Electrical Power Systems

By

Prof. Dr. Eng. Mohamed Ahmed Ebrahim Mohamed

Consultant of New and Renewable Energy Systems

E-mail: mohamedahmed_en@yahoo.com

mohamed.mohamed@feng.bu.edu.eg

Web site: http://bu.edu.eg/staff/mohamedmohamed033

Lecture (1) – Part (2)

Course Code: EPE 215

Study Hours: 2 Lect. + 2 Tut + 2 Lab

Assessment:

Final Exam: 90 marks (50%) .

Year Work & Quizzes & Midterm: 60 marks (33.33%).

Oral & Practical: 30 marks (16.67%)

Textbook:

1- M. S. Naidu, High Voltage Engineering, 2009.

2- B. L. Theraja, A textbook of electrical and technology in S. I. System of units, Vol. III

3- Hadi Saadat, Power System Analysis

Syllabus

1. Introduction.
2. AC and DC Transmission Systems.
3. AC and DC Distribution Systems.
4. Substations and circuit breakers.
5. Interconnections of power systems.
6. Electrical and Mechanical Design of Transmission Lines.
7. Insulators and Voltage Distribution.
8. Underground Cable Systems.
9. Overvoltage in Electrical Power Systems.
10. Protection of individuals, equipment and power system installations.
11. Protective devices and insulation co-ordination.

