Research on Integrated Monitoring System of Offshore Wind Farm

Mingsheng Zhang[1], Hesong Wu[2, *], Wenkui Wan[1] and Peilei Feng[3]

[1]Kunming University of Science and Technology Oxbridge College Kunming, China
[2]Diqing Grid Bureau, Yunnan Grid Corporation Limited, Diqing StateDiqing, China
[3]School of Electrical and Information TechnologyYunnan Minzu University Kunming, China

*Corresponding author e-mail: sci7663571@163.com

Abstract: Due to the wide distribution of offshore wind farms and the harsh climate of the sea, the operation of wind farms is very difficult. It is unrealistic to manage offshore wind farms according to the operation and management mode of land based wind farms. In order to ensure the safety, stability and economic operation of the offshore wind farm, the intelligent operation of the offshore wind farm is realized. A complete offshore operation monitoring technology scheme is proposed in this paper. Recently, operators can conduct centralized monitoring of wind farms on land onshore centralized control center, and offshore booster stations can be operated on an "unattended" mode. The long term wind farm runs on the way of "no man on duty and few people are on duty". Meanwhile, it supports operation managers to realize remote centralized monitoring of wind farms in remote centers.

1. Introduction

China solemnly promises to the world the target of greenhouse gas emission reduction by 2030, and the State takes the active development of new energy as an important direction of the energy strategy. In the "12th Five-Year" period, the new energy of our country entered the stage of large-scale development, and the offshore wind power is one of the most important areas. The state organized the coastal provinces (cities) to prepare the marine wind power development plan and promote the construction of pilot demonstration projects. It has formulated the policy system of the sea wind power price and the full guarantee of the purchase. It also actively promotes the development of offshore wind power. By the end of 2016, the installed capacity of offshore wind power in China was 148 ten thousand kilowatts, including 112 ten thousand kilowatts in Jiangsu, 300 ten thousand kilowatts in Shanghai and 60 ten thousand kilowatts in Fujian, and the offshore wind power industry chain was gradually built and developed [1].

In view of the characteristics of offshore wind power, the integrated monitoring scheme is innovatively applied in the demonstration of new technologies. The monitoring system has more complete functions which makes it possible for intelligent monitoring and early warning of wind farms. The main contents include the overall design of the offshore wind farm monitoring and control system and the detailed design of the subsystems.

2. Conceptual design

The integrated monitoring and control scheme is adopted in the computer monitoring and control system for offshore wind farms. The offshore wind farm monitoring and control system are responsible for the remote monitoring of the wind turbine and its booster equipment, the centralized control of the booster station and the electrical equipment of the centralized control center.

The integrated monitoring system of wind farms is divided into five functions, including operation monitoring, operation and control, information comprehensive analysis and intelligent alarm, operation management and assistance. The five applications are closely related to the input and output of data, as well as the collection of data and the transmission of information [2].

The operation monitoring functions include running state monitoring, equipment status monitoring, remote browsing and so on. Operation and control functions: dispatch control, station operation, reactive power optimization, load operation, sequence control, anti-error locking, intelligent operation ticket and so on. Information comprehensive analysis and intelligent alarm function: data identification in wind farm, comprehensive analysis of fault, intelligent alarm and so on.

Operation management functions: authority management, equipment management, fixed value management, maintenance management and so on. Auxiliary application functions: power monitoring, safety protection, environmental monitoring, auxiliary control and so on. The principle structure diagram of the technical scheme is shown in Figure 1.

