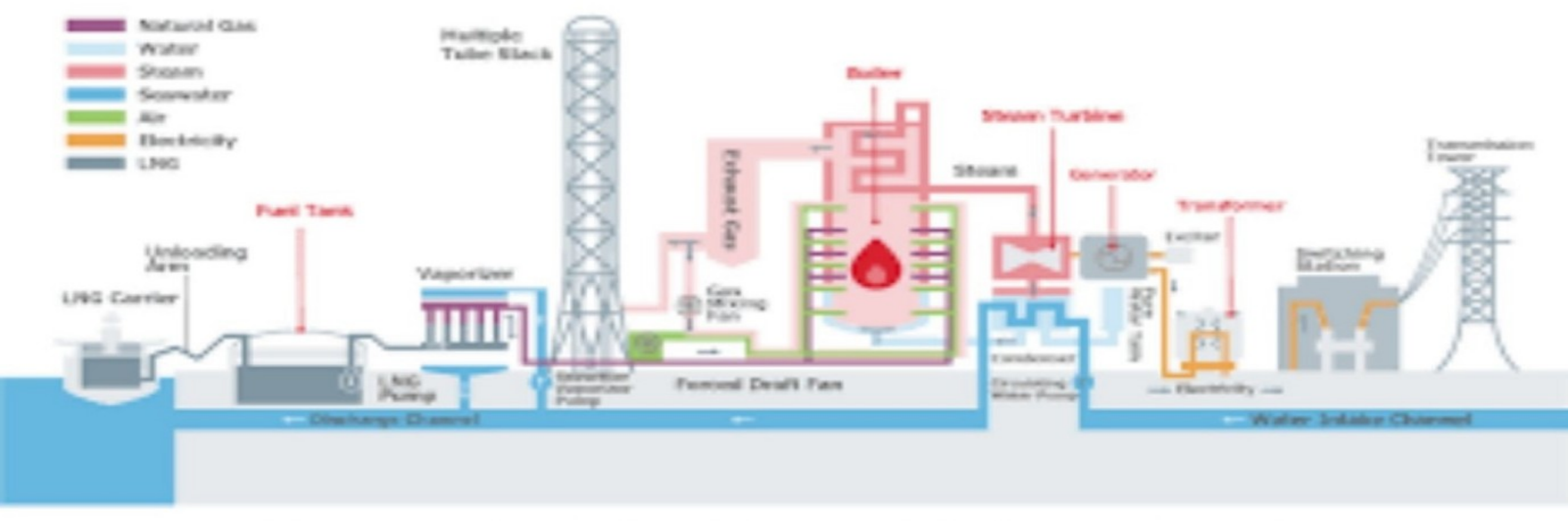
GENERATION OF ELECTRICAL POWER

LECTURE NOTES OF ELECTRICAL POWER GENERATION COURSE



BY

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Generation of Electrical Power

Lecture Notes of Generation of Electrical Power Course

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Introduction

This book includes my lecture notes for electrical power generation course. The layout, main components, and characteristics of common electrical power generation plants are described with application to various thermal power plants.

The book is divided to different learning outcomes

- CLO 1- Describe the layout of common electrical power generation plants.
- CLO 2- Describe the main components and characteristics of thermal power plants.

a) **CLO1 Describe the layout of common electrical power generation plants.**

 Explain the demand of base - power stations, intermediate - power stations, and peak- generation power stations.

- Describe the layout of thermal, hydropower, nuclear, solar and wind power generation plants.
- Identify the size, efficiency, availability and capital of generation for electrical power generation plants.
- Eexplain the main principle of operation of the transformer and the generator.

b) CLO2: Describe the main components and characteristics of thermal power plants.

- Identify the structure and the main components of thermal power plants.
- Describe various types of boilers and combustion process.
- List types of turbines, explain the efficiency of turbines, impulse turbines, reaction turbines, operation and maintenance, and

speed regulation, and describe turbo generator.

- Explain the condenser cooling - water loop.
- Discuss thermal power plants and the impact on the environment.

Part 1: Describe the layout of common electrical power generation plants.

