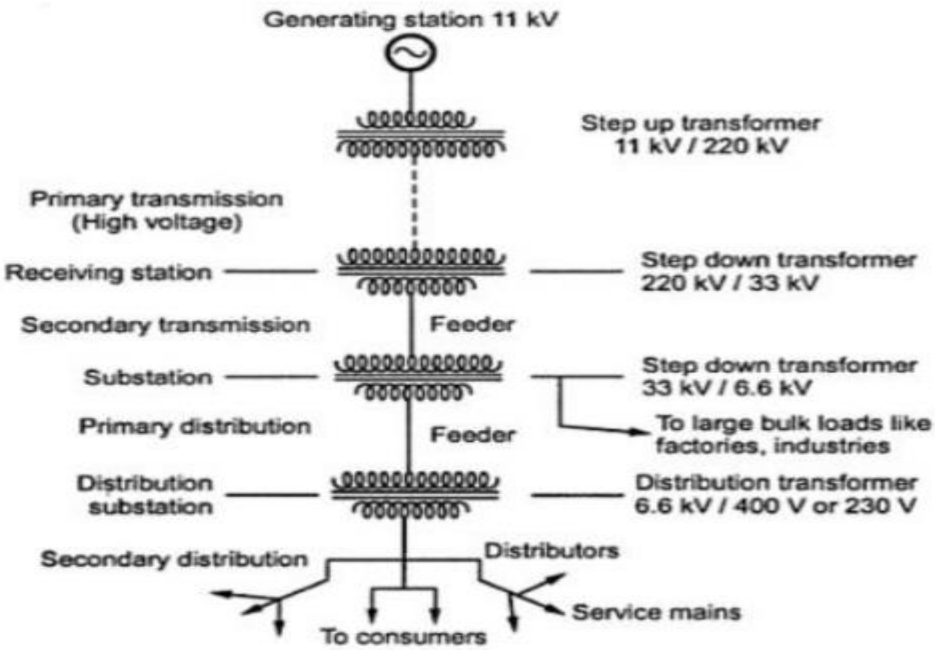
POWER SYSTEM COMPONENTS

BASIC COMPONENTS OF A POWER SYSTEM

Components of power system

- Generators - Convert mechanical energy in to electrical energy
- Transformers - Transfer Power or energy from one circuit to another circuit without change in frequency
- Transmission Lines - Transfer power from one place another place
- Control Equipment: Used for protection purpose

Structure of Power system



The power system is the complex enterprise that may be subdivided into the following sub-systems. The subsystems of the power system are explained below in details

Generating Substation

In generating station the fuel (coal, water, nuclear energy, etc.) is converted into electrical energy. The electrical power is generated in the range of 11kV to 25kV, which is step-up for long distance transmission. The power plant of the generating substation is mainly classified into three types, i.e., thermal power plant, hydropower plant and nuclear power plant. The generator and the transformer are the main components of the generating station. The generator converts the mechanical energy into electrical energy. The mechanical energy comes from the burning of coal, gas and nuclear fuel, gas turbines, or occasionally the internal combustion engine. The transformer transfers the power with very high efficiency from one level to another. The power transfer from the secondary is approximately equal to the primary except for losses in the transformer. The step-up transformer will reduce losses in the line which makes the transmission of power over long distances.

Transmission Substation

The transmission substation carries the overhead lines which transfer the generated electrical energy from generation to the distribution substations. It only supplies the large bulk of power to bulk power substations or very big consumers. The transmission lines mainly perform the two functions

1. It transports the energy from generating stations to bulk receiving stations.
2. It interconnects the two or more generating stations. The neighboring substations are also interconnected through the transmission lines.

The transmission voltage is operating at more than 66kv and is standardized at 69kv, 115KV, 138KV, 161KV, 230KV, 345KV, 500KV, and 765KV, line-to-line. The transmission line above 230KV is usually referred to as extra high voltage (EHV). The high voltage line is terminated in substations which are called high voltage substations, receiving substations or primary substations. In high voltage substation, the voltage is step-down to a suitable value for the next part of flow toward the load. The very large industrial consumers may be served directly to the transmission system.