Generating Station Components

1- Generators & Turbines

2- Transformers

3- Switches

4- Busses

5- Circuit Breakers

6- Capacitor Banks

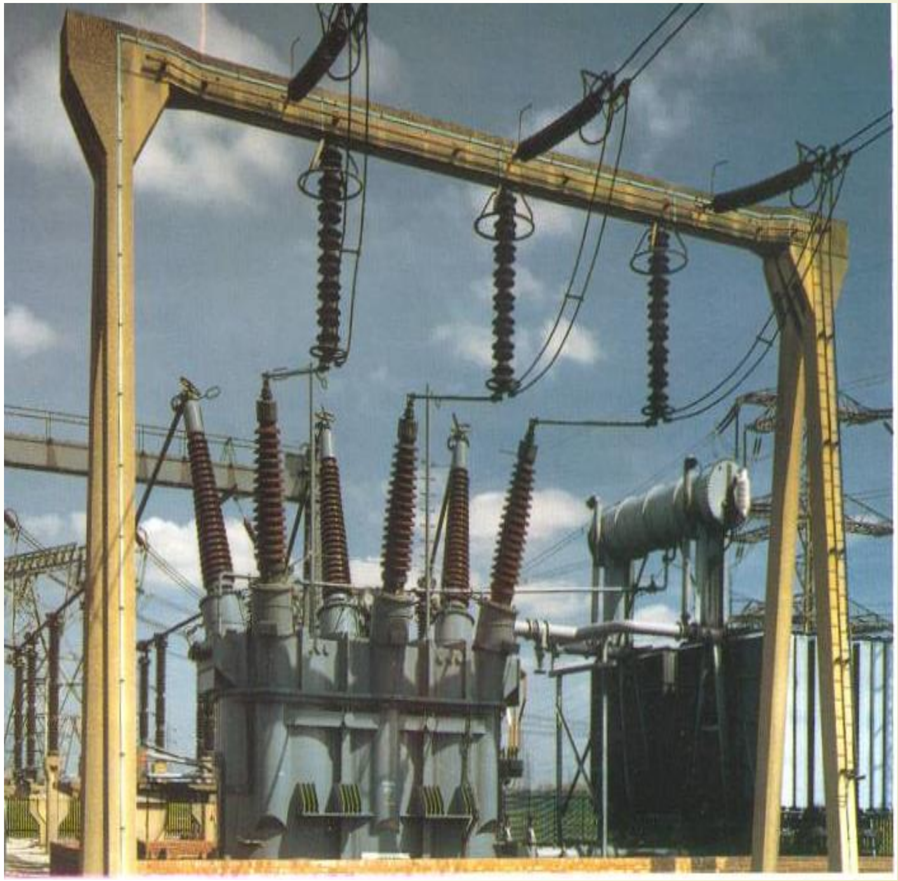
Generators

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

Transformers

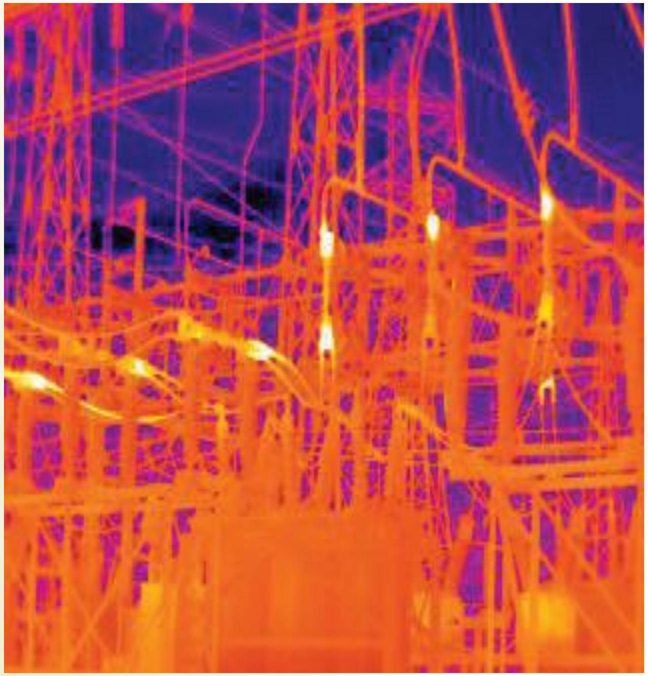
PURPOSE: to change the voltage

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



Busses

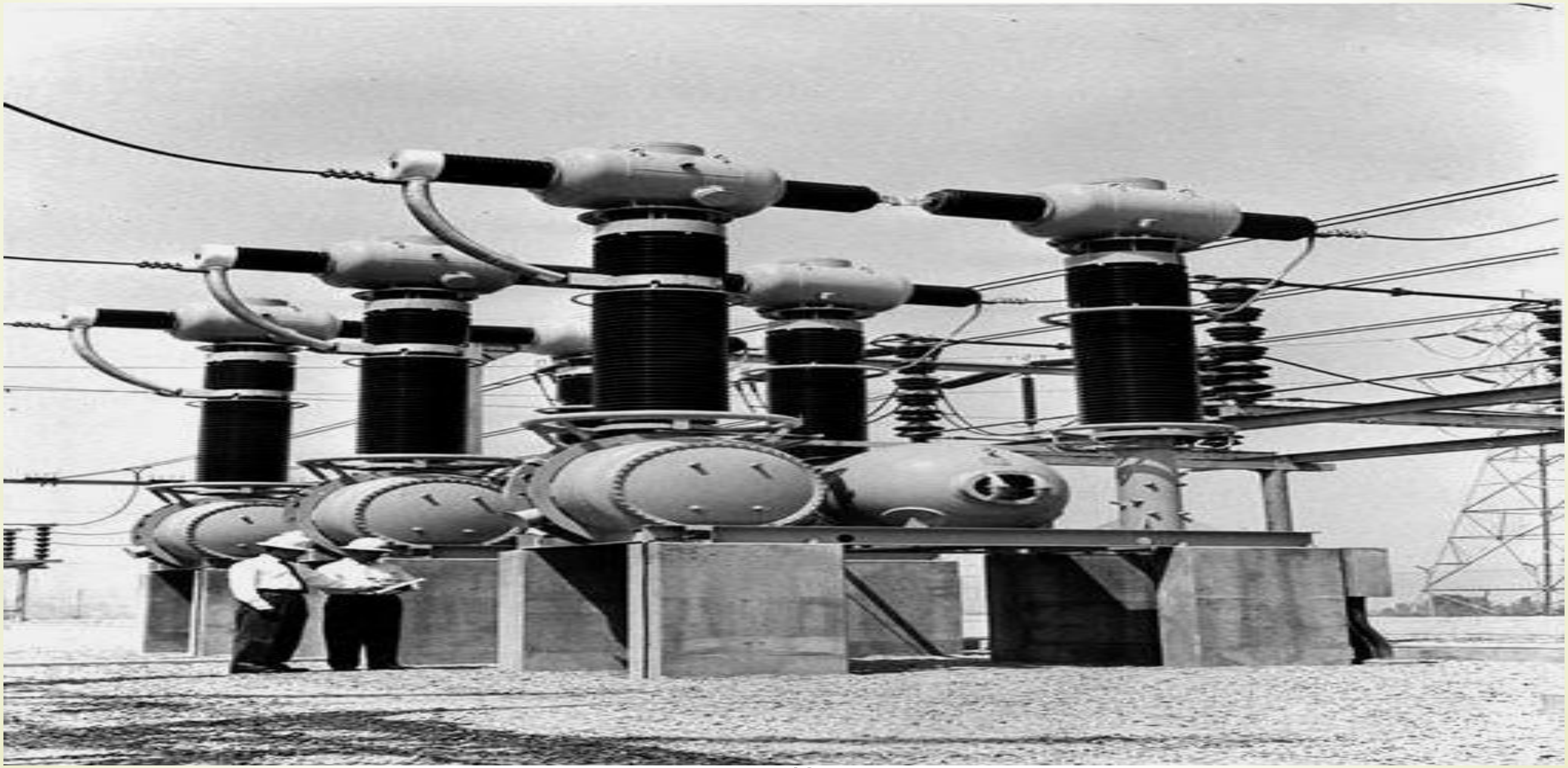
- uninsulated electrical conductors
- large cross-section = low resistance
- must be far from ground and other components to avoid arcing



