Journal of Frontiers in Engineering Technology
Clausius Scientific Press, Canada

DOI: 10.23977/jfet.2021.010109
Volume 1, Number 1, 2021

Research on State Perception Method of Electrical Equipment in Substation

Fan Yang[1,2], Weidong Kang[1], Wei Hou[1], Hao Gu[1*]

1. Anhui Nanrui Jiyuan Power Grid Technology Co., Ltd. , China

2. Anhui Qisheng Intelligent Technology Co., Ltd. , China

**Corresponding Author*

Keywords: Online monitoring, State perception, Artificial intelligence, Edge iot agent

Abstract: At present, the main online monitoring methods for converter stations are still traditional equipment online monitoring devices, which are mainly concentrated in converter transformers/station-use transformers, GIS equipment, cameras, etc. The reliability of the monitoring devices is not high, and the monitoring range Limited, the problem of insufficient sampling of equipment status features. This article proposes a new sensing technology research method for substation equipment, which integrates advanced technologies such as intelligent perception, artificial intelligence, big data, and three-dimensional inspections, which is suitable for converter transformers, station-use transformers, The state-sensing methods of electrical equipment such as step-up transformers and GIS equipment will be studied in detail, and a panoramic intelligent interconnected sensing system will be constructed to effectively improve the management efficiency and benefits of converter stations.

1. Introduction

At this stage, the main online monitoring methods of converter stations in the power system are still traditional equipment online monitoring devices, which are mainly concentrated in converter transformers/station-use transformers[1], GIS equipment, cameras, etc. The monitoring information is oil chromatogram, iron core current , Oil temperature, oil level, SF6 pressure, etc., the monitoring range is limited, there is insufficient sampling of equipment state characteristics, and the lack of voiceprint, casing end screen, UHF, optical fiber sensing and other new IoT sensing technology methods. Some monitoring devices have reliability problems. Traditional monitoring devices have insufficient on-site data processing capabilities[2], and are affected by the device’s own technology, communication attenuation, and calculation efficiency. In actual applications, there are often problems such as offline and inaccurate data. At the same time, there is a lack of personnel, The omni-directional perception of environmental information has problems such as management blind spots, lack of auxiliary means of operation and maintenance such as intelligent patrols and mobile operations[3], and the ineffective application of new technologies and equipment.

Aiming at the positioning of the substation itself, comprehensively considering safety and demonstration, this paper strictly controls the safety and reliability of the newly-added IoT sensor devices, strengthens the intrinsic safety of the equipment, and proposes a new sensing technology research method for substation equipment, which integrates intelligent perception and artificial intelligence[4]. Various advanced technologies such as intelligence, big data, and three-dimensional inspection, conduct detailed research on the state perception methods of electrical equipment such as converter transformers, station-use transformers, step-up transformers[5], and GIS equipment, so as to realize intelligent sensing of equipment status and flexible application of field operations[6]. Build a panoramic intelligent interconnected perception system.

2. State Perception of Converter Transformer, Station Transformer, and Boost Transformer

For converter transformers, station-use transformers, and step-up transformers, the operating status of the transformer is mainly sensed from various aspects such as dissolved gas in the transformer oil, voiceprint, partial discharge, iron core ground current, on-load tap changer vibration, infrared thermal imaging, etc. , To ensure the safe and stable operation of the transformer[7].

2.1 Voiceprint Online Monitoring

Voiceprint online monitoring mainly uses high-sensitivity voice collection terminals to collect audio data during transformer operation, combined with advanced voiceprint recognition algorithms and feature sample libraries in the background, to assist in realizing active early warning and abnormality judgment of transformer abnormalities[8].

The monitoring principle is based on artificial intelligence-based large-scale transformer voiceprint recognition and defect active early warning technology. By deploying high-sensitivity sound acquisition sensors to collect the audio signals generated during the operation of the commutation transformer, station transformer, and step-up transformer, compare the normal operating status of the transformer Download the voiceprint samples, and perform the voiceprint recognition when the main body is abnormally vibrated due to shocks such as transformer overload, lightning strikes or external operating overvoltages. By comparing the feature samples, combined with the transformer voice fault recognition model based on deep learning, rapid and accurate correction can be achieved. Intelligent identification and diagnosis of abnormal conditions, judgment of current transformer defects, and early warning of abnormal operating conditions.

The collection terminal collects the audio signal generated during the operation of the converter transformer in real time, and connects to the convergence node through a wired method[9]. The parameter configuration is shown in Table 1-1.