Sub-transmission Substation

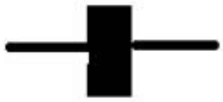
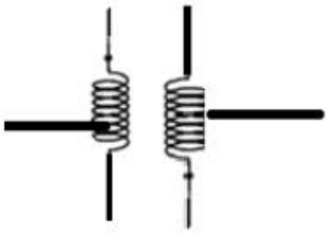
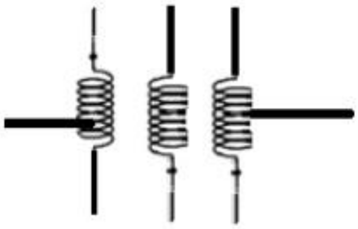
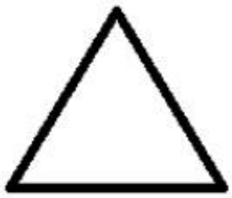
The portion of the transmission system that connects the high voltage substations through the step-down transformer to the distribution substations is called the sub-transmission system. The sub-transmission voltage level ranges from 90 to 138KV. The sub-transmission system directly serves some large industries. The capacitor and reactor are located in the substations for maintaining the transmission line voltage. The operation of the sub-transmission system is similar to that of a distribution system. Its differ from a distribution system in the following manner.

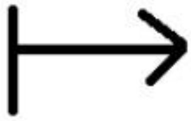
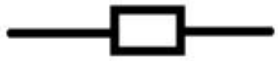
1. A sub-transmission system has a higher voltage level than a distribution system.
2. It supplies only bigger loads.
3. It supplies only a few substations as compared to a distribution system which supplies some loads.

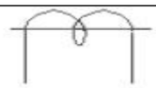
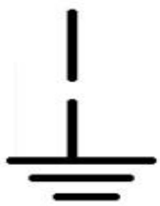
Distribution Substation

The component of an electrical power system connecting all the consumers in an area to the bulk power sources is called a distribution system. The bulk power stations are connected to the generating substations by transmission lines. They feed some substations which are usually situated at convenient points near the load centres. The substations distribute the power to the domestic, commercial and relatively small consumers. The consumers require large blocks of power which are usually supplied at sub-transmission or even transmission system.

REPRESENTATION

Sl.no	Components	Symbol
1	Rotating M/c(or) armature	
2	Bus	
3	Two winding power Transfomer	
4	Three winding power Transformer	
5	Delta connection (3Φ, 3 wire)	
6	Wye connection (3Φ, neutral un grounded)	
7	Wye connection (3Φ, neutral grounded)	

8	Transmission lines	
9	Static load	
10	Circuit Breaker	
11	Circuit Breaker (air)	
12	Disconnect	
13	Fuse	

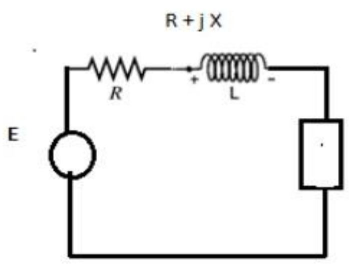
14	Capacitor	
15	Current transformer	
16	Potential transformer	
17	Lighting arrester	

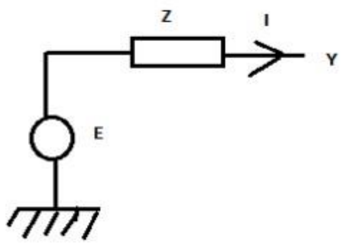
MODELING OF COMPONENTS FOR LOAD FLOW ANALYSIS

Generator model:

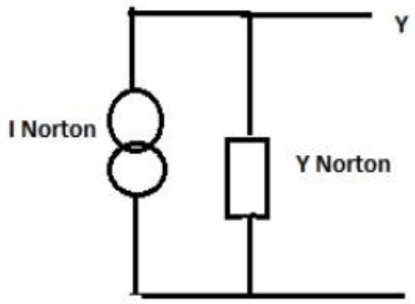
Generators

The thevenins equivalent circuit of the generator i.e. The voltage source in series with the thevenins equivalent impedance. Z = R + jX





The Norton form equivalent circuit of the generator i.e. the current source in parallel with the admittance