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

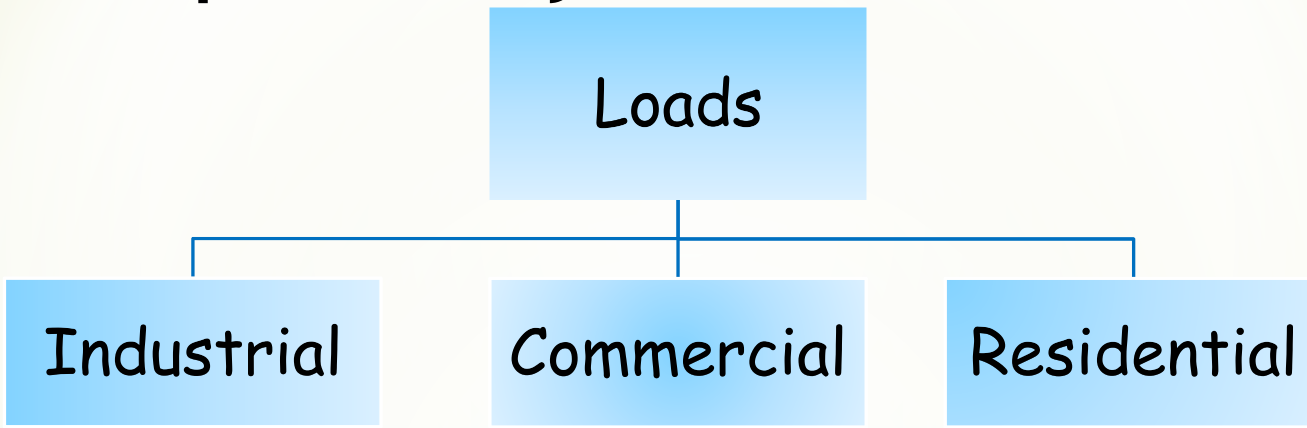
The distribution system is that part which connects the distribution substations to the consumers' service-entrance equipment. The primary distribution lines are usually in the range of 4 to 34.5 kV and supply the load in a well-defined geographical area. Some small industrial customers are served directly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

- The protective devices that directly connected to the circuits are called switchgear.
- Switchgears include instrument transformers, circuit breakers, disconnect switches, fuses and lighting 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 paced 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.
- All components of electrical power systems must be modeled before going into system analysis.
- Software packages will be used to perform the required analysis.

Thank You
For Your Attention

Mohamed Ahmed Ebrahim