Table 1 -1 Microphone Array Configuration Table

Serial number	Technical parameters	Parameter value
1	Sensitivity	⩾60mV/Pa
2	Noise level	⩽36dB
3	Signal-to-noise ratio	⩾60dB
4	Frequency response	50-8kHz
5	Waveform distortion	⩽7%
6	Capture voice format	Windows PCM WAV, mono, 16-bit quantization
7	Matching impedance	50Ω
8	Sampling Rate	16kHz sampling rate

2.2 Local on-Line Monitoring

Through the deployment of high-frequency current (500kHz~50MHz), ultrasonic (80kHz~200kHz), and smart sensors with high sensitivity, good stability, and different monitoring frequency bands[10], the partial discharge signals generated during the operation of the converter are collected to reflect the inside of the converter. Discharge defects such as insulation and levitation are generated. It can realize partial discharge live detection, positioning and defect type recognition.

When a partial discharge defect occurs in the converter transformer, physical phenomena and chemical changes such as sound, light, electrical and mechanical vibration will occur, and a steep pulse with a rise time of less than 1ns will be generated in a small space inside the device, thereby exciting hundreds of MHz Even UHF electromagnetic waves above GHz frequency. The high-sensitivity partial discharge sensor is used for coupling and reception, and the monitoring background uses the deep learning-based partial discharge type diagnosis function to realize discharge map analysis, discharge type recognition and auxiliary decision-making for equipment status maintenance.

The sensor periodically collects the partial discharge signal generated internally during the operation of the commutation transformer, and connects to the convergence node through LoRa. The parameter configuration is shown in Table 1-2.

Table 1 -2 Partial Discharge Parameter Configuration Table

Serial number	Technical parameters	Parameter value
1	Error	±1dB
2	Resolution	1dB
3	Frequency Range	High frequency 500kHz -50MHz, ultrasonic wave 80kHz~200kHz
4	communication method	LoRa
5	Battery life	≥7 years

2.3 Infrared Thermal Imaging Online Monitoring

Infrared thermal imaging technology based on full-pixel temperature map is used to realize real-time temperature monitoring of the temperature field of the converter transformer body, casing, clamp and other key parts by the thermometer, collect the highest temperature value of the corresponding area, and realize based on infrared map The defect diagnosis of temperature recognition can detect the heating defects and hidden dangers of substation equipment in real time, effectively and accurately.

Take the distribution of temperature measurement points in the converter substation area as an example. A total of 26 deployment control points are deployed in this area to monitor all converter substation area equipment and road-side outlet bushings, voltage transformers, lightning arresters and other equipment, as well as extremely II low-end equipment Three sides of the main body of the C-phase converter on the Δ side of the converter transformer. According to the layout principle, select key equipment, such as the bushing of the converter transformer, the arrester, the oil pillow, and the upper main body as the main monitoring objects. The bushing, lightning arrester, and voltage transformer of the nearby outlet are also the key equipment, and the other 1000 kV GIS equipment area and outgoing area can be used as auxiliary monitoring objects for monitoring. According to the objective conditions of the site, there are a total of 250 monitoring presets in this area, including 190 main monitoring equipment and 60 auxiliary monitoring equipment, which basically cover all the site equipment in the area. The temperature measurement distribution is shown in Figure 1-1. Show.

