Electrical Power Engineering

By

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Lecture (3)

Generating Station Components

1- Generators & Turbines

2- Transformers

3- Switches

4- Busses

5- Circuit Breakers

6- Capacitor Banks

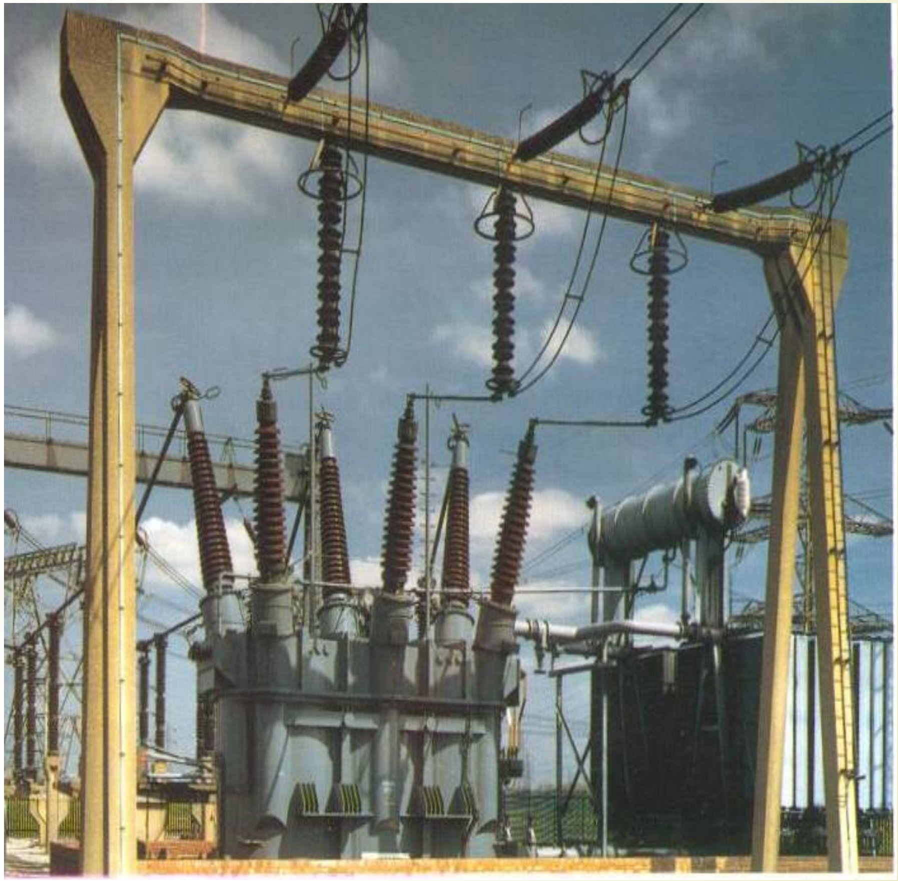
Generators

The whole point of the power plant is to turn the generators to produce electrical energy.

Transformers

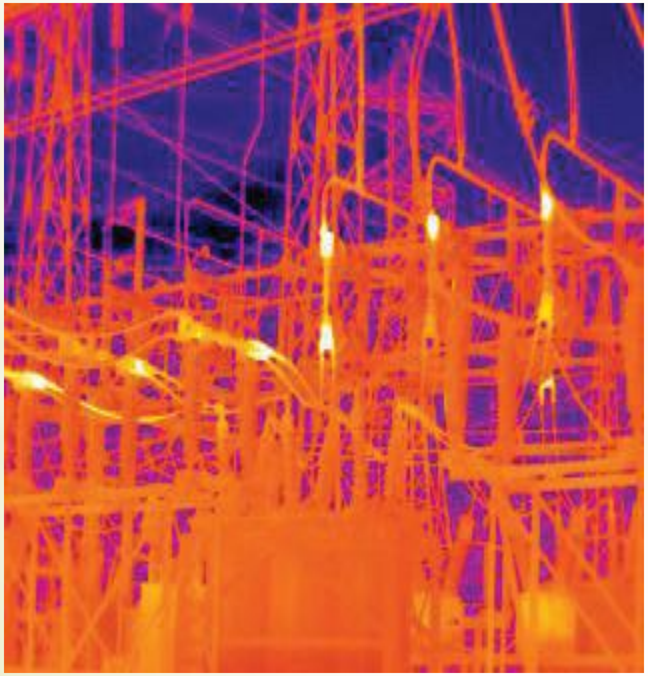
PURPOSE: to change the voltage

- increase = “step-up”
- decrease = “step-down”



