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# Technical code for designing computerized monitoring and control system of 220~500kV substations

200~500kV 变电所计算机监控系统设计技术规程

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# 1 Scope of application

This Code is applicable to the design of computerized monitoring and control system for the newly built 220kV hub substations and 500kV (330kV) substations. Expansion and reconstruction projects of the same voltage grade may be carried out with reference.

# 3 General

**3.0.1** This Code is specific design regulations for 500kV (330kV) substations and 220kV hub substations using the computerized monitoring and control system, and is supplementary regulations for implementing the relevant provisions of *Technical code for designing 220~500kV substations* and *Technical code for designing of electrical secondary wiring in fossil fuel power plants and substations*.

**3.0.2** The design of the computerized monitoring and control system of substations shall follow the following principles:

1) Improve the safety production level, technical management level and power supply quality of substations.

2) Make the substations easy to operate and simple to maintain, improve labor productivity and operating efficiency, and realize the reduction of labor and enhancement of efficiency.

3) Reduce connection between secondary devices, and save control cables.

4) Reduce the configuration of substation equipment, avoid repeated equipment settings, and achieve resource sharing.

5) Reduce the area of substations and the project cost.

**3.0.3** The selection of the computerized monitoring and control system of substations shall be safe, reliable, economical, advanced in technology, and in line with nationality. Mature and reliable products that are open, extensible, and highly resistant to interference shall be adopted.

**3.0.4** The computerized monitoring and control system of substations shall be able to realize reliable, reasonable and perfect monitoring of substations, shall have all telecontrol functions such as telemetering, tele-signalisation, tele-regulation, telecontrol, etc., and shall be capable of exchanging information with the computer system of the dispatching communication center.

**3.0.5** In addition to the implementation of this Code, the design of the computerized monitoring and control system of substations shall also carry out relevant standards, specifications and codes, and regulations.

# 4 Main terms

### 4.0.1 Hierarchical

A way to organize elements at different levels. Among which, the elements of the higher level have a control relationship with the elements of the lower level.

### 4.0.2 Distributed

Refer to the distribution of the composition of the computerized monitoring and control system of substations in resource logic or topology, mainly focusing on the distribution problem on processing and distribution problem on functions from the perspective of system structure.

### 4.0.3 Decentralized

Refer to the composition of the computerized monitoring and control system of substations in terms of physical significance relative to centralization, emphasizing the object-oriented and geographic decentralization.

### 4.0.4 Data acquisition

Convert all kinds of electrical quantity and status signals in the field into digital signals that can be recognized by the computer and store in the computer system.

### 4.0.5 Data processing

Systematize all kinds of data of related equipment to support the system to complete the functions of monitoring and control, protection, control and recording.

### 4.0.6 Monitoring and control

Verify whether functions are performed correctly by continuous or periodic monitoring and control of the system or equipment, and adapt their operating conditions to changing operational requirements.

### 4.0.7 Interface

Interface or connection device between two different systems or entities.

### 4.0.8 Communication protocol

The strict conventions necessary to initiate and maintain communication, i.e., a set of conventions regarding the sequence in which information is transmitted, the format of the information, and the content of the information.

# 5 System composition

## 5.1 System structure

**5.1.1** The computerized monitoring and control system of substations should be composed of two parts: station level and bay level, and connected by hierarchical, distributed, and open network system.

**5.1.2** The station level is composed of a main unit or/and an operator station and various functions of the computerized monitoring and control system connected by the computer network, provides the man-machine interaction interface running in the station, realizes the functions of management and control of bay level equipment, forms a full station monitoring and management center, and can communicate with the dispatching communication center.

**5.1.3** The bay level consists of several monitoring and control subsystems connected by the industrial control network/computer network. In the case of station level and network failure, the local monitoring and control function of the bay equipment can still be completed independently.

**5.1.4** The station level can be directly connected to the bay level or connected via a pre-layer device. The pre-layer can communicate with the dispatching communication center.

**5.1.5** The station level equipment should be set centrally. The bay level equipment should be decentralized in a relatively centralized manner. When the technology is economically reasonable, it can also be set in a fully decentralized manner or in a fully centralized manner.

## 5.2 Network structure

**5.2.1** The station level and bay level of the computerized monitoring and control system may adopt a unified computer network, or different networks, respectively. When adopting a unified network, it is advisable to adopt a network structure recommended by international standards.