- Explain the demand of base - power stations, intermediate - power stations, and peak generation power stations.
- Describe the layout of thermal, hydropower, nuclear, solar and wind power generation plants.
- Identify the size, efficiency, availability and capital of generation for electrical power generation plants.

<u>LO 1</u>

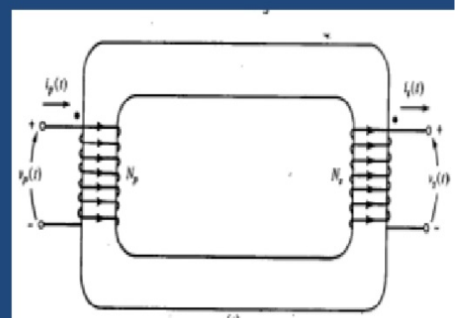
Describe the layout of common electrical power generation plants

- Explain the demand of **base** - power stations, **intermediate** - power stations, and **peak**- generation power stations.
- Describe the layout of **thermal**, **hydropower**, **nuclear**, **solar** and **wind** power generation plants.
- Identify the **size**, **efficiency**, **availability** and **capital** of generation for electrical power generation plants.

1.1 Eexplaining the main principle of operation of the transformer and the generator.

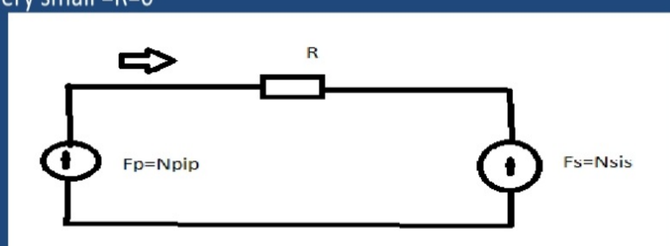
Transformer

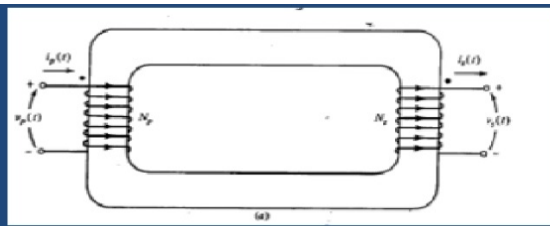
- The ideal transformer
- Vp ~=>ip ~ => Ø~=> induced voltage in primary
- => induced voltage in secondary winding
- The induced voltage in the primary winding
- $v_p = N_p \frac{d\emptyset}{dt}$
- The induced voltage in the secondary winding
- $v_s = N_s \frac{d\emptyset}{dt}$
- $\frac{Vp}{Vs} = \frac{Np}{Ns} = a$



(a)

- The current equation
- $N_p i_p - N_s i_s = \emptyset R$
- $R = \frac{lc}{\mu A}$
- Reluctance of core very small =R=0
- $N_p i_p - N_s i_s = 0$
- $\frac{ip}{is} = 1/a$





- The active power equation:

