Research and Application of 5G Technology in Power System

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Abstract. 5G, as the cutting-edge technology of wireless network access, it has the advantages of high-speed, low delay, high-density access and slicing function. Combined with the data transmission of intelligent equipment in the substation, it can greatly improve the wireless network access ability of intelligent equipment and sensing unit. For the purpose of improving the intelligent inspection ability of the substation and providing the communication foundation for the big data analysis of the operation state of the substation equipment. We can build a high-density, high bandwidth, low delay wireless network platform through 5G wireless communication network. According to the business requirements, the system can realize the rapid state perception and IOT interaction of data sensors in the transmission terminal layer. With all communication and data transmission requirements satisfied.

1. Introduction
5G network technology has excellent air port combination performance, comprehensive cloud and flexible network architecture. Compared with other communication technologies (2G, 3G, 4G, WiFi, etc.), the comprehensive performance is more outstanding. A single cell can achieve 10Gbps bandwidth, 1ms delay and 1 million connections. Using 5G technology, real-time transmission of media, accurate obstacle judgment and prediction, and more intelligent patrol function can be realized [2].

5G based mobile broadband networks will drive the full digital process through the integration of wireless connectivity, mobility, the internet of things, cloud computing and big data. In the era of intelligent interconnection, how to promote the application of 5G technology is a problem [3]. By continuously enhancing the vitality of the power grid industry and related enterprises through 5G technology, the efficiencies can be effectively improved and reduced [4]. Power grid is an important energy infrastructure related to national economy and people's livelihood [5]. Big data analysis of existing equipment can be realized through the 5G technology. Predict the hidden danger of the equipment in advance. Realize real-time and high-speed transmission of data, image and video. The delay of 5G network is 1 millisecond, and the
network upload rate can reach 800m, which ensures the transmission rate required by the multi-dimensional information data collection of the equipment. The dual network backup of wired optical network and wireless 5G high-speed transmission network is realized to ensure the real-time transmission of all transport and inspection data information and ensure no interruption for 365 days. 5G technology is used to realize remote diagnosis and maintenance of equipment.

2. Power application scenario

2.1. Inspection robot

5G network environment brings new opportunities for the industrial development of remote control cooperative robots\(^6\). The in-station inspection robot is limited to the network transmission rate, so it cannot execute two-way interaction and high-quality picture transmission between the station end and the remote end. At present, the data of the substation is collected by the inspection robot using the on-site WIFI to collect the operation data, pictures and videos of the equipment in the operation area, and then transmitted to the central node through the local system via optical fiber. In terms of the quality and speed of data transmission at present. The ideal transmission rate based on WIFI router is 100Mbps. But in fact, the average transmission rate is only 30Mbps. Video transmission is often jammed\(^7\), which can only ensure the transmission of photos of field equipment, the transmission of operation data and intermittent video acquisition. Through the communication between the robot and the 5G base station, the robot is connected to the 5G network through 5G CPE(Customer Premise Equipment) equipment, and the measured downlink rate of a single user can reach more than 1Gbps and more than 100Mbps by the network. Through inspection robot and 5G network. The way of deploying 5G CPE terminal in the background of the station is adopted to send back the pictures and data collected by the robot to the monitoring center in real time through 5G network, so as to realize the remote function of intelligent inspection robot. To achieve remote station robot control, data browsing and query functions (bandwidth requirements of 80mbps). For the need to patrol the equipment, instrumentation shooting effect is clearer. The identification of equipment failure point is more accurate, which greatly improve the inspection efficiency.

2.2. Access of intelligent sensor equipment in the station

The application scenario of 5G can meet the demand of sensor acquisition with high connection number and low delay in wireless communication. Such scenarios require 100Mbps of large bandwidth. 5G can also support scene applications such as intelligent sensor devices in the station better. Through the access of 5G network, all data information can be transmitted in real time without interruption. The element micro meteorological sensor is shown in Figure 1, and some accessible sensors are listed in Table 1.

![Element micro meteorological sensor](image)

Figure 1. Element micro meteorological sensor.
Table 1. List of accessible sensors.

| Serial number | Sensor                                      | Effect                                                                 |
|---------------|---------------------------------------------|----------------------------------------------------------------------|
| 1             | Noise monitoring                            | The sound source visualization technology is used to quickly image and identify the abnormal sound caused by the loose parts of the equipment. |
| 2             | Wireless temperature and humidity monitoring | Monitoring the temperature and humidity linkage heating and moisture driving device inside various boxes               |
| 3             | Water level monitoring of fire pool          | Monitor the water level of the fire pool to ensure that the fire water meets the requirements in real time.          |
| 4             | Water fire pipeline pressure monitoring      | Monitor the stability of fire water pipe pressure to ensure the normal operation of fire system.                     |
| 5             | Water immersion monitoring of cable trench (accident oil pool) | Monitor the water accumulation in the cable trench to prevent flooding and protect the chamber.                     |

2.3. HD camera equipment

Finally, the video monitoring system will develop into 5G wireless HD camera, achieving a qualitative leap [8]. The whole scene video transmission is realized through 5G webcam and HD video. At any time, the operation status of equipment and the behavior of operators in the station can be detected. Realize intelligent management and control. In combination with security, equipment analysis, arc/lightning monitoring analysis, remote diagnosis and supervision of maintenance operations. While traditional HD video shooting can only be based on wired transmission, 5G network is a more mobile and innovative communication technology.