**5.2.2** The station level should use Ethernet recommended by international standards. The station level system shall have good openness.

**5.2.3** The bay level should adopt industrial control network, which shall have sufficient transmission rate and extremely high reliability. Direct communication between bay level monitoring subsystems should be realized.

**5.2.4** The network topology should be either bus type or ring type, or star type. The physical connection between the station level and the bay level

should be of star type.

**5.2.5** When the station level and the bay level adopt the same network, nodes should be arranged in layers or segments to meet the requirements of network capacity and communication load rate.

**5.2.6** The station level of 500kV (330kV) substations should adopt a dual network, and run in hot standby mode, while the bay level can adopt a single network. A single network can be used for 220kV substations.

**5.2.7** The computer network of substations shall have the ability to connect with the national power data network, and realize the remote transmission of dispatching automation, protection, management and other information within the substations as required.

### 5.3 Hardware equipment

**5.3.1** The hardware equipment of the computerized monitoring and control system of substations should be composed of the following parts:

1) Station level equipment: Include the main unit or/and operator station, engineer station, telecontrol communication device, interface with electric energy billing system, public interface, etc.;

2) Network equipment: Include the network connection device, optical/electrical converter, interface device and network connections, cable, optical cable, etc.;

3) Bay level equipment: Include the I/O unit, control unit, bay level network, interface with station level network, relay protection communication interface device, etc.

**5.3.2** The main unit configurations of the station level shall meet the functional requirements and performance indicator requirements of the entire system. The main unit capacity shall be compatible with the planned capacity of the substation. Products with excellent performance and in line with industrial standards shall be selected.

**5.3.3** The operator station shall meet the requirements of the operator for intuitive, convenient, safe and reliable operation.

**5.3.4** The main unit should be configured in a dual-unit redundancy.

**5.3.5** 500kV (330kV) substations should be equipped with dedicated engineer stations, while 220kV substations may not be equipped with dedicated engineer stations.

**5.3.6** Two sets of telecontrol communication equipment shall be set up. The

provide standard interface for users to access the database.

**5.4.6** The network software shall meet the requirements of information transmission, data sharing and distributed processing between each node of the computer network, and the communication rate shall meet the real-time requirements of the system.

**5.4.7** All necessary tools and software shall be configured.

**5.4.8** Application software must meet system functional requirements, mature, reliable, and have good real-time response speed and extensibility.

**5.4.9** The telecontrol communication equipment shall be configured with a tele-transmission database and a communication protocol that interfaces with the relevant dispatching communication centers at various levels to achieve telecommunication with the dispatching communication centers. The two sets of equipment shall be able to automatically switch between the alternate channels when the main channel fails.

**5.4.10** When a front-end unit is provided, the front-end unit should be configured with database and telecontrol protocol processing software to complete real-time data processing and data communication with the dispatching communication centers.

The station level network should communicate according to the TCP/IP protocol. The bay level network should communicate using the relevant national standard or IEC standard protocol.

**5.4.11** The application layer protocol for real-time communication with the dispatcher should adopt relevant national, industry and international standards for power. When configuring this interface, it shall be able to adapt to the various remote access needs after the completion of the national power data network.

## 5.5 Technical indicator

**5.5.1** The availability of the station level system is not less than 99.9%.

**5.5.2** The mean time between failures (MTBF) of the station level is not less than 20,000h.

**5.5.3** The mean time between failures (MTBF) of the bay level is not less than 30,000 hours.

**5.5.4** For the main unit, the normal load rate should be less than 30%, and the accident load rate should be less than 50%. For the network, the normal load rate should be less than 20%, and the accident load rate should be less than 40%.

**5.5.5** The analog-to-digital conversion resolution is not less than 12 bits, and the maximum error shall meet the requirements of DL/T 630-1997.

**5.5.6** The analog dead-band transmission time is no more than 2s (to the station level display).

**5.5.7** The on-off displacement transmission time is no more than 1s (to the station level display).

**5.5.8** The correct rate of telecontrol operation is not less than 99.99%, and the correct rate of tele-regulation is not less than 99.9%.

