**Overview of Central Monitoring System**

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# System Overview

The Central Monitoring System, namely The Central Monitoring Security Version System (hereinafter referred to as The Central Control System), is a basic platform for functional requirements design and new research and development based on years of experience in wind farm monitoring operation and maintenance. Platform-based distributed system architecture, modular design, full use of network programming technology, multi-threaded concurrency, asynchronous mode, real-time library, cross-platform development (Windows, Linux), predictive algorithms, embedded development and other technologies to achieve a set of a safe wind farm monitoring system with high stability, high operating efficiency, easy to use, low maintenance, and convenient for secondary development.

# System Structure

The Central Control System is mainly divided into three layers：

* Network Layer

The network layer is mainly for Wtgs monitoring network equipment, including Wtgs switches and optical fiber networks.

* Database Layer

The database of the central control system includes a real-time database and a historical database, and the database layer mainly completes the function of connecting the previous and the next. The real-time database reads and writes data from the Wtgs, and then sends the current data to the client interface, and accepts the client's operation control request.

* Human-machine Interface Layer

The human-machine interface layer of the central control system can vividly display the current status of the Wtgs on the computer monitor, and allow the user to complete the control operation of the Wtgs. The client of the central control system can be configured with multiple, but the standard configuration is two.

The central control system is installed in the central control room of the wind farm to complete the monitoring and control of the Wtgs and provide a data platform for the expansion of the system. In the central control system, real-time data is the data that the data acquisition subsystem regularly transmits to the master station. These data mainly constitute the basis for various monitoring screen status, alarm information and report display in the monitoring system. In the case of a failure of the central control system, the operation of each Wtgs will not be disturbed. Similarly, in the case of a failure of each Wtgs, the operation of the central control system will not be disturbed.

# Network Layer

The central control system generally uses a double closed-loop network to connect all Wtgs(shown in Figure 1), and the system supports a larger number of closed-loop networks.

Each Wtgs is equipped with an industrial-grade switch. In the server cabinet, each closed-loop network needs to be configured with an industrial switch, and the model of the industrial switch is the same as all the switches in each Wtgs. The switch uses 2 optical ports and 3 electrical ports.

If the installation conditions on site are complex, more closed-loop networks can be configured. The optical fiber closed-loop network supports any point of network disconnection without affecting the network operation, and all data communication is normal.

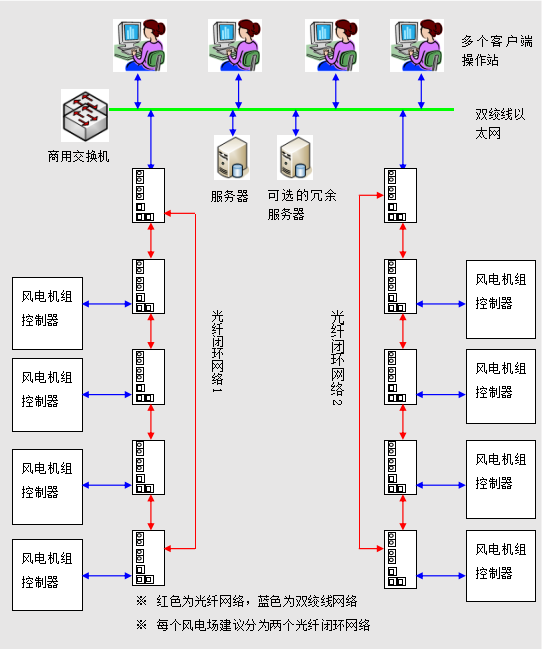


Figure 1. The Network Structure of The Central Control System

# Data Layer

The central control system supports simultaneous collection of data from all Wtgs in the wind farm, and all data collection uses concurrent connections.

The data collection of the central control system uses data memory blocks for data exchange to improve communication efficiency. At the same time, data collection also supports the designation of the data exchange rate of each memory block, which improves the need by reducing the refresh rate of unnecessary high-speed data collection memory blocks the data refresh rate of the high-speed acquisition data memory block.

## Real-time data

The real-time database can support redundant server configuration. If configured as mutually redundant servers, the system will automatically switch the servers in the dual computers.

The following are some data collection indicators:

* The real-time data processing module supports at least 20 client-side concurrent access, and it supports 20 operator stations.
* Supports continuous transmission when the network is disconnected to avoid loss of operating data caused by network failures.
* The communication protocol interface supports the CDT protocol, 104 protocol, ModbusRTU serial protocol, ModbuTCP network port protocol, etc. of the power industry, and other communication protocols can be dynamically added according to demand.
* Data collection supports remote configuration and maintenance, and remote centralized management of equipment.
* Support multi-device collection, such as Wtgs, box-type transformers, wind measurement towers, booster stations, electric energy metering, reactive power compensation, etc., and all device data supported by interfaces can be collected.

