Fig.3 (left). Network.

3) Controllers, that interfaces with peripheral devices.
4) Databases where information collected.

SCADA forms the heart of power systems supervision and remote control systems. SCADA is a significantly important and progressive used in national infrastructures way to develop automatic of power stations and substations. However, SCADA systems may have security vulnerabilities, so the systems must identify risks and make the solutions to fetch down those risks.

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Types of Substations Differences in Equipment and Functions

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Introduction

A substation is a part of an electrical generation, transmission, and distribution system. Substations transform voltage from high to low, or the reverse, or perform any of several other important functions. Between the generating station and consumer, electric power may flow through several substations at different voltage levels.

Substations may be owned and operated by an electrical utility, or may be owned by a large industrial or commercial customer. Generally substations are unattended, relying on SCADA for remote supervision and control.

A substation may include transformers to change voltage levels between high transmission voltages and lower distribution voltages, or at the interconnection of two different transmission voltages. The word substation comes from the days before the distribution system became a grid. As central generation stations became larger, smaller generating plants were converted to distribution stations, receiving their energy supply from a larger plant instead of using their own generators. The first substations were connected to only one power station, where the generators were housed, and were subsidiaries of that power station.

Elements of a substation

Substations generally have switching, protection and control equipment, and transformers. In a large substation, circuit breakers are used to interrupt any short circuits or overload currents that may occur on the network. Smaller distribution stations may use recloser circuit breakers or fuses for protection of distribution circuits. Substations themselves do not usually have generators, although a power plant may have a substation nearby. Other devices such as capacitors and voltage regulators may also be located at a substation.

Substations may be on the surface in fenced enclosures, underground, or located in special-purpose buildings. High-rise buildings may have several indoor substations. Indoor substations are usually found in urban areas to reduce the noise from the transformers, for reasons of appearance, or to protect switchgear from extreme climate or pollution conditions.

Where a substation has a metallic fence, it must be properly grounded to protect people from high voltages that may occur during a fault in the network. Earth faults at a substation can cause a ground potential rise. Currents flowing in the Earth's surface during a fault can cause metal objects to have a significantly different voltage than the ground under a person's feet; this touch potential presents a hazard of electrocution.

Types

Substations may be described by their voltage class, their applications within the power system, the method used to insulate most connections, and by the style and materials of the structures used. These categories are not disjointed; to solve a particular problem, a transmission substation may include significant distribution functions, for example.

Transmission substation

A transmission substation connects two or more transmission lines. The simplest case is where all transmission lines have the same voltage. In such cases, substation contains high-voltage switches that allow lines to be connected or isolated for fault clearance or maintenance. A transmission station may have transformers to convert between two transmission voltages, voltage control/power factor correction devices such as capacitors, reactors or static VAR compensators and equipment such as phase shifting transformers to control power flow between two adjacent power systems.

Transmission substations can range from simple to complex. A small "switching station" may be little more than a bus plus some circuit breakers. The largest transmission substations can cover a large area (several acres/hectares) with multiple voltage levels, many circuit breakers and a large amount of protection and control equipment (voltage and current transformers, relays and SCADA systems). Modern substations may be implemented using international standards such as IEC Standard 61850.

Distribution substation

A distribution substation transfers power from the transmission system to the distribution system of an area.[2] It is uneconomical to directly connect electricity consumers to the main transmission network, unless they use large amounts of power, so the distribution station reduces voltage to a level suitable for local distribution.

The input for a distribution substation is typically at least two transmission or subtransmission lines. Input voltage may be, for example, 115 kV, or whatever is common in the area. The output is a number of feeders. Distribution voltages are typically medium voltage, between 2.4 kV and 33 kV depending on the size of the area served and the practices of the local utility. The feeders run along streets overhead (or underground, in some cases) and power the distribution transformers at or near the customer premises.

In addition to transforming voltage, distribution substations also isolate faults in either the transmission or distribution systems. Distribution substations are typically the points of voltage regulation, although on long distribution circuits (of several miles/kilometers), voltage regulation equipment may also be installed along the line.

The downtown areas of large cities feature complicated distribution substations, with high-voltage switching, and switching and backup systems on the low-voltage side. More typical distribution substations have a switch, one transformer, and minimal facilities on the low-voltage side.

Collector substation

In distributed generation projects such as a wind farm, a collector substation may be required. It resembles a distribution substation although power flow is in the opposite direction, from many wind turbines up into the transmission grid. Usually for economy of construction the collector system operates around 35 kV, and the collector substation steps up voltage to a transmission voltage for the grid. The collector substation can also provide power factor correction if it is needed, metering and control of the wind farm. In some special cases a collector substation can also contain an HVDC converter station.

Collector substations also exist where multiple thermal or hydroelectric power plants of comparable output power are in proximity. Examples for such substations are Brauweiler in Germany and Hradec in the Czech Republic, where power is collected from nearby lignite-fired power plants. If no transformers are required for increase of voltage to transmission level, the substation is a switching station.