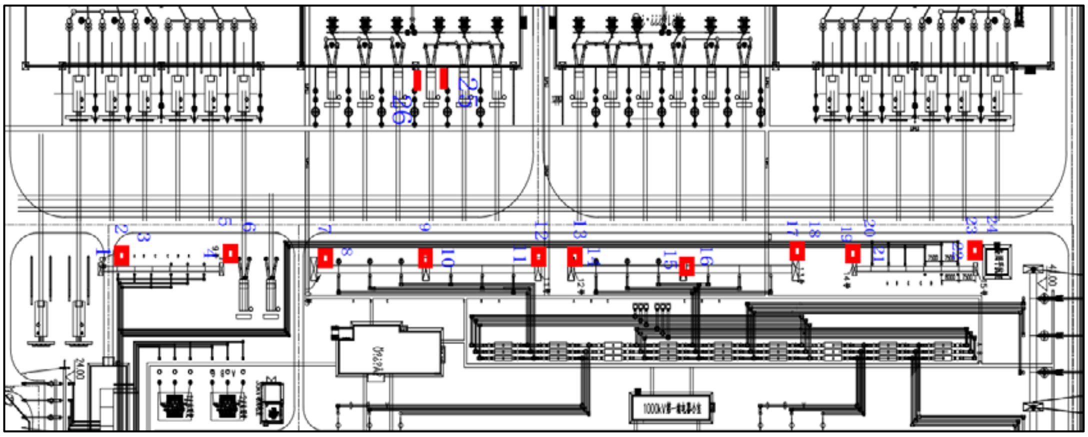

Fig.1 Temperature Measurement Distribution Diagram of Converter Transformer Area

3. Gis Equipment Status Awareness

GIS equipment is mainly distributed in 500kV AC indoor power distribution area and 1000kV AC outdoor power distribution area. It mainly senses the operating status of GIS equipment from the aspects of GIS partial discharge, SF6 gas pressure, and mechanical characteristics of circuit breakers, and discovers various types in time Failure to ensure the safe and stable operation of the equipment. Among them, the online monitoring of SF6 gas density and the online monitoring of arresters have been installed and deployed, and the online monitoring of the mechanical characteristics of partial discharge and circuit breakers will be gradually expanded.

Take the on-line monitoring of mechanical characteristics of circuit breakers as an example, by installing current transformers and on-line monitoring of the mechanical characteristics of the convergence node, the circuit breaker opening and closing coil currents and energy storage motor currents can be detected, and the monitoring data can be analyzed through the host computer software. Calculate and analyze the characteristic parameters of the relevant variables in the circuit breaker action process, find potential defects in the motion of the circuit breaker mechanism, and draw the characteristic parameter trend curve to provide a basis for the development trend of the circuit breaker state. The sensor adopts wireless transmission (Lora), low-power sleep, and wake-up working modes, which greatly reduces the power consumption of the system, resists strong electromagnetic interference, does not need wiring, and is easy to install and use. The principle of mechanical characteristics monitoring is shown in Figure 20. As shown in Figure 2.

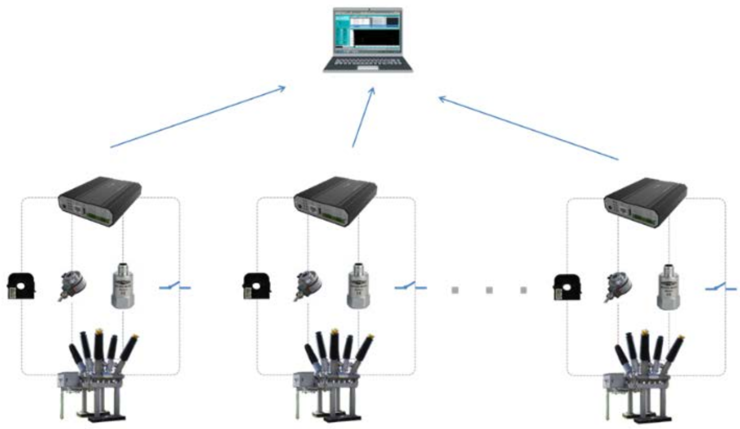

Fig.2 Schematic Diagram of Mechanical Characteristics Monitoring Principle

4. Panoramic Intelligent Interconnection Perception System

The system hardware consists of an independent management unit and an acquisition unit. The acquisition unit is responsible for process-level data acquisition and analysis, and the management unit is responsible for the realization of monitoring, diagnosis, and operation and maintenance functions. The system network architecture is shown in Figure 3.

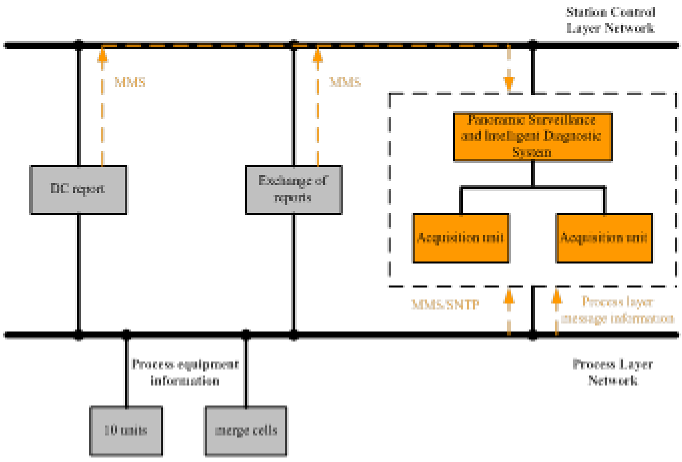

Fig.3 Network Diagram of Panoramic Monitoring and Intelligent Diagnosis System

4.1 Collecting Operating Status Information

Through the relay protection online monitoring sub-station of the converter station, real-time acquisition of DC such as the converter protection device (CPR) and its three-out-of-two device (C2F3), pole protection device (PPR) and its three-out-of-two device (P2F3) The operating status of the protection, as well as the operating status information of AC protection devices such as line protection, switch protection, bus protection, main transformer protection, AC filter protection, etc., to achieve a panoramic perception of the operating status of AC and DC protection. The collected information includes the running status of the device plug-in, the protection analog value, the protection switch value, the protection alarm information, the protection action information, the protection function switching status, the optical fiber loop status, the transient fault recorder, the protection setting value, the pressure plate status, etc. Establish the topological relationship of the DC protection secondary fiber loop, including the fiber loop of DC protection and distributed IO, three-out-two host, control host, real-time detection of the operating status of each optical fiber link, timely alarm when failure occurs, and display through visualization Location of the faulty fiber.