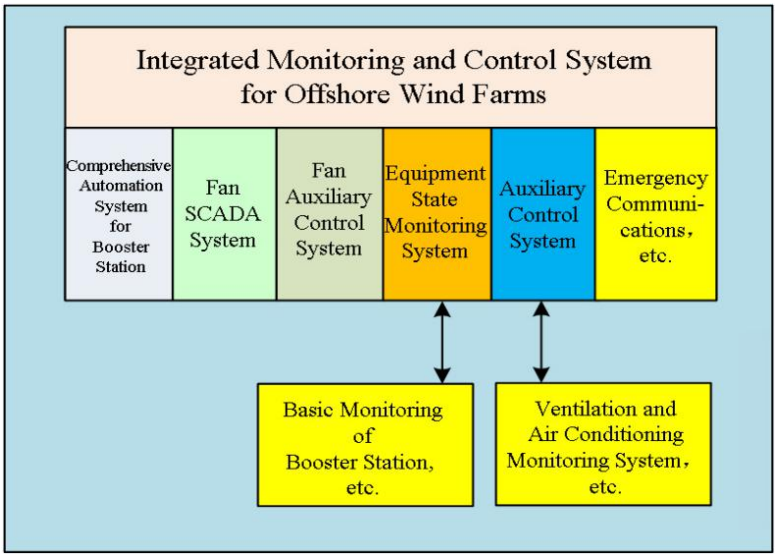

Figure 1. Principle structure diagram of technical scheme

The advantage of the scheme is that the technology is mature, the control level is clear, the operation background is effectively integrated, the operation and maintenance personnel are monitored conveniently, the number of operation and maintenance personnel can be effectively reduced, and it is suitable for occasions where few people are on duty. The shortcoming is that the application is less and the operation experience is short. At present, there have been a number of monitoring system manufacturers (such as NARI-RELAYS, Nari, Beijing Quartet etc.) to develop the monitoring system scheme. This scheme has offshore wind farm applications, such as the Zhuhai Shan offshore wind farm, Huaneng Jiangsu Rudong offshore wind farm.

3. The overall architecture of the system

The offshore wind farm monitoring system adopts the layered, distributed and open network structure.

It is mainly composed of station control layer equipment, interlayer equipment and network equipment.

(1) Station control layer equipment

The monitoring equipment of the station control layer collects the monitoring information of the wind turbine and its booster equipment through the data acquisition system, and the monitoring information of the booster station and the centralized control center. Save processing data on a local data server. Display on the monitoring background. At the same time, the command of the power grid dispatching and the work instruction on the spot control the wind farm [3].

The offshore wind farm integrated monitoring system, wind farm power prediction module, collects meteorological data from wind farms, and accepts numerical weather forecast data from meteorological departments. The output power of the wind farm is predicted by the corresponding model. Send the prediction results to the system host of the centralized control center to support the power dispatching center of the power dispatching center.

(2) Interlayer equipment

The interlayer mainly includes the wind turbine control system, the boost station and the electrical measurement and control device of the centralized control center and so on. On the one hand, the interlayer equipment collect the information from the field and send it to the station control layer, on the other hand, the command of the receiving station control layer controls the equipment on the spot.

Wind farm monitoring system network construction through 10/100M Ethernet 10/100M switch, using the international standard network protocol. Each communication manager and server use dual hot standby. Automatically complete the network data synchronization function. Network configuration grid has a dual function of load balancing and hot standby. Under normal circumstances, once the load is balanced, once one of the network failures occurs, the other network will completely replace the communication load and ensure the reliability of the real-time system.

The communication between wind turbines and marine booster stations on every collection line adopts optical fiber double ring network. The physical medium adopts submarine cable composite single mode optical fiber. It has the advantages of high speed, good real-time and high reliability.

(3) Intermediate link layer equipment

The middle layer device for SDH optical transceiver 2.5G, as the offshore booster station to the land in the information transmission channel between the control centers.

Optical fiber communication is used to connect the remote center of Zhanjiang and the centralized control center of Zhanjiang roonland.

3.1. The comprehensive automation system of the booster station

Integrated automation system of booster station responsible for 220kV submarine cable line, main transformer, 35kV line, 35kV station centralized control and monitoring and public equipment etc.

The structure of layered, distributed and open network is mainly composed of station control layer equipment, interlayer equipment and network equipment. The station control layer equipment includes the mainframe and operator workstation, the telecontrol workstation, the five defense system, the time synchronization system, and the redundant configuration of the telecontrol communication equipment. The interlayer equipment mainly includes the inner measuring and controlling unit and the intelligent equipment of the booster station. Network equipment mainly includes network switch, optical / electrical converter, interface equipment and network cable and network security equipment. The Ethernet of the station control layer network should have good openness and communication with other monitoring subsystems. The interlayer network adopts Ethernet, which should have enough transmission rate and high reliability [4].

The booster station and the control center control room set up the host / operator station of the monitoring system for the booster station, respectively. Booster station and control center monitoring equipment by 2*24 core composite fiber 1 back in 220kV cable communication.

3.2. Wind turbine monitoring system and fan auxiliary control system

The monitoring system of wind turbine and its booster equipment mainly includes the monitoring system of wind turbine and the monitoring system of the booster equipment.