Busses

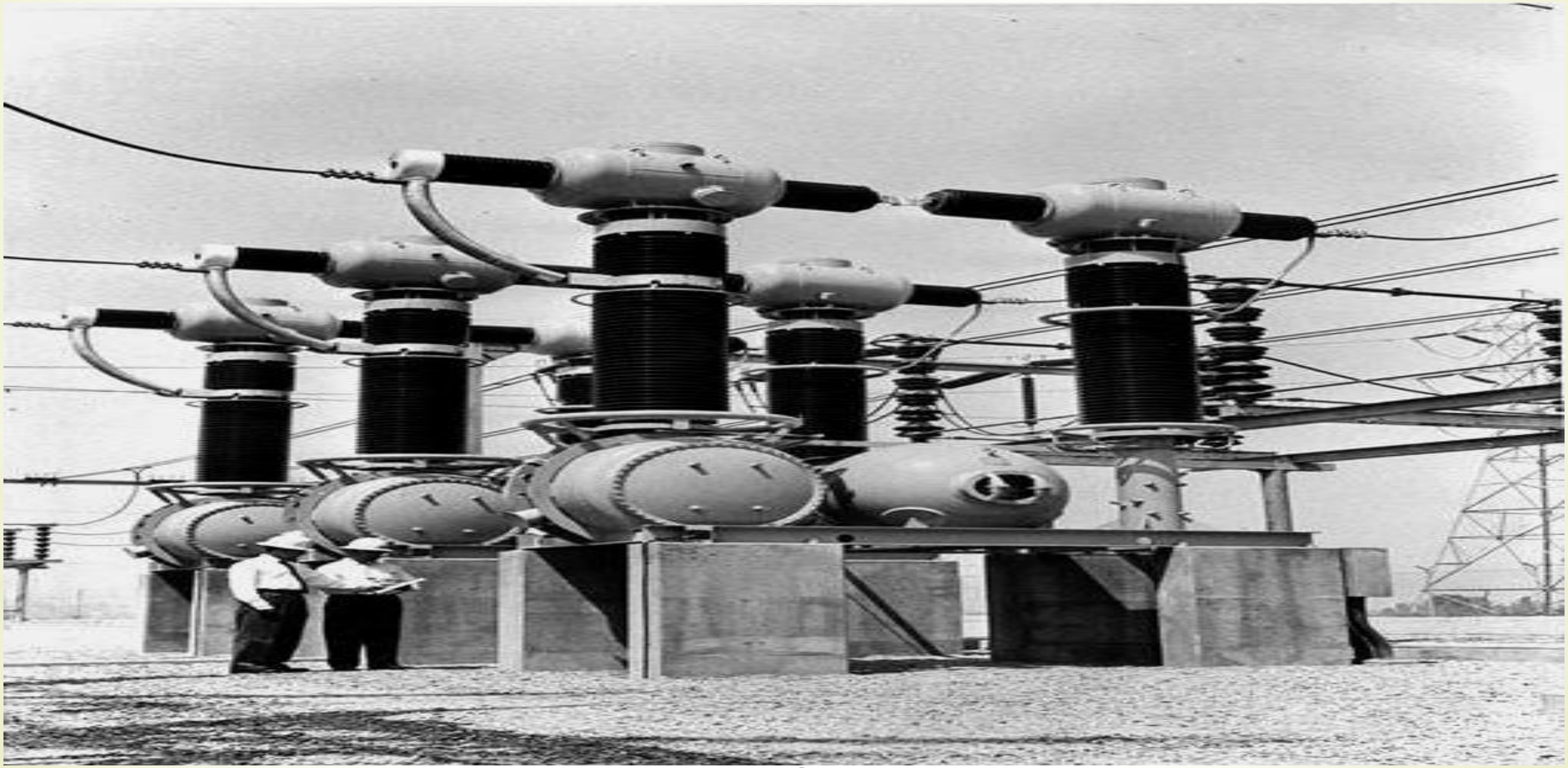
- uninsulated electrical conductors
- large cross-section = low resistance
- must be far from ground and other components to avoid arcing



Switches & Switchyards

Circuit Breakers

PURPOSE: stop the flow of current if too much flows (due to short circuit or excess demand)



230 kV breaker

Capacitor Banks

Purpose: to smooth out spikes or “glitches” in the line voltage.