Transformer model

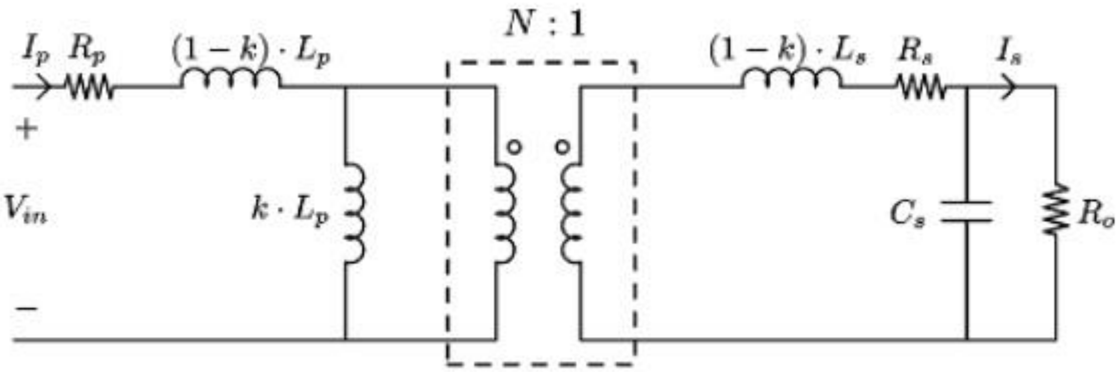


Fig. 5. Simplified model of a transformer.

Transmission system model

Transmission Line

Transmission line are modelled as

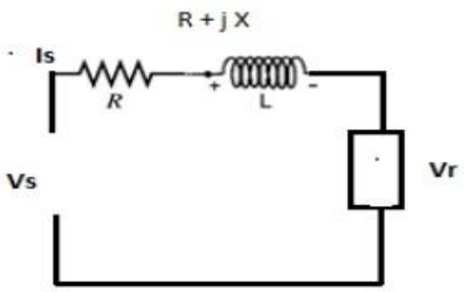
(i) Short line model

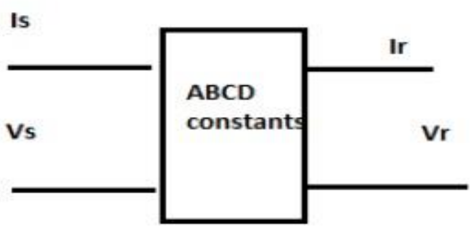
(ii) Medium line model

(iii) Long line model

(i) Short line model:

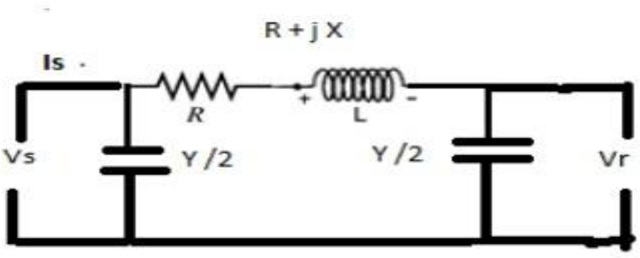
Resistance & inductance are assumed to be lumped





(ii) Medium line model (lines between 80 to 250km)

Resistance &inductance are assumed to be lumped &the total shunt admittance is divided in to two equal parts & placed at the receiving and sending ends.



$$\begin{bmatrix} Vs \\ Is \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} Vr \\ Ir \end{bmatrix}$$

$X = L\omega$

$Y/2 = C\omega/2$

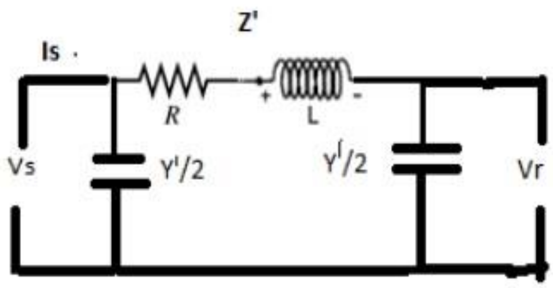
$A = 1+ZY/2$

$B=Z$

$C=Y(1+ZY/4)$

$D=1+ZY/4$

(iii) Long line model (lines above 250)



$Z'=Z \sinh\gamma L / \gamma L$

$Y'/2 = 1/Zc \tan h (\gamma L/2)$

$$\begin{pmatrix} Vs \\ Is \end{pmatrix} = \begin{pmatrix} \cosh \gamma l & Zc \sinh \gamma l \\ 1/Zc \sinh \gamma l & \cosh \gamma l \end{pmatrix} \begin{pmatrix} Vr \\ Ir \end{pmatrix}$$

Shunt Elements:

The shunt capacitor is connected to bus i. If S is MVAR rating of shunt capacitor. So is base MVA admittance P.u. Y P.u. = 0+jS/S0

Shunt reactors is connected to bus i. If S is MVAR rating of shunt capacitor. So is base MVA admittance P.u. Y P.u. = 0-jS/S0

Load representation

Load:

Load is represented by a constant power representation. Both MW (P) & MVAR (Q) – constant