Power System -

Power systems :

1. Power system Generation
2. Transmission and distribution
   - ↳ Tx- line constants
   - ↳ Tx- line performance.
   - Wave nature
   - surges
   - Voltage control
   - UG cable.
   - Insulators.
   - • corona
   - • Distribution Sy
   - • HVDC
3. Fault Analysis ⟶ Geometrical component
   - → sequence n/w
   - → symmetrical fault
   - → unsymmetrical fault
   - → Z bus based fault
4. P.S stability ⟶ steady state Stability
   - Transient stability
5. P. rotection ⟶
6. load flow
7. Economic Dispatch (IES)

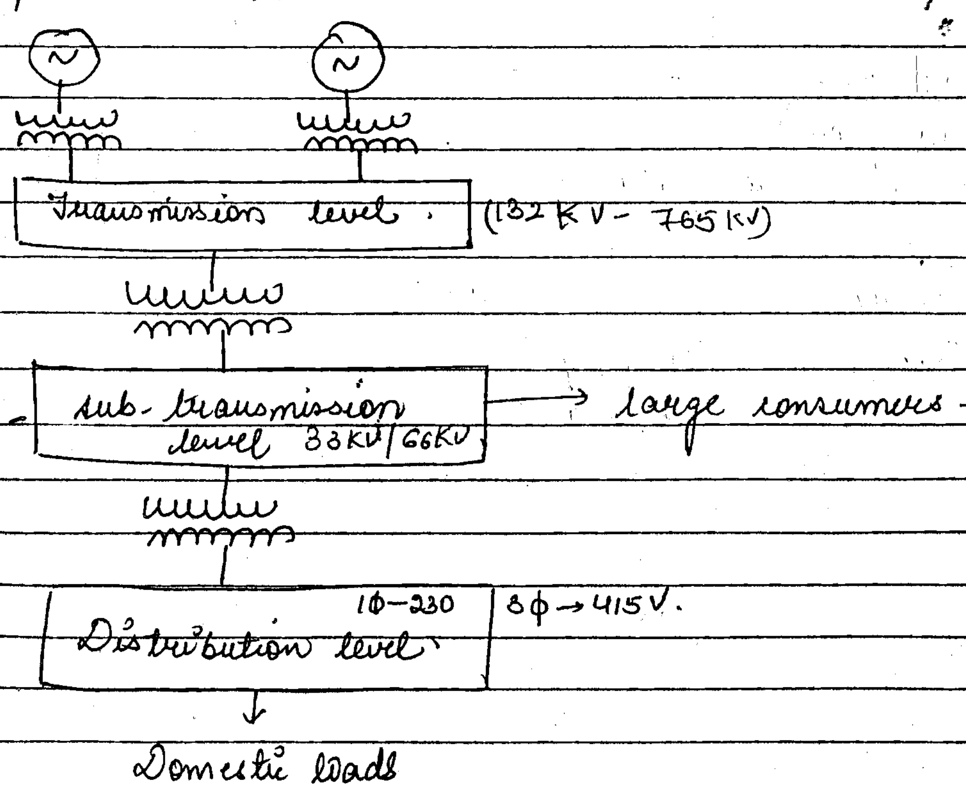
Weightage ⟶ (8-10) marks.

Books : JB Gupta
CL Wadhwa.

Introduction to Power system :-

India → Southern, Western, Northern, Eastern, North Eastern • Inter connection P.S.

* India has 5 regional grids which are inter connected with each other in order to supply power from energy surplus areas to energy deficit area.
* In inter connected P.S there is more efficient utilization of energy but at the same time there is a risk of fault propagation from one part of P.S to the other.
* So, we realize the concept of smart grid in which load scheduling is automatic but there must be effective protection by developing communication b/w the substation.



Objectives of power system :

⇒ cost of per unit energy should be minimized . (per kwh) .

↳ ~~economic generation~~

↳ economic load dispatch : → (load sharing)

↳ power generation method .

⇒ effective protection against fault .