3.2.1. Wind turbine monitoring. The wind turbine monitoring system is used to monitor and control the operation of wind turbines, including the unit control system and the remote monitoring system (SCADA), which are provided by fan manufacturers. The communication protocol of the monitoring system must be open. The unit control system meets the requirements of "unattended" operation. It should have a complete state monitoring function. It can detect all the unsafe conditions and stop operation so that the fan is in a state of safety or no damage. The control system of wind turbine should be able to adjust the active power, reactive power and voltage of the unit, so as to meet the requirements of remote control of active power, reactive power and voltage automatically. The SCADA system of wind turbines should be able to allocate active power and reactive power instructions to each typhoon unit, so as to meet the requirements of remote control of active power, reactive power and voltage automatically.

The wind turbine monitor screen, two sides, which are placed in the sea boost station; the fan monitors the host screen, two sides, which are placed on the land centralized control center.

3.2.2. Fan auxiliary control system. Fan auxiliary control system mainly includes fan video surveillance system, fan emergency IP telephone system, fan fire alarm system, wind measurement system. The fan video surveillance system.

Each typhoon machine is equipped with video surveillance equipment (select the high quality brand products confirmed by the tenderer). The product must have the performance of the installation and operation of the wind field at home and abroad. The device needs to be able to monitor video in the environment of high salt fog and strong interference. The system uses video management server as the core of the video system. Based on the enterprise server and stable operation system, it can update seamlessly according to functional requirements without changing the whole system architecture. Video should use advanced H.264, MJPEG, MPEG-4 and other coding techniques to carry out video display and storage of smooth and high compression ratio [5].

1) The fan emergency IP telephone system

Each typhoon machine is equipped with a set of emergency IP telephone, which is required to be able to communicate in high salt fog and strong interference on the spot environment. The bottom of the fan tower and the engine room should have 1 IP telephone interfaces for temporary access to the IP telephone. Each IP telephone is used to monitor the system network with the aid of the high and low voltage equipment of the unit. It is connected to the small program control switch of the land centralized control center and the post and telecommunications network through the network port. Thus the IP-PBX voice telephone system is set up.

2) The blower fire alarm system

The fire detectors in the wind turbine fire detection system mainly include smoke detector, air sampling detector and cable type linear temperature detector. The smoke detector is extremely sensitive to the smoke particle reaction and can react quickly to the smokeless fire with obvious temperature change; Because of the high sensitivity, the air sampling detector can detect the smoke particles at the primary stage of the fire, so that the potential fire can be alerting early; The cable type linear temperature detector reaches the rated starting temperature at any point within its length range, which will produce a fire alarm signal.

3) Wind measurement system

The wind power station weather station needs to configure two sets of wind measurement system (the wind velocity measurement range is not less than 75m/s).

3.3. Equipment state running monitoring system

The monitoring system of equipment state operation mainly includes the basic monitoring system of the booster station, Main variable state monitoring system, GIS state monitoring system and 220kV submarine optical cable composite cable integrated on-line monitoring system.

3.3.1. The basic monitoring system of the booster station. The basic monitoring includes the monitoring of the slope of the booster station, the monitoring of horizontal displacement and vibration acceleration, the monitoring of the reinforcement stress in the foundation cap of the booster station, and the strain monitoring of the foundation steel pipe pile. The basic monitoring should meet the performance of monitoring reliability, adaptability of interface, adaptability to bad environment, lightning protection and anti electromagnetic interference.

3.3.2. Main change and GSI state monitoring system. The main transformer and GSI state monitoring system of the sea booster station, which monitor the state of the 2 220kV main changes and the GIS. The SVG step-down state monitoring system of the land centralized control center, which monitors the SVG step-down changes.

3.3.3. Integrated online monitoring system for 220kV submarine optical cable electrical composite cable. The 220kV submarine optical cable electrical composite cable integrated on-line monitoring system is used to monitor the state of the 220kV submarine optical cable.

3.4. Auxiliary control system

The auxiliary control system includes: ship traffic management system (AIS system), automatic fire alarm and fire control system, ventilation and air conditioning monitoring system, video surveillance and access control system.

3.4.1. Ship traffic management system. A set of marine marine automatic identification system (AIS). We use very high frequency (VHF) antenna receiving high voltage cable around the ship course, a route, ship name, etc. It can real-time tracking of submarine vessels near the information, and can focus on tracking the submarine ships into the warning area.