$$P_{in} = V_P I_P \cos \theta_P$$

$$P_{out} = V_S I_S \cos \theta_S$$

$$P_{out} = \frac{V_P}{a} a I_P \cos \theta$$

$$P_{out} = V_P I_P \cos \theta = P_{in}$$

- The reactive power equation

$$Q_{in} = V_P I_P \sin \theta = V_S I_S \sin \theta = Q_{out}$$

$$S_{in} = V_P I_P = V_S I_S = S_{out}$$

Referring the load to primary

- Referring the load from the secondary to primary

$$Z_L = \frac{\mathbf{V}_S}{\mathbf{I}_S}$$

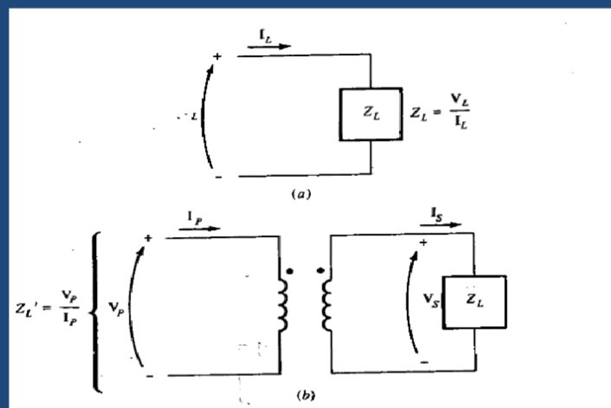
$$\mathbf{V}_P = a\mathbf{V}_S$$

$$\mathbf{I}_P = \frac{\mathbf{I}_S}{a}$$

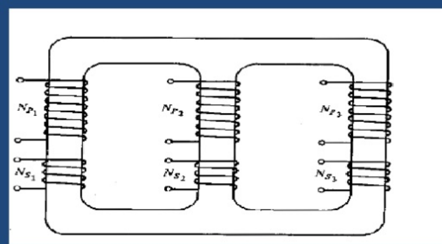
$$Z'_L = \frac{\mathbf{V}_P}{\mathbf{I}_P}$$

$$Z'_L = \frac{\mathbf{V}_P}{\mathbf{I}_P} = \frac{a\mathbf{V}_S}{\mathbf{I}_S/a} = a^2\frac{\mathbf{V}_S}{\mathbf{I}_S}$$

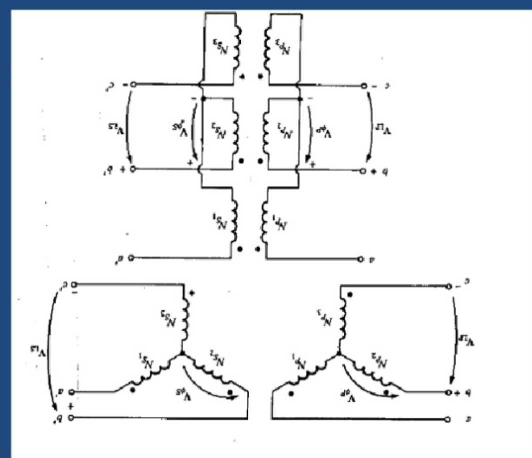
$$\boxed{Z'_L = a^2 Z_L}$$



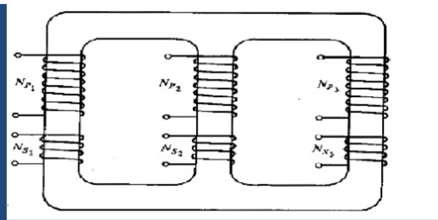
Three phase transformer



- Wye-Wye Connection



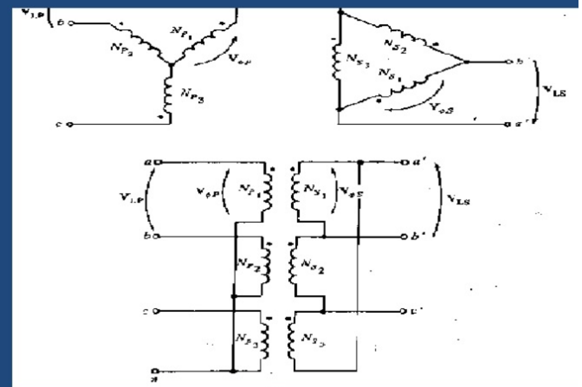
$$\frac{V_{LP}}{V_{LS}} = \frac{\sqrt{3}V_{\phi P}}{\sqrt{3}V_{\phi S}} = a$$



- Wye Delta Connection

$$\frac{V_{LP}}{V_{LS}} = \frac{\sqrt{3}V_{\phi P}}{V_{\phi S}}$$

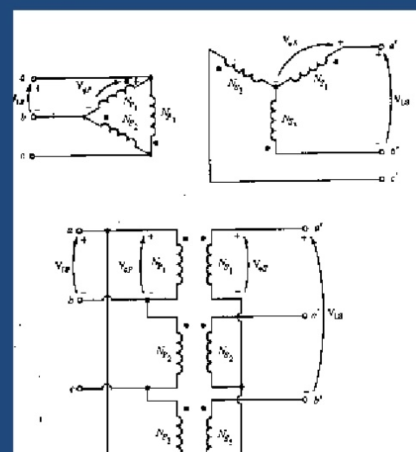
$$\boxed{\frac{V_{LP}}{V_{LS}} = \sqrt{3}a \qquad \text{Y-}\Delta}$$