↳ fault analysis

↳ switch gear and protection .

⇒ rated v/g and frequency must be supplied to consumer .

↳ automatic v/g control .

↳ load freq. control . → speed governor .

⇒ Power system must be stable .

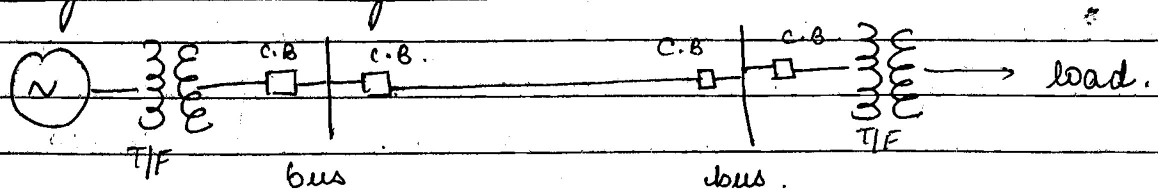
↳ Power s/m stability

⇒ reliable power supply to consumer

↳ Transmission and distribution

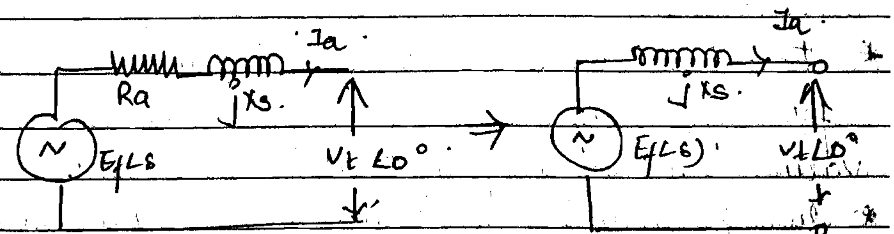
Per unit System :

single line diagram :



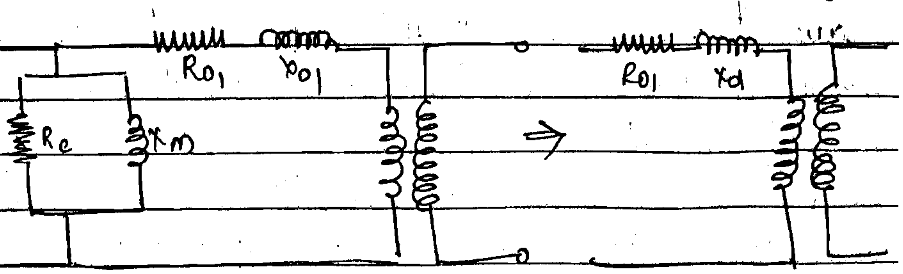
actual ckt :

1. Generator.



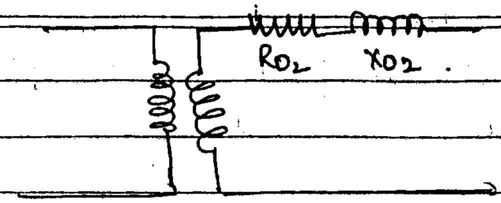
2. Transformer.

primary ⇒



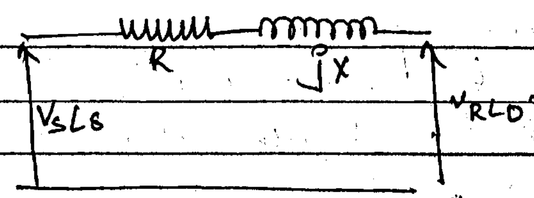
⇒ shunt branch ignored.

secondary ?