## Historical Data

The central control system uses an industrial-grade historical database to support unlimited data records without increasing the query time due to the increase in data volume. The following are some indicators:

* Data storage period: 0.2~2S; data statistics period: 1s real-time value, 1min, 5min, 10min, 1h average value.
* On-site second-level data storage time is greater than 6 months.
* On-site data preservation integrity: 99.99%.
* The fault start/end time is accurate to 1S.

# Human-machine Interface Layer

For the wind farm monitoring system, the operating conditions and main parameters of each Wtgs must be displayed first, and then the Wtgs must be remotely controlled. As one of the main components of monitoring application software, the human-machine interface is a direct way to realize the monitoring and control functions of the wind farm monitoring system, as shown in Figure 5. The human-machine interface of the central control system (shown in Figure 6) contains the following 8 modules: real-time monitoring, real-time data, data query, report statistics, curve analysis, box-type transformer monitoring, Wtgs control, and the following will introduce the functions of each module in detail.

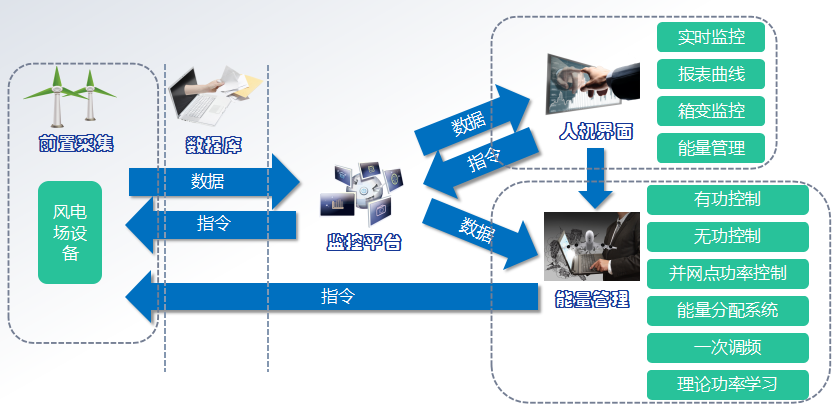


Figure 2. System Data Instruction Interaction Diagram

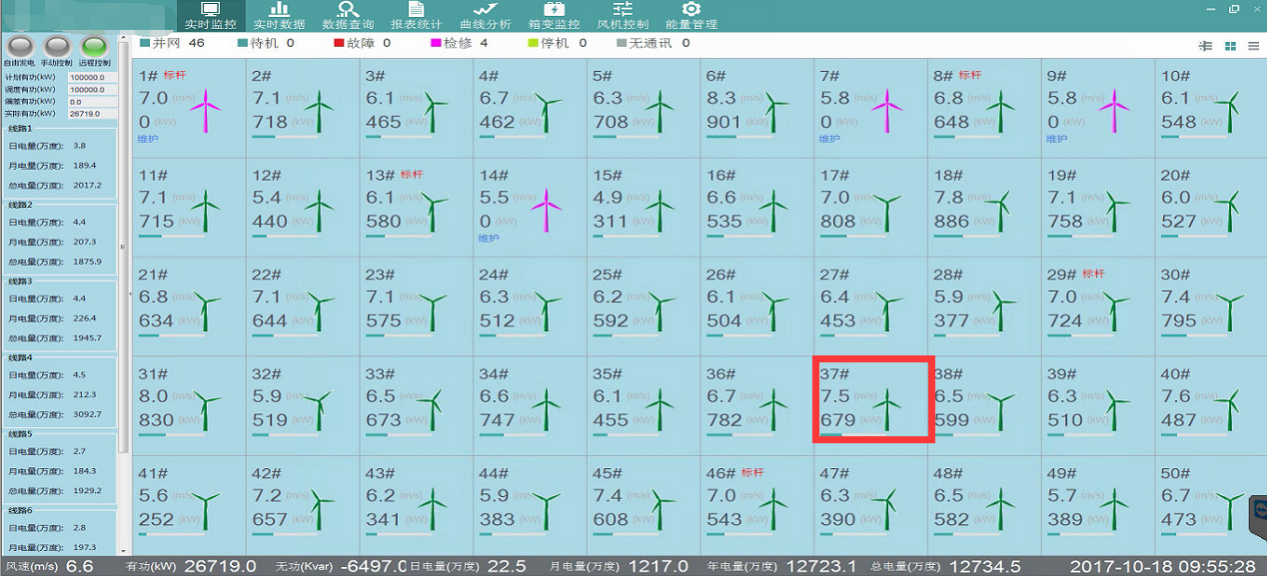


Figure 3. The Central Control System Interface

## Real-time Monitoring

Real-time monitoring can support free switching between the whole Wtgs monitoring screen and the single Wtgs monitoring screen. The real-time monitoring interface of the whole wind farm is the main interface of system start-up, which can view the distribution of all Wtgs in the entire wind farm, as well as the operating status, real-time wind speed and power of each Wtgs. Real-time monitoring of a single machine can view the real-time status of a single Wtgs. The detailed functions are as follows:

* Display the wind direction of the Wtgs to the north angle, wind speed, power, variable pitch angle, and speed information in the form of a dashboard.
* Display the static information, status and some statistical information of the Wtgs, the name and address of the owner.
* It can realize remote start, remote stop and remote reset, active/reactive power control. Also, real-time curve and real-time data can be browsed.
* Display the status history and fault history of the last month.
* The monitoring points of the data panel can be customized to achieve multiple monitoring points comparison according to actual needs (multi-temperature comparison, multi-IO comparison, etc.).

