Study on Remote Monitoring System of Crossing and Spanning Tangent Tower

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Abstract. In order to grasp the vibration state of overhead transmission line and ensure the operational security of transmission line, the remote monitoring system of crossing and spanning tangent tower was studied. By use of this system, the displacement, velocity and acceleration of the tower, and the local weather data are collected automatically, displayed on computer of remote monitoring centre through wireless network, real-time collection and transmission of vibration signals are realized. The applying results show that the system is excellent in reliability and accuracy and so on. The system can be used to remote monitoring of transmission tower of UHV power transmission lines and in large spanning areas.

1 Introduction

Cross-Tower is an important part of power network structure, transmission line cross tower is mainly across the road, railway, river and port and other important areas\textsuperscript{[1]}. Independent for strained towers and directly across Tower is the main form of cross-Tower, the anti-risk ability of crossing and spanning tangent tower is weak, Once the collapse of the tower and other accidents are often likely to cause significant economic losses and social impact, master its safety performance is critical for the reliable operation of the power grid\textsuperscript{[2]}. With the frequent occurrence of extreme climate in the world, the growing power grid disasters caused by severe climate, especially the strong convection disasters caused huge losses to the power grid in the world. Our country is one of the countries that have suffered severe convective weather disasters in the power grid, frequent occurrence of large area disaster, causing great economic losses and serious social impact. Especially in recent years, with the aggravation of grid wind disasters, the influence scope of wind disaster is expanding day by day, the damage is more and more serious\textsuperscript{[3,4]}.

The dynamic displacement, velocity and acceleration of the transmission tower are the important parameters of the health condition of the structure, which is an important part of the health diagnosis of the transmission tower\textsuperscript{[5,6]}. According to the specific conditions of finalized the design of the tower in China, developed a remote monitoring system for vibration of crossing and spanning tangent tower, realized on-line testing of the vibration state of transmission tower, remote transmission through wireless network, real-time analysis of vibration and modal change and vibration response of sudden loads of transmission tower under complex environment, which lays a foundation for evaluating the health status of transmission tower\textsuperscript{[7,8]}. 

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2 Overall design of monitoring system

In order to establish a transmission safety monitoring system to adapt to complex environments, for the current grid, computer and mathematical theory, by considering the grid security, enhance the level of information integration, improve the accuracy of information and the degree of Visual considerations to overall design the system.

2.1 Physical structure model of the system

Crossing and spanning tangent tower security monitoring system can be understood as a Internet which is established on the basis of Internet. We can query information in the database by authorized and protect the internal network through the firewall. The physical structure model of the system is shown in Figure 1.

![Physical structure model of the system](image)

Figure 1. Physics structure model of the system

2.2 Dynamic displacement monitoring

Displacement measuring points are arranged in the junction of the tower head and the lower cross-arm, the tower head and the middle cross-arm. It is needed to install 4 vibration sensor arrangement to monitor two horizontal directions (x, y direction) of displacement for every two points. Two vibration sensors and data acquisition chassis are connected together in each layer, Data acquisition box built-in wireless communication module to communicate with the computer, will transfer these vibration signal collected to computer for data storage, Processing and analysis.

Magnetic-electric acceleration vibration pick-up are used to monitor the dynamic displacement. The pick-up are equipped with four tap positions for Corresponding to acceleration, low speed, medium speed and high speed. By using a hardware or software integration to do once integration, it can also be used to measure dynamic displacement. medium speed tap position can be used to measure vibration condition for the transmission tower-monitoring. In order to facilitate the processing and analysis of test signal, wind speed and direction, temperature need to be measured synchronously.
2.3 Wind speed and direction, temperature monitoring
Measuring the local open flat on the ground 10 m height in 10 min average wind speed as the observation data, Using probability statistical method to get the maximum wind speed which will happen once 50 years, Sensors are installed on the Tower from the ground height of the 10m, the average wind speed measurement time is 10 min. In order to research the wind speed at the different height, one wind speed and direction sensor should be installed on the Tower from the ground height of the 20 m. Meanwhile, layout temperature measurement points from the ground height of the 10m, the temperature sensor is used to measure dynamic temperature.

Wind speed and direction sensor and temperature sensor uses intelligent sensors, which has high detection accuracy and reliability and a long service life. Sensors are connected to data acquisition instruments for Measuring wind speed and direction, and temperature.

2.4 Data acquisition system
The key of remote monitoring system of transmission tower is the field data acquisition system. The system is designed for the long-term monitoring and design of the harsh field environment. The system adopts the waterproof and anti electromagnetic interference case to satisfy the working environment of the field condition, the modular design is adopted, for the system with high compatibility and good compatibility.

Different data acquisition card can be selected according to the actual monitoring requirements, so that a machine can be used to complete the signal acquisition of the physical quantity such as speed, acceleration, displacement, force, pressure, strain, temperature and so on. Online monitoring data acquisition system can be a variety of data transmission (100M Ethernet, Fiber, 3G / 4G) available for field testing and laboratory tests provide a high-performance test solution. According to the different needs of users, it is easy to set up data collection network.

Using wireless transmission mode can eliminate the noise caused by cable transmission. Data acquisition system can set the sleep function, when no data is collected, the instrument can be set to sleep mode to reduce power consumption; Data can be transmitted to the remote client computer in real time, and can also be saved to the field industrial control computer hard disk; When the wireless signal is interrupted, the industrial computer can real-time save the collected data, until the signal is restored, the data acquisition system can resume and continues from the interrupt point data acquisition and transmission of data.

