

Power supply of industrial enterprises

Laboratory work

Open switchgear of substation

The objective of the work is to study principle of operation of transformer substations and construction of open switchgears.

After execution of work student should

- know types and functions of transformer substations; construction of open switchgears, advantages and disadvantages of open switchgears; functions of power electrical equipment, sequence of switching-on and switching-off actions.
- read and compose electrical schemes of substations and open switchgears, change schemes of electrical supply when basic equipment (power lines or transformer) is in outage.

Substation has been defined as an electrical device for voltage transformation and power distribution. Depending on type of the connection to power system substations are divided into: terminal substations, junction (drop) substations, communicating (intercommunicating) substations,

Open switchgears are used mostly with voltage 35 kV and above. The main advantages of open switchgears as compared with indoor switchgears are:

- 1) less construction work content;
- 2) materials (steel, concrete) saving;
- 3) capital costs saving;
- 4) lower danger of equipment damage spreading because of wider distances between electrical devices;
- 5) lower construction terms;
- 6) easier and more convenient equipment reconstruction and installation.

Disadvantages of open switchgears as compared with indoor switchgears are:

- 1) less convenient outdoor equipment service because of influence of weather conditions;
- 2) big area of switchgear;
- 3) apparatus for outdoor installation are more expensive because they are exposed to moisture, dust, high and low outside air temperatures, so they have special construction.

Substation shown at the Fig. 1 has been designed as terminal (tapped, one end) substation without high-voltage circuit breakers on the high-voltage side 154 kV. Two power transformers are supplied by built-up lines from substations 1 and 2. Disconnect switches (*QS*), circuit switchers (*QR*) and grounding switchers (*QK*) are applied. Between power lines jumper with circuit breaker *Q_ε* and two disconnect switches is installed.