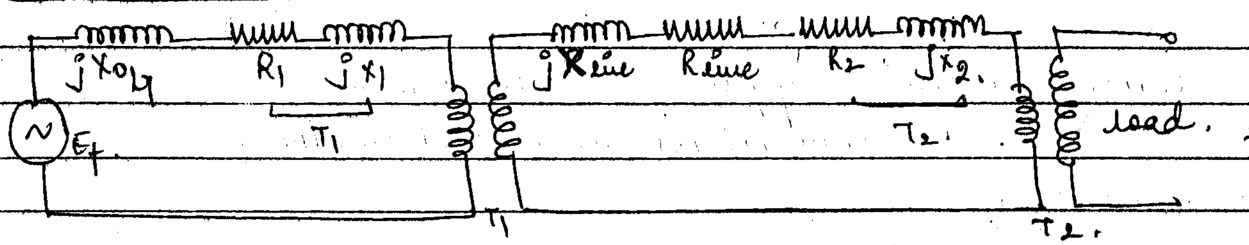
3. Transmission line

short transmission line.



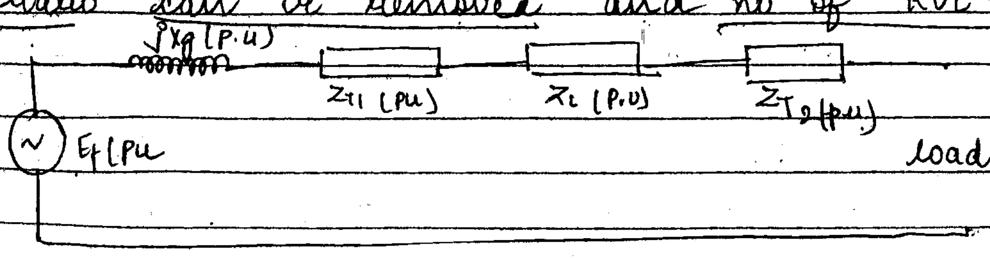
* the loads are generally modelled as *constant power load* where the real and reactive powers of the load is specified.

Overall circuit



The eq circuit of P.S is complicated due to multiple component being present but single line diagram is a simplified representation which is easily readable

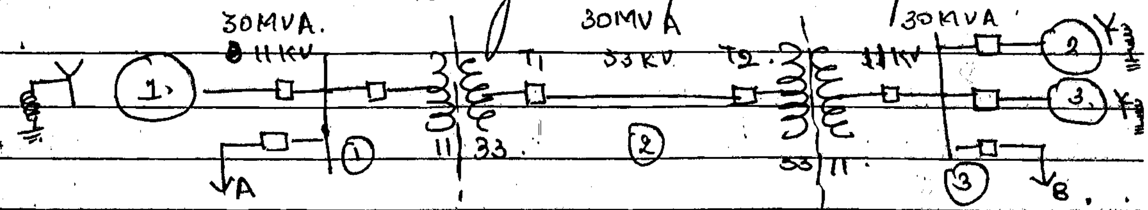
* to analyze the given circuit, we need 3 KVL eq for 3 loops and hence analysis in absolute values is complicated.
* In per unit system, the pu values of all quantities are same on both sides of Tformer so the turns ratio can be removed and no of KVL eq reduces.



To convert a P.S in per unit :-

we must use a universal base so that results are consistent with the actual values.

Q Draw the reactance diagram for the p.s shown in fig.



G1 :- 30 MVA, 10.5 KV, $X'' = 1.6\,\Omega$.

G2 :- 15 MVA, 6.6 KV, $X'' = 1.2\,\Omega$.

G3 :- 25 MVA, 6.6 KV, $X'' = 0.56\,\Omega$.

T_1 & T_2 :- 15MVA, 33/11 KV. $X = 15.2\,\Omega/\phi$ on HV side.

Trans. line → $20.5\,\Omega/\phi$.

P Base = 30 MVA. [power base will be same].