- Delta Wye Connection

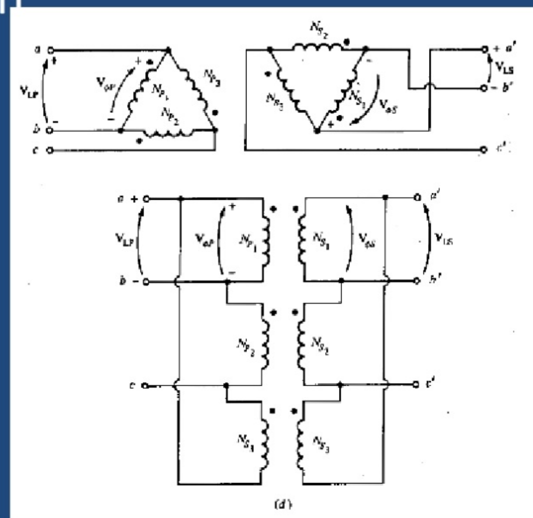
$$\frac{V_{LP}}{V_{LS}} = \frac{V_{\phi P}}{\sqrt{3}V_{\phi S}}$$

$$\boxed{\frac{V_{LP}}{V_{LS}} = \frac{a}{\sqrt{3}} \qquad \Delta\text{-Y}}$$

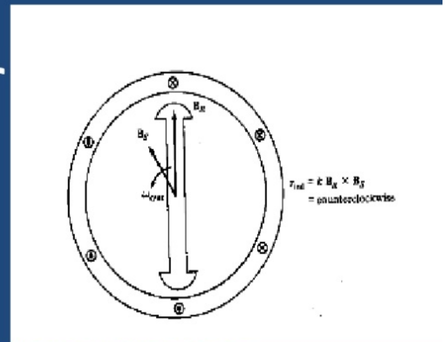


- Delta Delta Connection

$$V_{LP} = V_{\phi P}$$
$$V_{LS} = V_{\phi S}$$



Synchronous Generator



- Principle of Operation
- 1)The DC current applied to rotor winding produces magnetic field B_R
- 2) The rotor turned by primemover so there will be rotating magnetic field within the machine.
- 3) The rotating magnetic field induces 3 phase set of voltages within the stator windings.

Equivalent Circuit

- The relation between the speed of rotation and the frequency of the synchronous machine

$$f_e = \frac{n_m P}{120}$$

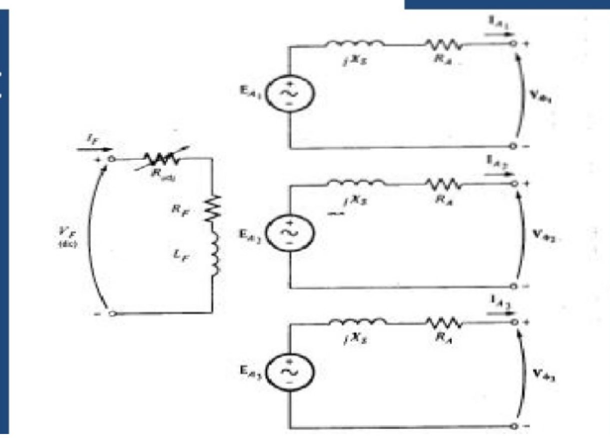
where f_e = electrical frequency, Hz
n_m = mechanical speed of magnetic field, r/min (= speed of rotor for synchronous machines)
P = number of poles