Transformer Sub-Station

Purpose:

To reduce the very high voltages from the transmission lines (>100kV) to intermediate voltages used to serve an individual town or section of a city (typically 66 kV or 33 kV)

To your house…

smaller transformers (on power line poles or green boxes on the ground) reduce the voltage further to the 240V delivered to individual homes

Electricity Transmission

- Electrical energy is transferred from the power station to the consumer.
- Electricity is sent for many kilometres along transmission lines.

Electricity Transmission

The purpose of an overhead transmission network is to transfer electric energy from generating units at various locations to the distribution system which ultimately supplies the load.

Standard transmission voltages are established in the United States by the American National Standards Institute (ANSI). Transmission voltage lines operating at more than 60 kV are standardized at 69 kV, 115 kV, 138 kV, 161 kV, 230 kV, 345 kV, 500 kV, and 765 kV line-to-line. Transmission voltages above 230 kV are usually referred to as extra-high voltage (EHV).

Distribution

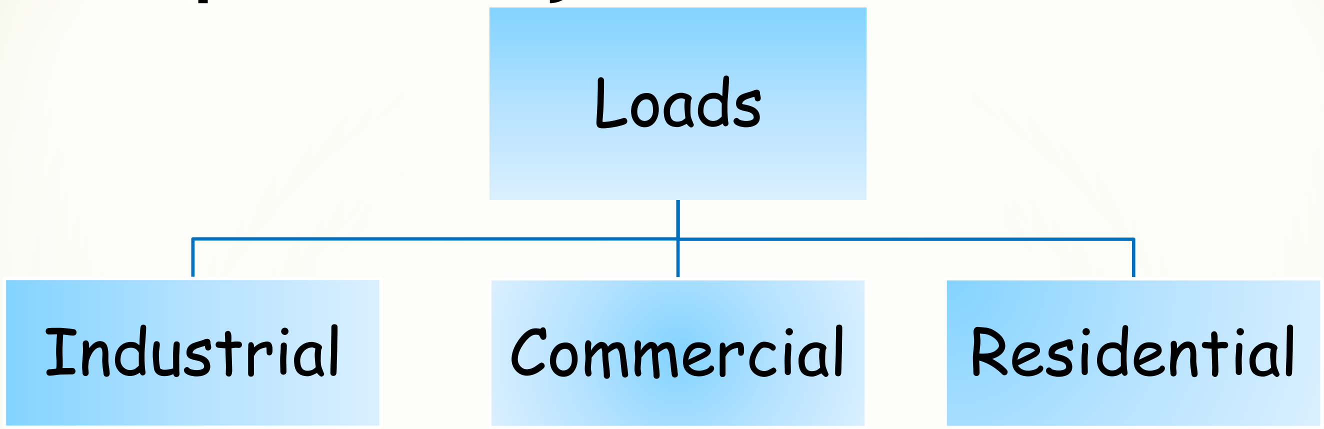
The distribution system is that part which connects the distribution substations to the consumers' service-entrance equipment. The primary distribution lines are usually in the range of 4 to 34.5 kV and supply the load in a well-defined geographical area. Some small industrial customers are served directly by the primary feeders.

The secondary distribution network reduces the voltage for utilization by commercial and residential consumers. Lines and cables not exceeding a few hundred feet in length then deliver power to the individual consumers. The secondary distribution serves most of the customers at levels of 240/120 V, single-phase, three-wire; 208Y/120 V, three-phase, four-wire; or 480Y/277 V, three-phase, four-wire. The power for a typical home is derived from a transformer that reduces the primary feeder voltage to 240/120 V using a three-wire line.