Online monitoring data acquisition system can be equipped with a variety of sensors to meet the needs of large-scale structure monitoring. The collection system meets the requirements of the standard specification, the acquisition equipment has high precision, and can work reliably for a long time; Synchronization between the acquisition instrument channel is good, satisfy the requirements for synchronization; acquisition instrument adopts waterproof and dustproof design, and can work continuously under harsh environment.

2.5 Wind-solar Complementary Power Supply System
Monitoring system using wind-solar complementary power supply system for on-site power supply. Wind-light complementary system consists of solar panels, solar inverter controllers, wind turbine, wind inverter controller, storage battery, battery container. The principle is: The current generated by the solar cells irradiated by sunlight through the inverter controller for battery charging, the batteries can be converted into DC power through the inverter controller used for electrical components. The wind turbine is working in the wind, the resulting current through the inverter controller to charge the battery, the batteries can be converted into DC power through the inverter controller used for electrical components.
2.6 Arrangement of measuring points
Figure 2 is a schematic diagram of transmission tower displacement, wind speed and direction, temperature test system. In the figure: ● represents the displacement measuring point, ⊕ indicates wind speed and direction measuring point, ⊙ indicates the temperature measuring point.

![Diagram of measuring points](image)

(a) The practical height of 27 m straight line tower
(b) The practical height of 24 m straight line tower

Figure 2. Measuring point layout diagram

3 Measuring instruments and data analysis

3.1 Online monitoring and data acquisition system
Online monitoring data acquisition system is a kind of multifunctional test system used in ultra-low frequency or low frequency vibration measuring, mainly used for pulse measurement of ground and structure, industrial vibration measurement of general structure, ultra-low frequency and large amplitude measurement and weak vibration measurement of high flexible structures. Magneto-electric acceleration vibration pickup using passive closed-loop servo technology, obtained the good ultra-low frequency characteristics. Vibration pickup is equipped with four gears: acceleration, low-speed, medium speed and high speed. The resolution of the online monitoring data acquisition system AD is 16-bit, and the sampling frequency is 200Hz. It can be installed on the site or within the standard cabinet for monitoring room, testing or long-term monitoring about civil engineering, building and large equipment, make continuous, real-time, on-line health monitoring and assessment on the state of the whole structure, and make the real-time and accurate evaluation of structural safety, greatly extended the traditional manual testing content, to achieve predictive maintenance, improve the management level of maintenance, ensure the reliability, safety and durability of transmission tower and large building structure, and avoid catastrophic events.
3.2 Wind speed and direction sensor
The wind speed and direction sensor adopt the integrative design, and the dynamic characteristic is good. The wind cup is made from carbon fiber materials, high strength, good start; The wind transducer is configured with low inertia wind vane and precision potentiometer, high sensitivity, high precision. The product has the advantages of large measuring range, good linearity, convenient observation, stable and reliable, can be widely used in meteorology, marine, environment, airports, ports, laboratory, industry and agriculture and transportation and other fields. Convenient for users to further process analysis of meteorological data.

3.3 Temperature Sensor
Temperature sensor is a kind of resistance temperature detector made of platinum (Pt), belonging to the positive resistance coefficient, the relationship between resistance and change of temperature are as follows: \( R = R_0 (1+\alpha T) \), \( \alpha = 0.00392 \), \( R_0=100\Omega \) (at 0 ℃ resistance value), T is Celsius. This project adopts the platinum resistance temperature sensor, temperature measuring probe part consisting of fixed screw thread and temperature measuring protective tube, precision can reach the grade A, conductor adopts four wire system, eliminate outside interference, ensure the accuracy of temperature monitoring.

3.4 magnetic-electric vibration pickup
Sensor uses a passive closed loop servo technology to get a good ultra-low frequency characteristics. There are fourth gears about acceleration, small speed, medium speed and high speed in sensor. According to need, user can select sensor miniature toggle switch different files to the acceleration or velocity measurement. It is mainly used for ground and structures of pulsation measurements, the general structure of industrial vibration measurement, high soft structure ultra low frequency and large amplitude measurement and weak vibration measurements.

3.5 data analysis and processing
According to the data provided by measurement to obtain professional status analysis spectrum (Figure 3), and the persons can easily grasp the equipment operating status by analyzing the spectrum. The spectrum comprises:
   a) Time-Domain diagram ---- the time-domain waveform display waveform data of the currently selected measuring point;
   b) Spectrogram ---- Spectrogram display the results of spectral analysis of the currently selected measuring points;
   c) Trend chart ---- software can select trend characteristic value curve at different time periods.

![Figure 3. Analysis of the state atlas](image)

4 Conclusion
Remote monitoring system for crossing and spanning tangent tower can collect vibration status parameters of the transmission tower and local weather data, it can also get transmission towers’ status information from the remote monitoring center. The system has been successfully applied on part of
crossing and spanning tangent tower and provides the basis for secure diagnosis and assessment of transmission tower.

From the previous strong convection weather disaster, we can know that there are no essential difference between the tower collapse accident caused by hurricane in china and abroad, it is urgently-needed to study diagnosis and evaluation technology of transmission tower safety for providing guidance to protection and reconstruction of crossing and spanning tangent tower and ensuring the safety of transmission line operation.

The design of transmission tower is mainly based on the calculation of static load and instability, and seldom based on dynamic analysis. So the research and data accumulation of the research on safety assessment and protection technology of crossing and spanning tangent tower in strong convective weather can provide an important basis for the transmission towers design standard modifications in China.

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