is uniformly uploaded to the cloud platform. The transmission link adopts a communication standard with strong anti-interference ability, which can effectively resist the unstable signal problems caused by electromagnetic interference in industrial sites and the obstruction of building walls, ensuring the stable and reliable transmission of data.

4.3 Core functions of the cloud-based intelligent detection platform have been implemented

The cloud-based intelligent platform undertakes core functions such as data storage, intelligent analysis and judgment, risk early warning, ledger management, and permission control, serving as the central carrier of the entire system. The platform sets standardized parameter thresholds in accordance with the current lightning protection technical specifications, connects to the terminal to upload data in real time, automatically completes data comparison and status classification, and accurately determines different states of equipment such as normal operation, performance warning, and fault failure [5].

5. Conclusion

Lightning protection safety management is an important part of the operation and maintenance of site infrastructure. The traditional manual detection mode has many shortcomings such as lagging timeliness, scattered data, and weak control, and is no longer suitable for the current refined and digitalized safety management standards. The lightning protection online monitoring and intelligent detection system built on the Internet of Things, relying on a complete technical system of intelligent perception, stable transmission and cloud analysis, realizes all-weather dynamic monitoring of the operating status of lightning protection devices, effectively making up for various shortcomings of the traditional operation and maintenance mode.

The entire system is easy to deploy, highly adaptable and operates stably. It can be widely adapted to the lightning protection upgrade and transformation of various scenarios such as industrial plants, public buildings, outdoor mechanical and electrical facilities, and transportation stations, with extremely high adaptability and promotion value. The application of the system can not only enhance the ability to prevent and control lightning risks in advance, reduce the probability of disaster accidents from the source, and ensure the safety of precision equipment and infrastructure within the site, but also effectively streamline manual operation and maintenance costs, reduce repetitive inspection work, and standardize the lightning protection safety management process. Continuously promoting the in-depth application of Internet of Things (IoT) intelligent monitoring technology in the field of lightning protection, constantly optimizing the accuracy of sensor collection and the intelligent judgment capabilities of the platform, can continuously enhance the safety protection level of infrastructure, drive the lightning protection safety management industry to break away from the traditional extensive mode, and steadily develop in the direction of digitalization, standardization and intelligence.

References

- [1] Li Qianyou Lightning Protection Technology and Application of Online Monitoring and Early Warning System for Tailings Ponds [J]. Fujian Metallurgy, 2024, 53(5):5-9.
- [2] Chen Wei. Design and Application of Intelligent Online Monitoring System for Airport Lightning Protection [J]. Modern Building Electrical, 2021, 012(005):67-69.
- [3] He Jing, Zeng Xiangping, Li Weiping, et al. Comparative Analysis and Research on the On-line Monitoring of Grounding Resistance of Lightning Protection Devices by Loop Method and Three-pole Method [J] Electrical Technology and Economy, 2022(000-003).
- [4] Zhang Hao, An Jie Design of Intelligent Integrated Protection, Early Warning and Monitoring Device and System [J]. Automation & Instrumentation, 2021, 036(009):103-105.
- [5] Zhou Wensheng, Dai Wei, Chen Shaodong, et al. Design and Implementation of Online Monitoring Platform for Lightning Protection Devices [J]. Guangdong Meteorology, 2023, 45(1):77-80.

Author Bio

Rujia Zhang (July 1984 -), female, Han ethnicity, from Jieyang City, Guangdong Province, with a bachelor's degree, junior engineer, project manager. Research Field: Building Electrical Engineering.