2.4. Expand application functions

Virtual reality technology is one of the focuses in the 5G era and is expected to become a brand new application [9]. 5G network can support 360-degree camera ball, VR technology and AR technology. It plays an active role in the training, inspection, maintenance and assembly of power grid. Through AR equipment to achieve the whole scene and the whole workspace operation data monitoring, so that the operation and inspection more intelligent. Ensure the safe and normal operation of substation and improve the safe operation level of power grid.

3. System study

The main construction contents of 5G site and network scenarios include 5G core network, transmission bearing network, The requirements of 5G sites and network scenarios include the combined application of 5G patrol robot, 5G uav, 5G camera and 5G communication in substation. Real-time data acquisition through 5G network. To provide reliable application environment support for safety and economic operation, the interconnection architecture is shown in Figure 2.
3.1. Network layer

The rapid development of 5G technology is closely combined with the construction of Internet of things network layer [10]. In view of the realization of 5G network full coverage in the substation, the robot can continuously access 5G network on the patrol inspection route, and carry out real-time HD video return and analysis. Relying on the technical advantages of 5G large bandwidth, low delay and multi connection. Realize real-time transmission of large bandwidth video signal. By deploying 5G network to achieve continuous coverage effect, 5G carrier network equipment and special line from core network to power data center network shall be deployed to build 5G wireless base station, so as to achieve the end-to-end service connectivity.

3.2. Platform layer

The platform layer adopts the power standardization background, the minimum storage of hard disk is 4T, and provides data support for the application layer.

3.3. Application layer

The application layer adopts intelligent inspection robot as the core, integrating robot technology, non-contact detection technology of power equipment, multi-sensor fusion technology, pattern recognition technology, navigation and positioning technology and Internet of things technology. It can realize all-weather, all-round, independent intelligent inspection and monitoring of substation, effectively reduces the labor intensity and operation and maintenance cost of substation And improve the automation and intelligence level of normal patrol inspection and management.

4. Network performance

The DT traverse test has been completed in the substation area. The coverage is good, the strength is above -95dbm, the download speed is 930mbps, and the upload speed is 140mbps, as shown in Figure 3. According to NR test of Liaoning maintenance branch of State Grid, SS rsrp is -72.25dbm, SS SINR is 18.63db, and PDCP rate is 1038.71mbps, as shown in Figure 4. According to the test results, the 5G coverage can reach 800m without blocking and 400m with blocking. 5G network will provide 20 times of LTE cell capacity, 10 times of user experience and 1 / 10 of air port delay. 5G network can meet the needs of the services of embB
(ultra wide bandwidth), ullc (ultra high reliability, ultra low delay) and mmtc (ultra large connection). 5G is faster than the current AP transmission speed, to achieve a clearer and visible real-time video (now only pictures); based on the characteristics of 5G low delay and 360 degree monitoring, remote accurate fault judgment can be achieved. It can realize the range supervision of UAV through 5G.

![Figure 3. Ergodicity test.](image1)

5. Key points analysis

5.1. Base station location

5G base station is set in the substation area, and it is suggested to take the principle of "priority selection of open space, avoidance of space blocking and appropriate safety distance". At the same time, the number of 5G base stations shall be set reasonably considering the operation area of the site.

5.2. Hanging point selection

It is suggested that the hanging height of 5G field station should be 20-30m, and the distance between
stations should be within 400m. The actual hanging points are shown in Figure 5. Combine the terrain and functional zoning of the test site. It is suggested that 5G stations should be arranged on the basis of the existing network site. The distance between stations is 300-350m, and the stations shall be reasonably planned to meet the requirements of signal coverage in the station.

Figure 5. Substation area hang point

5.3. Equipment connected to power supply
5G equipment adopts DC (-48V) power supply, and it is recommended to take the principle of "DC power is introduced nearby to meet the two-way power supply", and at the same time, it has AC inverter DC power supply system.

5.4. Network security protection
The wide application of 5G technology brings great convenience and puts forward new requirements for mobile communication security [11]. 5G base station signal has space openness. In the application of substation scenario, it should ensure that the relevant network information security meets the requirements of relevant technical specifications of grid company, and is limited to the access and use of 5G network resources by specific system, designated equipment and professional personnel of substation.

5.5. Base station tower foundation
5G base station tower is set in the substation. The foundation shall be firm and meet the requirements of power tower foundation. Ensure that the tower will not affect the power grid equipment under extremely severe conditions.

6. Conclusion
In this paper, through the research and application of 5G wireless power communication network platform, the remote browsing function of inspection robot is realized. The platform can be used to monitor the operation status of power equipment in real time, and meet the requirements of value, real-time and security of power equipment. By promoting the two-way interaction and deep integration of the station end and the remote end, the patrol inspection mode of the isolated island barrier at the station end is broken. By using the unified management of robot centralized control platform, big data, Internet of things and other means, it can effectively monitor the equipment in real time and ensure the operation safety of power equipment. At the same time, based on 5G technology communication platform, the data collected in the whole scene can also be accurately analyzed to achieve fault prediction. 5G technology power communication platform lays a solid foundation for the operation data monitoring of the whole scene and working area, makes the operation inspection more intelligent, the operation of the substation more safe, and greatly improves the safe operation level of the power grid.

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