* While chosing the base, KVA base remain same for the entire p.s but we only choose v/g base for 1 section and then scaled it on the basis of turns ratio or transformation ratio of X-mer.

$$X_1\ pu :- \frac{1.6}{(11^2/30)} = 0.396.$$

$$X_{T1}(pu) = \frac{15.2}{(33^2/30)} = 0.4187.$$

$$X_{TLine} = \frac{20.5}{33^2/30} = 0.5647.$$

$$X_{T2}(pu) = \frac{15.2}{33^2/30} = 0.418$$

$$X_2 = \frac{1.2}{(11^2/30)} = 0.297$$

$$X_3 = \frac{0.56}{11^2/30} = 0.138$$

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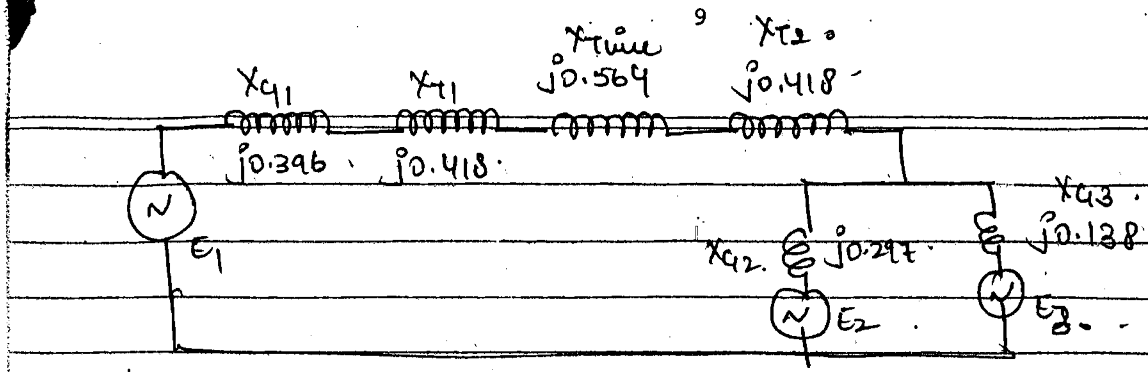
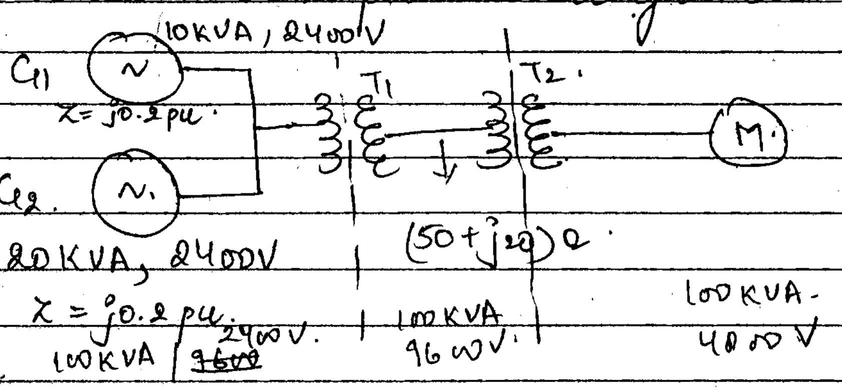


2. Draw the impedance diagram



T_1 = 40KVA
2400/9600V
x = 0.1j

T_2 = 80KVA
10KV/5KV
Z = 0.1pu

M = 25KVA, 4KV
x = j0.3pu

Choose base for Generator 1 as 2400V | 100KVA

∴ Given Base = 100 KVA, 2400V.

$G_1 = j0.2 \times \left(\frac{100}{10}\right) \times \frac{2400}{2400} = 2j$

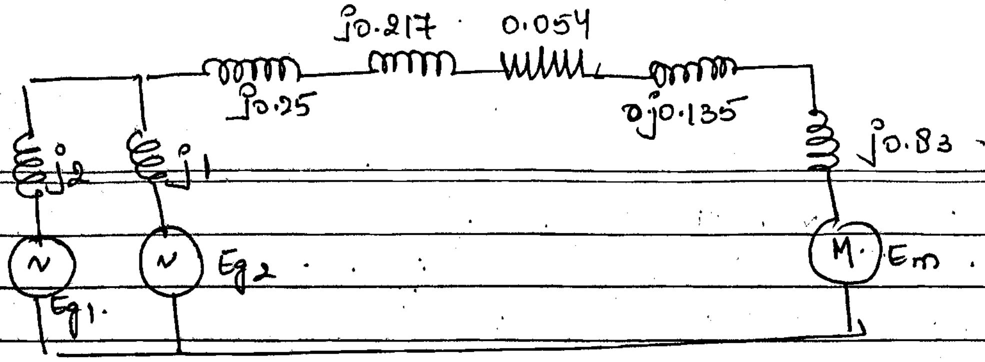
$G_2 = j0.2 \times \left(\frac{100}{20}\right) \times 7 = j1$