**5.5.9** The response time of the on-off signal input to screen display is no more than 2s.

**5.5.10** The resolution of the sequence of event (SOE) is no more than 2ms.

**5.5.11** The dynamic screen response time is no more than 2s.

**5.5.12** The timing accuracy error of the entire system shall be no more than 1ms.

**5.5.13** For equipment installed in the main control room, the electromagnetic immunity requirements can be referred to the general industrial standards; and the bay level equipment and the network equipment installed in the relay kiosk shall have immunity to this electromagnetic environment. The immunity of the bay level equipment and network equipment of the relay kiosk for 500kV (330kV) substations should meet the following test level requirements:

For electrostatic discharge In line with GB/T 17626-4-2, Level 4

For radiated electromagnetic field In line with GB/T 17626-4-3, Level 3 (Level 4 required for network)

For fast transient In line with GB/T 17626-4-4, Level 4

For impact (surge) In line with GB/T 17626-4-5, Level 3

For electromagnetic induction conduction In line with GB/T 17626-4-6, Level 3

For power frequency electromagnetic field In line with GB/T 17626-4-8, Level 4

For pulse electromagnetic field In line with GB/T 17626-4-9, Level 5

For damped oscillating magnetic field In line with GB/T 17626-4-10, Level 5

# 6 System functions

## 6.1 Data acquisition and processing

**6.1.1** The computerized monitoring and control system of substations shall enable data acquisition and processing functions, including analog quantities, on-off quantities, electrical energy, and data from other intelligent devices.

**6.1.2** Analog acquisition includes the signals of current, voltage, active power, reactive power, power factor, frequency, and temperature.

**6.1.3** On-off acquisition includes the position signals of breaker, isolation switch and grounding switch, action and alarm signal of relay protection device and automatic safety device, operation monitoring signal, and on-load tap changing transformer tap position signal.

**6.1.4** Electric energy harvesting shall include active energy and reactive energy data, and can achieve functions such as time-sharing accumulation and energy balance.

**6.1.5** For the on-load tap changing transformer tap position signal equivalent, it is advisable to use a hard-wired point-to-point acquisition method, and BCD codes or analog acquisition method can be used.

**6.1.6** For the analog quantity collected in real time, the validity check and corresponding processing shall be carried out. For the on-off quantity collected in real time, filtering shall be performed to eliminate contact jitter.

**6.1.7** The various information acquired through the data communication interface shall be processed separately.

## 6.2 Database establishment and maintenance

**6.2.1** The computerized monitoring and control system of substations shall establish a real-time database to store and continuously update all real-time data from the I/O units and communication interfaces.

**6.2.2** The computerized monitoring and control system of substations shall establish a historical database to store and regularly update historical data and operation report data that need to be saved.

**6.2.3** The data in the historical database shall be easily selected and combined as needed, dumped to a disc, and stored for a long time.

**6.2.4** The database shall be able to perform online maintenance, add, reduce, and modify data items.

**6.2.5** The database shall be extremely secure and all acquired data cannot be modified.

**6.2.6** It shall be possible to use the database management program offline to generate the database and have reasonable initialization data.

### 6.3 Control operation

**6.3.1** The control operation object of the computerized monitoring and control system of substations should include: breakers and isolation switches of various voltage levels, electrically operated grounding switches, main transformers and used transformer tap positions, and start/stop of other important equipment in the substations.

**6.3.2** The computerized monitoring and control system of substations shall have two control modes of manual control and automatic control.

**6.3.3** Manual control includes control of dispatching communication center, control of main control room in the substation, and local manual control. It also has the control energy switching function of dispatching communication center/main control room in the substation, and main control room in the substation/local manual operation. The sequence of control level from high to low is: local, main control in the substation, and remote dispatching center. Three control levels shall be interlocked with each other, and only one level of control is allowed at the same time.

**6.3.4** The step-by-step operation carried out on the dispatching communication center by the operator station for the main control in the substation shall be able to be executed after guiding and verifying the operation commands one by one.

**6.3.5** When the station level and network of the computerized monitoring and control system are out of service, the breaker shall be able to perform one-to-one operation at the bay level.

**6.3.6** Automatic control shall include sequence control and regulation control, which shall be set by the main control in the substation for adoption.

**6.3.7** Sequence control refers to the operation in the order of setting steps, i.e., select and combine the bypass generation, inverted bus and other groups of operations in the operator station (or dispatching communication center) in advance, and after the correct verification, automatically execute as required.

**6.3.8** Regulation control indicates that after the voltage and reactive power control target value is set, the computerized monitoring and control system automatically conducts a joint regulation of voltage and reactive power as

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