3.4.2. Fire automatic alarm and fire control system. The fire alarm and fire control control can be carried out on the sea lift station by the fire alarm and the fire control control panel. The design of automatic fire alarm and fire fighting linkage system is in accordance with the relevant provisions of the "fire protection code for the design of thermal power plants and substations" GB50229. It can be operated and monitored by the land centralized control center. When there is a fire in the sea rising pressure station, the automatic fire alarm system can act with video surveillance and entrance guard system and ventilation and air conditioning monitoring system.

In the same way, the corresponding content of the land centralized control center is similar to the sea boost station.

3.4.3. Ventilation and air conditioning monitoring system. A ventilation and air conditioning monitor is set up at the sea boost station.

A set of ventilation and air conditioning monitoring system is set up to realize centralized monitoring and control of ventilation and air conditioning equipment at sea boost station.Ventilation control system adopts the combination of automatic control and remote control, set the local control box.Operate and monitor of equipment in the field, can control room host control machine remote monitoring of equipment in.

3.4.4. Video surveillance and access control system. The sea boost station and the land centralized control center set up a video surveillance and entrance guard system screen respectively.Video surveillance and access control system can effectively monitor, record and replay the important parts and areas, such as main electrical equipment, channel, entrance and exit and so on.

Meet the requirements of safe operation, fire prevention and anti-theft.Video monitoring and access control system and fire automatic alarm system linkage, and can be in the land centralized control center to realize the screen switching.The function of the entrance guard management system should

include real-time monitoring, access control, recording, alarm and fire alarm linkage.The equipment selection of the entrance control management system should be in accordance with the relevant regulations of the current national standard "code for engineering design of the entrance and exit control system" GB 50396 [6].

3.5. Wind power prediction system

Wind power forecasting system of wind power generation includes:

(1) The micro power real time wind acquisition system: collecting the meteorological information of the wind farm in real time.

(2) prediction of wind power output: according to the data of the wind farm for many years, the actual running power curve of the fan is fitted.Including the ultra short term prediction of wind and wind power output forecast.The prediction system should have 0~48h short-term wind power prediction and 15min~4h ultra short term wind power prediction function, and submit the load prediction curve according to the requirements of the dispatching department.

3.6. Emergency communication system

A set of emergency communication systems, including satellite telephone and other equipment, is used for the safe communication of personnel under extreme conditions.The marine booster station is equipped with two-way wireless walkie talkie, search and rescue radar responder (SART), satellite emergency location indicator (EPIRB), navigation warning (NAVTEX) receiver and maritime satellite communication mobile phone, etc., as marine emergency communication.

4. Summary

In this paper, a set of fully functional, stable and reliable offshore wind farm monitoring and control system is built to monitor and manage the whole offshore wind farm.In the near future, the personnel in the land centralized control center carry out the centralized monitoring of the wind farms, and the sea booster stations can operate by "unattended".The long-term wind farm is operated by the way of "no man on duty and few people are on duty". The operators can realize the remote centralized monitoring of the wind farms in the remote center of the city.So as to realize the intelligent operation of the offshore wind farm.

References

[1] Xu Long Bo, Li Yudong, Wang Xiao Yong, Yang Li. A tentative plan for the digital development of offshore wind power field [J]. power system automation.2014.38 (3): 189-194.

[2] Yuan Zhaoxiang, Qi Lizhong intercalated Peili, etc. two offshore wind farm design key technology [J]. electric power construction.2015.36 (4): 128-133.

[3] Dong Yingrui, Chen Xiaoyun, Tan Jiangping. Research on the configuration of uninterrupted power system for offshore wind farms [J]. enterprise technology development.2017.36 (11): 82-84.

[4] Dai Jianjun, Zhao Guoqun, shaoke, Cai Lulu. Application of wireless Ethernet communication system in wind power field [J]. wind farm.2013.9 (6): 68-73.

[5] Yang Ning, Li Ping, Yang Xuhong. Application and analysis of ground wireless measurement and control network in electric power inspection [J]. Journal of Shanghai University of Electric Power: Natural Science Edition, 2009, 25 (1): 23- 25.

[6] Liu Lin, Ge Xubo, Zhang Yibin and so on. The current situation of the development of China's offshore wind power and analysis of [J]. energy technology and economy, 2012, 24 (3): 66-72.