- The output voltage

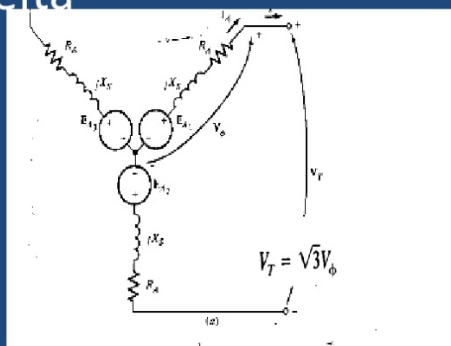
$$E_A = K\phi\omega$$

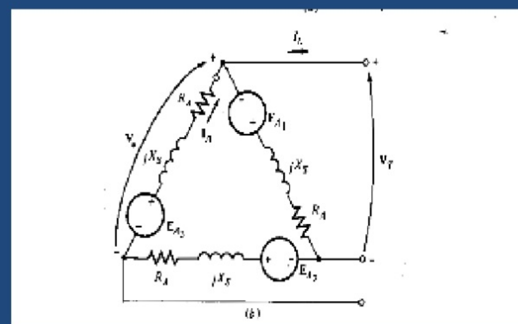
- The equivalent circuit

$$V_\phi = E_A - jX_S I_A - R_A I_A$$

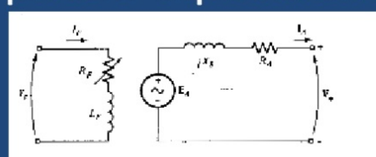


- The windings can be connected in Star or Delta



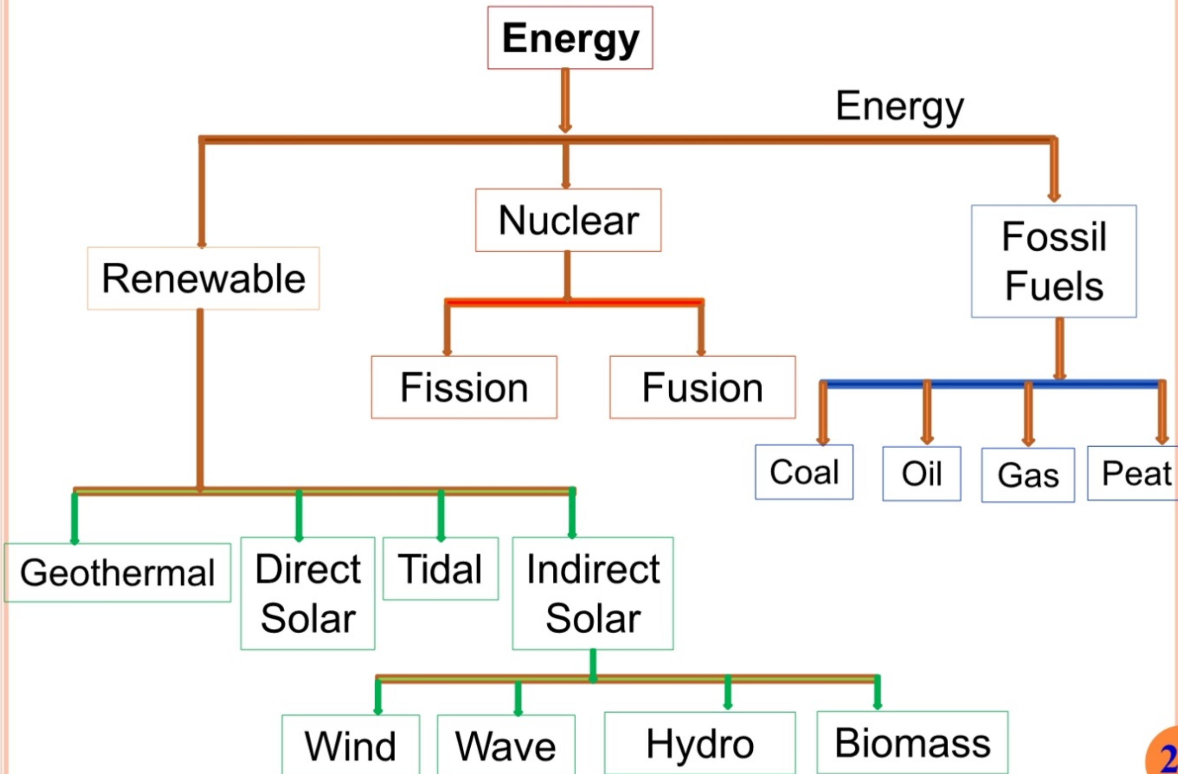


- The per phase equivalent circicuit



1.2. Explaining the demand of base - power stations, intermediate - power stations, and peak generation power stations.

SOURCES OF ELECTRICAL ENERGY



SOURCES OF ELECTRICAL ENERGY

The problems associated with the use of large quantities of energy are:

- ❖ Depletion of reserves
- ❖ Pollution and environmental degradation
- ❖ High financial cost
- ❖ Security of supply