$T_1 = j0.1 \times \left(\frac{100}{40}\right) = 0.25j$

$Z_L = \frac{50+20j}{\frac{9600^2}{100\times10^3}} \Rightarrow 0.054 + j0.217$

$Z_{T2} = j0.1 \times \left(\frac{100}{80}\right) \times \left(\frac{5000}{4000}\right)^2 = j0.135$

$X_M = 0.3j \times \left(\frac{100}{25}\right) \times \left(\frac{4000}{4000}\right)^2 = 0.833j$



Q A 3 bus system is given as shown in fig

G1 : 50MVA, 13.8KV, X'' = 0.15 pu

G2 : 40MVA, 13.2KV, X'' = 0.2 pu

G3 : 30MVA, 11KV, x'' = 0.25 pu

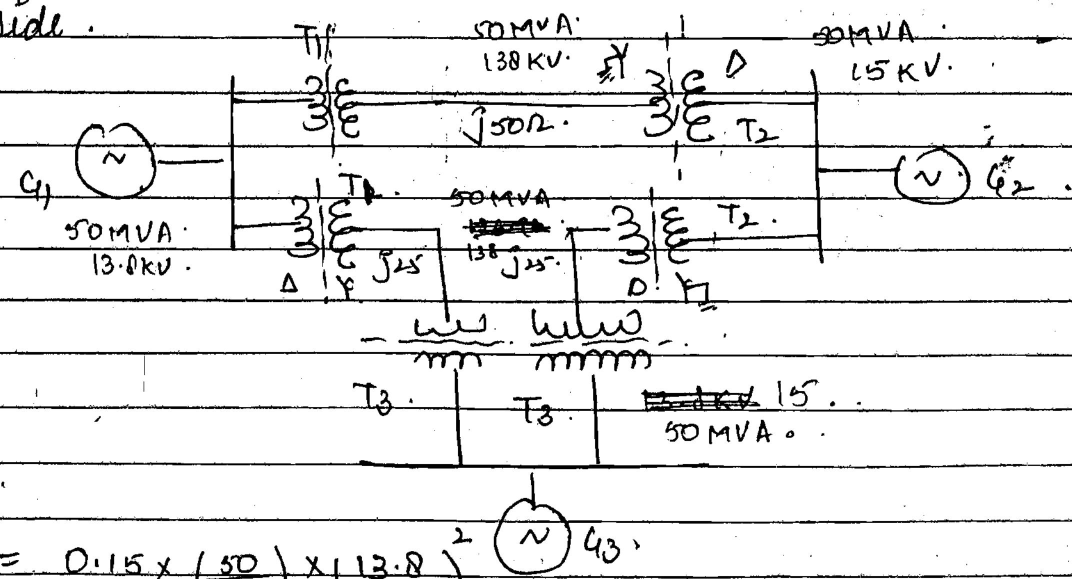
T-1 : 45MVA, 11KV Δ / (110KV) Y (Δ - Y) X = 0.1 pu

T-2 = 25MVA, 12.5KV (Δ) / 115KV (Y) X = 0.15 pu

T-3 = 40MVA, 12.5 KV (Δ) / 115 KV Y X = 0.1 pu

line Z : are shown in fig

Choose base values as 50 MVA, and 13.8 KV on G1 side.



$$G_1 = 0.15 \times \left(\frac{50}{50}\right) \times \left(\frac{13.8}{13.8}\right)^2 = 0.15j$$

$$G_2 = 0.2 \times \left(\frac{50}{40}\right) \times \left(\frac{13.2}{15}\right)^2 = 0.1936j$$

$$G_3 = 0.25 \times \left(\frac{50}{30}\right) \times \left(\frac{11}{15}\right)^2 = 0.2240j$$