## Real-time Data

The real-time data module displays the current monitoring results of the Wtgs in the wind farm. The specific functions are as follows:

* Wtgs data of the whole wind farm is displayed in table form.
* Wtgs data of the whole wind farm is displayed in the form of a bar graph.
* Freely configure the Wtgs IO information that needs to be displayed.
* Real-time data can be exported to local.

## Data Query

The data query contains three sub-modules: fault data, status data, and minute data. High-integrity, high-precision fault data can help determine the cause of the fault, and take timely measures to solve the problem to reduce the loss of wind abandonment. The historical status statistics will provide important data support for Wtgs performance evaluation. Each sub-module can freely choose to query partial or full-field Wtgs data, and customize the query time range. All data can be exported to the local report. The specific functions of each sub-module are as follows:

**Failure Data:**

* View the fault details, fault number, duration and power loss of a single fault of the selected Wtgs.
* The start and end time of the fault data is accurate to the second.

**Status data:**

* View the historical status code, status description, first touch code, and first touch code description of the selected Wtgs.

**Minute data:**

* The client-side supports 1min, 5min, 10min, 1h data query, and second-level data is stored in the database.
* Freely choose the IO points you need to query, support custom data query templates, and add, delete, and modify the IO list of the template.

## Report Statistics

Statistics the various data in the form of reports to help users to conduct comprehensive data analysis. Report statistics include three sub-modules: power generation statistics, Wtgs performance statistics, and lost power generation statistics. All reports can be exported to the local area, and each sub-module can be freely choose to query partial or full-site Wtgs reports, and customize the statistical time range. Through power generation statistics, Wtgs performance statistics, and lost power generation statistics, the performance of Wtgs can be objectively and comprehensively evaluated, and a long-term power balance monitoring system can be established to ensure the wind farm in the early stage of power loss, it can be detected in time and dealt with effectively to prevent the expansion of power loss and ensure that economic benefits are not affected. The specific functions of each submodule are as follows:

**Power generation statistics:**

* Support time report, daily report, monthly report and all data.
* The statistical results include Wtgs, time, average wind speed, maximum wind speed, minimum wind speed, power generation, and full power hours.
* Total data of query results can be displayed.

**Wtgs performance statistics:**

* The statistical results include Wtgs, wind speed, effective wind hours, power generation hours, equivalent utilization hours, power generation, number of failures, failure hours, maintenance hours, hours of waiting for wind, hours of power restriction, hours of yaw and availability.
* Total data of query results can be displayed.

**Statistics of lost power generation:**

* The statistical results include the number of Wtgs, potential power generation, actual power generation, failure loss power generation, maintenance loss power generation, remote shutdown loss power generation, maintenance loss power generation, grid power curtailment loss power generation, and master control power curtailment loss power generation.

## Curve Analysis

The curve analysis includes four sub-modules: power curve, free trend, relational curve, and wind frequency graph. Each sub-module supports data display, freely selects the time range to be queried, and exports graph data or table data to the local.

**The power curve** is the corresponding curve between the power of the Wtgs and the wind speed. During the operation of the Wtgs, the power always changes with the change of wind speed. The trend of the power curve can describe the relationship between power and wind speed intuitively. The monitoring system power curve module can query 5 Wtgs at the same time, and provide the standard power curve as a reference. The display methods include trend graph and scatter graph.

**The free trend module** can freely select IO points to view the trend graph (curve), and supports single Wtgs multi-points and multi-Wtgs single point modes. Single Wtgs multi-points can display the trend of multiple IO points for a single Wtgs in a certain period of time figure, supports simultaneous selection of three IO points for comparative analysis. Multi-Wtgs single point modes can display the trend graph of the same IO point for multiple Wtgs within a certain period of time, and supports simultaneous selection of three Wtgs for comparative analysis.

**The relational curve** can view the relationship trend chart between any two IO points of a certain Wtgs within a certain period of time, and at the same time, the XY axis can be switched according to needs.

The wind frequency chart is used to count the occurrence frequency of different wind speeds of a specified Wtgs in a certain period of time. The X axis is the wind speed, and the Y axis is the number of occurrences of the corresponding wind speed. It supports selecting three Wtgs at the same time for comparison and query.

## Box-type Transformer Monitoring

View the remote measurement and remote signaling value of the Wtgs box-type transformer, and can perform remote opening or closing operations.

## Wind Turbine Generator System(Wtgs) Control

The selected Wtgs can be remotely started/stopped, and all control actions will be saved in corresponding records, and the Wtgs control command history query will be provided to ensure that the operation records can be traced.