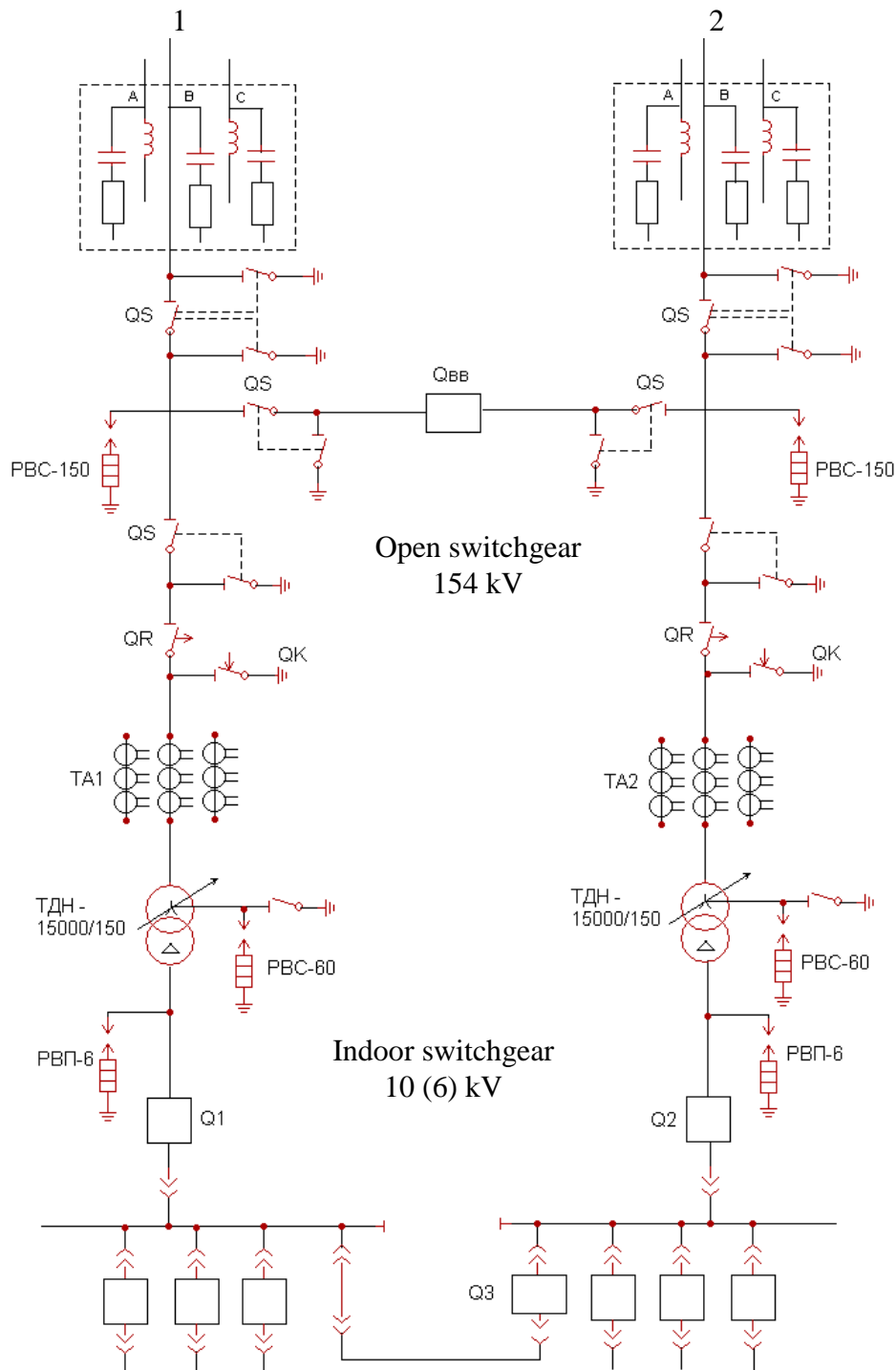


Figure 1. Single-line diagram of substation.

Circuit breaker is a large switch that interrupts the load and fault current. Fault detection systems automatically open the circuit breaker, but it can be operated manually.

Disconnect switch provides visible circuit separation and permits circuit breaker maintenance. It can be operated only when the circuit breaker is open, in no-

load condition. Disconnect switches are equipped with the grounding blades to the de-energized equipment for worker protection.

Potential transformers and current transformers (TA) reduce the voltage and the current, and insulate the low-voltage circuit from the high-voltage. The secondary level of current and voltage are used for metering and protective relays. The relays operate the appropriate circuit breaker in case of a fault.

Surge arresters (PBC-150, PBT-6) are used for power lines protection against lightning and switching overvoltages. To protect transformers surge arresters PBC-60 in transformers' neutral are set up. Surge arresters are voltage dependent, nonlinear resistors.

In an electric system the voltage and current can be controlled. The voltage control uses parallel connected devices, while the flow or current control requires devices connected in series with the lines.

In the substation **to switch off fault transformer** when relay protection responses high-frequency communication bus is used to deliver switching off signal to circuit breakers on supplying substations 1 and 2.

As a communication bus power line 154 kV with high frequency filters, communication condensers, signal receivers and transmitters are used.

When communication bus is fault grounding switcher operates to provide a deliberate ground on the transformer bank. It causes operation of the transmission line breakers at the remote end of the line 1 or 2 supplying the transformer. Thus when one of the power transformers breaks down operates circuit breaker on supplying substation 1 or 2 and circuit breaker on jumper line. During no-current condition circuit switch of the damaged transformer is switched off. Then circuit breaker on supplying substation and circuit breaker on jumper line are automatically switched on. Ringed power supply of the substation resumes.

For **normal transformer switch off** in the substation it is necessary to switch off load current by circuit breaker Q1 (or Q2) at low-voltage side of the transformer. Then circuit switch QR disconnects no-load current of the transformer. After that disconnect switch QS is allowed to switch off.

To switch the power transformer on first circuit switch is should to be switched on and then disconnect switch. Voltage resumes when circuit breaker Q1 or Q2 connects.

Equipment protection from direct lightning strokes 4 core lightning rods are set up on the portal tangent towers.

In the open switchgear 154 kV flexible ferroaluminum bus bar is used. Transformers are connected with the indoor switchgear 6 kV by flexible bus bars placed in underground cable channels.

Nowadays in substations 110, 150 and 220 kV vacuum, SF6 and oil circuit breakers are widely used. Scheme of substation with circuit breakers on high-voltage side instead of circuit switchers and grounding switches is shown on Fig. 2.