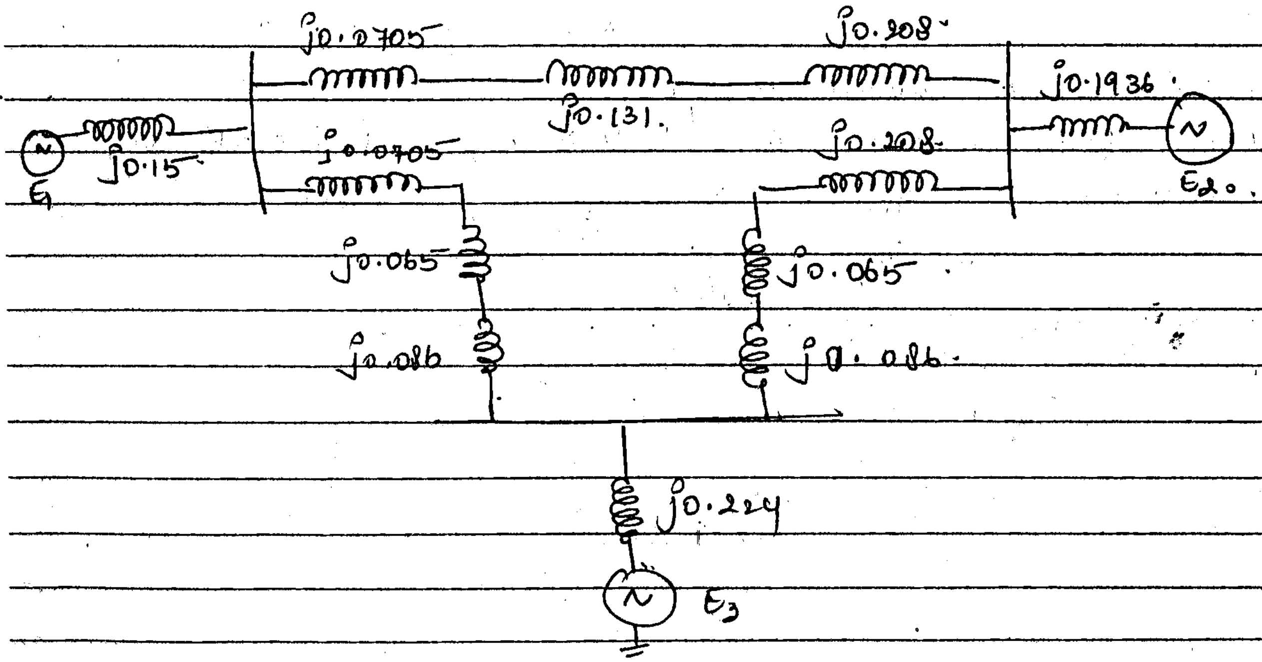
$T_1 = 0.1 \times \left(\frac{50}{45}\right) \times \left(\frac{11}{13.8}\right)^2 = 0.0705$

$T_2 = 0.15 \times \left(\frac{50}{25}\right) \times \left(\frac{12.5}{15}\right)^2 = 0.208$

$X_{T3} = 0.1 \times \left(\frac{50}{40}\right) \times \left(\frac{12.5}{15}\right)^2 = \sout{0.806}\ 0.0806$

$T_{L1} = 50 / (138^2/50) = 0.131$

$T_{L2} = T_{L3} = 0.065$



Q A 220 MVA, 66 KV, 3ϕ generator has $X'_{sub.} = 30\%$, the G is connected to 3 Motors through a X-mission line and transformers as shown in fig, the motors have rated inputs of 60 MVA, 40 MVA, 100 MVA with 40% sub-Transient reactance, the rating of X-mer are shown in fig. draw the reactance diagram assuming X-mission line reactance = (100 Ω)