Converter substations

Substations may be associated with HVDC converter plants, traction current, or interconnected non-synchronous networks. These stations contain power electronic devices to change the frequency of current, or else convert from alternating to direct current or the reverse. Formerly rotary converters changed frequency to interconnect two systems; such substations today are rare.

Switching substation

A switching substation is a substation without transformers and operating only at a single voltage level. Switching substations are sometimes used as collector and distribution stations. Sometimes they are used for switching the current to back-up lines or for parallelizing circuits in case of failure. An example is the switching stations for the HVDC Inga –Shaba transmission line.

A switching substation may also be known as a switchyard, and these are commonly located directly adjacent to or nearby a power station. In this case the generators from the power station supply their power into the yard onto the Generator Bus on one side of the yard, and the transmission lines take their power from a Feeder Bus on the other side of the yard.

Classification by structure

Outdoor, above-ground substation structures include wood pole, lattice metal tower, and tubular metal structures, although other variants are available. Where space is plentiful and appearance of the station is not a factor, steel lattice towers provide low-cost supports for transmission lines and apparatus. Low-profile substations may be specified in suburban areas where appearance is more critical. Indoor substations may be gas-insulated switchgear (at high voltages), or metal-enclosed or metal-clad switchgear at lower voltages. Urban and suburban indoor substations may be finished on the outside so as to blend in with other buildings in the area.

A compact substation is generally an unmanned outdoor substation being put in a small enclosed metal container in which each of the electrical equipment is located very near to each other to create a relatively smaller footprint size of the substation.

Automation

Early electrical substations required manual switching or adjustment of equipment, and manual collection of data for load, energy consumption, and abnormal events. As the complexity of distribution networks grew, it became economically necessary to automate supervision and control of substations from a centrally attended point, to allow overall coordination in case of emergencies and to reduce operating costs. Early efforts to remote control substations used dedicated communication wires, often run alongside power circuits. Power-line carrier, microwave radio, fiber optic cables as well as dedicated wired remote control circuits have all been applied to Supervisory Control and Data Acquisition (SCADA) for substations. The development of the microprocessor made for an exponential increase in the number of points that could be economically controlled and monitored. Today, standardized communication protocols such as DNP3, IEC 61850 and Modbus, to list a few, are used to allow multiple intelligent electronic devices to communicate with each other and supervisory control centers. Distributed automatic control at substations is one element of the so-called smart grid.

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Voltage control in the electrical network

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The current flow through the elements of the electrical network is attended with losses of voltage. It causes voltage reduction with increasing distance from the power supply. However voltage supplied to the electric consumer can vary slightly from the nominal voltage and should be within acceptable limits. In accordance with State Standard 13109-97 voltage deviation from the nominal value shall not exceed ± 5% for most consumers. In the post-emergency conditions, the duration of which is relatively small, voltage tolerance is increased by 5%. There are also acceptable voltage limit in the high voltage network. In particular, peak working voltage makes from 105 to 120% of nominal value and is determined by conditions of reliable operation of isolation for the high-voltage devices. In the electric power system voltage reductions are determined by the stability conditions of parallel operation of power station generators and load node. In supply networks lower voltage deviations reaches 10-15%. When we assess voltage levels, we should bear in mind that the load are continually changing during the day, therefore voltage losses and voltage levels of power consumers also change.

The electricity transmission scheme (fig. 14.1) demonstrates that it is impossible to ensure compliance the requirements for voltage deviations in modern power system without using special measures and devices. If we assume that on the path from the power generators to the receiver we have four transformation of electric energy. The voltage losses is 5 % at each transformation and 10 % in each of the networks. So the total voltage losses may reach 60%.

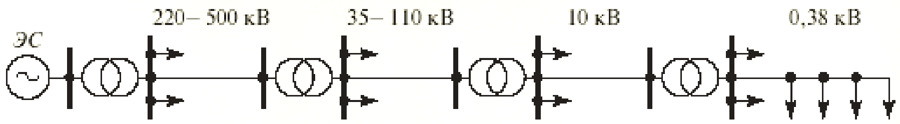

Рис. 14.1. Схема передачи электроэнергии в сети

For ensure acceptable voltage levels in the EPS we use special equipment – regulation devices. Their appointment is the reduction or compensation losses of voltage.

For the analysis of opportunities to reduce voltage losses in elements (lines, transformers), we use the expression.

$$\Delta U = \frac{PR + QX}{U}$$

P,Q – active and reactive powers in the network element;
R,X – resistance and reactance element;
U – the voltage at the end of the element, where we set the powers.

Expression shows that the voltage losses decreases with increasing mains voltage. At operation the change in the nominal mains voltage requires reconstruction of this network. Furthermore, increasing the nominal voltage allows to reduce voltage losses, but it can not be considered as a means of voltage regulation. Decision about the level of nominal voltage