4.2 Protection Plug-in Operation Monitoring Optimization

The parallel monitoring method is adopted between each plug-in of the relay protection to monitor the operation of the protection plug-in, and find the abnormality of the plug-in in time. By adding an additional acquisition unit in the converter station to receive the homologous parallel port signals of the analog quantity and switching value of the DC protection host, the perception of the voltage, current and switching status collected by the DC protection host is realized.

4.3 Integration of Edge Iot Agents

The relay protection online monitoring sub-station is deployed in the safety zone II in the station, and transmits protection operation data to the edge IoT agent integrated platform through a one-way isolation device. The protection model information is transmitted through the SCD file, including the configuration of the protection device, the relationship between the protection device and the primary equipment, etc.; the protection status file in the CIME format is regularly exported, and the real-time operating status of the protection device is transmitted, including the device communication status, panel light status, Alarm status, pressure plate switching status, binary input status, operating setting, protection measurement, device parameters, online monitoring, etc.; timing export of alarm event files in CIME format, transmission of protection event information, including protection actions, fault location, and faults Phase difference, abnormal alarm, pressure plate displacement, binary input displacement, etc. When the power grid fails, the related information of a fault in the station is automatically collected and integrated into a fault report. The content includes the name of the primary and secondary equipment, the time of the fault, the fault location, the difference of the fault, the protection action event, the wave recording file, etc., through XML The format file sends a fault report to the edge IoT agent integration platform.

5. Conclusion

In this paper, through the installation and deployment of infrared temperature measurement, online monitoring, and GIS equipment and other electrical equipment intelligent sensors for status perception methods, a panoramic intelligent interconnected perception system is constructed, which comprehensively improves the control of equipment status, and improves the inspection personnel's ability to control station equipment. , Environment and personnel status information monitoring and management capabilities, effectively improving the management efficiency and benefits of converter stations.

References

[1] Li Peng, Bi Jiangang, Yu Hao, Xu Yuan. Intelligent sensing and state perception technology and application of substation equipment[J]. High Voltage Technology, 2020, 46(09): 3097-3113.

[2] Li Cong, Xu Mingkai, Pan Huichao, Fu Zhaoyuan, Xu Zhiyuan. Research on Substation State Perception System Based on Standardized IoT Smart Sensors[J]. Shandong Electric Power Technology, 2020, 47(07): 27-31.

[3] Huang Hong, Xiong Zhuo, Wang Yu, Lei Taoling, Wang Junqi. Research on multi-dimensional perception and intelligent diagnosis system of substation equipment status based on big data[J]. Electric Power Big Data, 2019, 22(10): 51 -57.

[4] Liu Yan. Research on the digital method of artificial inspection and perception information of power equipment status[D]. Huazhong University of Science and Technology, 2019.

[5] Xie Li, Zhu Jiang. The application of Internet of Things technology in power equipment state maintenance [J]. China New Telecommunications, 2016, 18(09): 48-50.

[6] Li Yuanfang, She Wei, Ye Yangdong, Sun Zhen, Li Jianglin, Shi Yi. State perception and trend analysis of power equipment based on hybrid system[J]. Computer Measurement and Control, 2013, 21(12): 3352 3355.

[7] Pu Tianjiao, Qiao Ji, Han Xiao, Zhang Guobin, Wang Xinying. Research and application of artificial intelligence technology in the operation and maintenance of power equipment[J]. High Voltage Technology. 2020(02)

[8] Yu H , Qian Z , Yao J , et al. Research of on-line monitoring equipment for power capacitor based on wireless sensor network[C]// Seventh International Symposium on Precision Mechanical Measurements. International Society for Optics and Photonics, 2016.

[9] Kim Y , Kweon D , Park T , et al. Classification of Fault and Failure Types Determined by Dissolved Gas Analysis for Transformers[J]. Journal of Electrical Engineering & Technology, 2019, 14(2).

[10] Mallikar-Godbole L , Kushare B E . Online condition monitoring of SF6 circuit breaker[C]//2016 10th International Conference on Intelligent Systems and Control (ISCO). IEEE, 2016.