Distribution systems are both *overhead* and *underground*. The growth of underground distribution has been extremely rapid and as much as 70 percent of new residential construction is served underground.

Loads

Loads of power system divided into:



1. Very large industrial loads may be served from the transmission system.
2. Large industrial loads are served directly from the sub transmission network.
3. Small industrial loads are served from the primary distribution network.

Loads

- The industrial loads are composite loads, and induction motors form a high proportion of these load. These composite loads are functions of voltage and frequency and form a major part of the system load.

- Commercial and residential loads consist largely of lighting, heating, and cooling. These loads are independent of frequency and consume negligibly small reactive power.

Loads

- The magnitude of load varies throughout the day, and power must be available to consumers on demand.

- The load factor is the ratio of average load over designated period of time to the peak load occurring in that period.

$$\text{Daily L.F.} = \frac{\text{average load}}{\text{peak load}}$$

Example

The daily load on a power system varies as shown in Table 1.2. Use the **barcycle** function to obtain a plot of the daily load curve. Using the given data compute the average load and the daily load factor (Figure 1.2).

Table 1.2 Daily System Load

Interval, hr			Load, MW
12 A.M.	–	2 A.M.	6
2	–	6	5
6	–	9	10
9	–	12	15
12 P.M.	–	2 P.M.	12
2	–	4	14
4	–	6	16
6	–	8	18
8	–	10	16
10	–	11	12
11	–	12 A.M.	6

Solution of Example

The following data:

Interval, hr		Loads, MW
0	2	6
2	6	5
6	9	10
9	12	15
12	14	12
14	16	14
16	18	16
18	20	18
20	22	16
22	23	12
23	24	6

Solution of Example

Sum (Dt) =

(2-0)+(6-2)+(9-6)+(12-9)+(14-12)+(16-14)+(18-16)+(20-16)+(22-20)+(23-22)+(24-23)=24

W = P * Dt=

6*(2-0)+5*(6-2)+10*(9-6)+15*(12-9)+12*(14-12)+14*(16-14)+16*(18-16)+18*(20-16)+16*(22-20)+12*(23-22)+6*(24-23)=277

P_{avg}= W / Sum(Dt)=277/24=11.5417

P_{peak}= 18

Load Factor=P_{avg}/P_{peak}= (11.5417/ 18)=64.12%

System Protection

In addition to generators, transformers, and transmission lines, other devices are required for the satisfactory operation and protection of a power system. Some of the protective devices directly connected to the circuits are called *switchgear*. They include instrument transformers, circuit breakers, disconnect switches, fuses and lightning arresters. These devices are necessary to deenergize either for normal operation or on the occurrence of faults. The associated control equipment and protective relays are placed on *switchboard* in *control houses*.

Energy Control System

For reliable and economical operation of the power system it is necessary to monitor the entire system in a control center. The modern control center of today is called the *energy control center* (ECC). Energy control centers are equipped with on-line computers performing all signal processing through the remote acquisition system. Computers work in a hierarchical structure to properly coordinate different functional requirements in normal as well as emergency conditions. Every energy control center contains a control console which consists of a visual display unit (VDU), keyboard, and light pen. Computers may give alarms as advance warnings to the operators (dispatchers) when deviation from the normal state occurs. The dispatcher makes judgments and decisions and executes them with the aid of a computer. Simulation tools and software packages written in high-level language are implemented for efficient operation and reliable control of the system. This is referred to as SCADA, an acronym for "supervisory control and data acquisition."

Computer Analysis

For a power system to be practical it must be safe, reliable, and economical. Thus many analyses must be performed to design and operate an electrical system. However, before going into system analysis we have to model all components of electrical power systems. Therefore, in this text, after reviewing the concepts of power and three-phase circuits, we will calculate the parameters of a multi-circuit transmission line. Then, we will model the transmission line and look at the performance of the transmission line. Since transformers and generators are a part of the system, we will model these devices. Design of a power system, its operation and expansion requires much analysis. This text presents methods of power system analysis with the aid of a personal computer and the use of *MATLAB*.

Thank You
For Your Attention

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