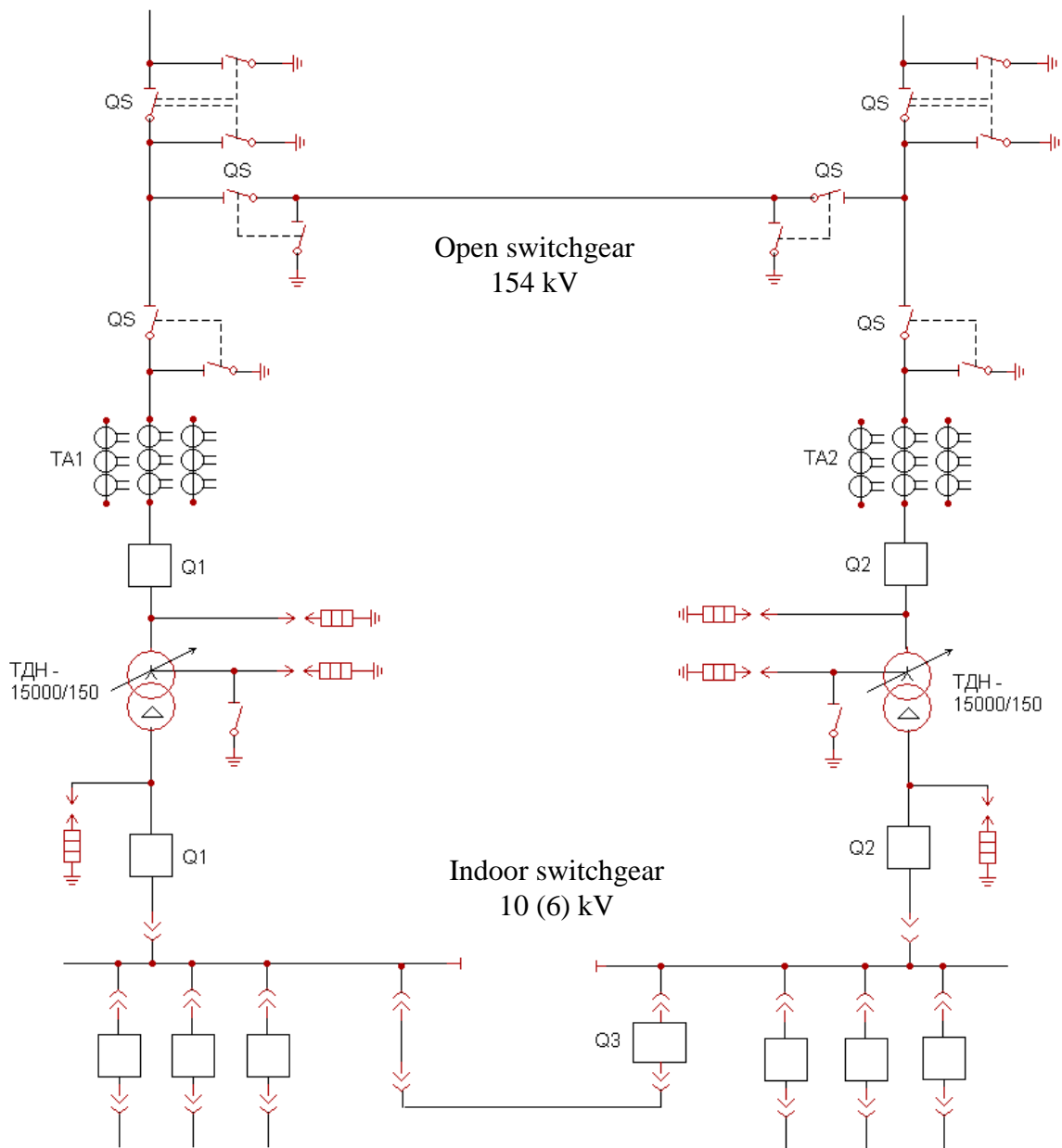


Figure 2. Single-line diagram of substation with circuit breakers on high-voltage side

Circuit breakers are more reliable than circuit switches especially at winter time. Another advantage of this scheme is absence of high-frequency communication bus for disconnection of circuit breakers in the feeding substation.

Guidelines

At the work bench introduction of open switchgear construction should be done.

Student should study purpose and range of application of open switch gears, advantages and disadvantages of indoor and open switchgears, purpose of equipment, construction and materials that are used, main protection measures.

Report contents

Title, objective and one-line scheme of substation, brief description of the equipment and order of its operation.

Quiz

1. Range of application of open switchgears.
2. Main advantages and disadvantages of open switchgears in comparison with indoor switchgears.
3. Main equipment of the open switchgear.
4. What are functions of the grounding switches?
5. What is the order of operation for normal transformer switch off?
6. What is the order of operation for fault transformer switch off?
7. What are functions of circuit breakers?
8. What measures of protection are used in substation to avoid overvoltages?
9. Advantages of switchgear with high-voltage circuit breakers.
10. Placement and materials of current-carrying parts of the switchgear.
11. The functions of the surge arresters.
12. Operation of commutation equipment when substation is fed by one transformer.

Further reading

1. Ермилов А. А. Основы электроснабжения промышленных предприятий – : Энергоатомиздат, 1983.– 208 с.
2. Рожкова Л. Д., Козулин В. С. Электрооборудование станций и подстанций. – : М.: Энергоатомиздат, 1987. – 648 с.
3. Handbook of Electrical Engineering: For Practitioners in the Oil, Gas and Petrochemical Industry. Alan L. Sheldrake – 2003. John Wiley & Sons, Ltd.
ISBN: 0-471-49631-6