جامعة الموصل / كلية الهندسة

قسم الهندسة الكهربائية

Subject Title: Power system analysis (PSA)

Subject Code: PSAN400

Class 4: Power & Machine

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Course Description (15 weeks) or Outlines

- Introduction; Syllabus; basic components of a power system,single line diagram ,
- Per unit analysis, generator, transformer, transmission line and load representation for different power system
- Construction of Y-bus and Z-bus
- Load Flow Analysis using GS ,NR ,FDC
- Short Circuit Study :Symmetrical Short-Circuit , Symmetrical Component
- Unsymmetrical Fault
- Economical Operation of Power System
- Stability Analysis

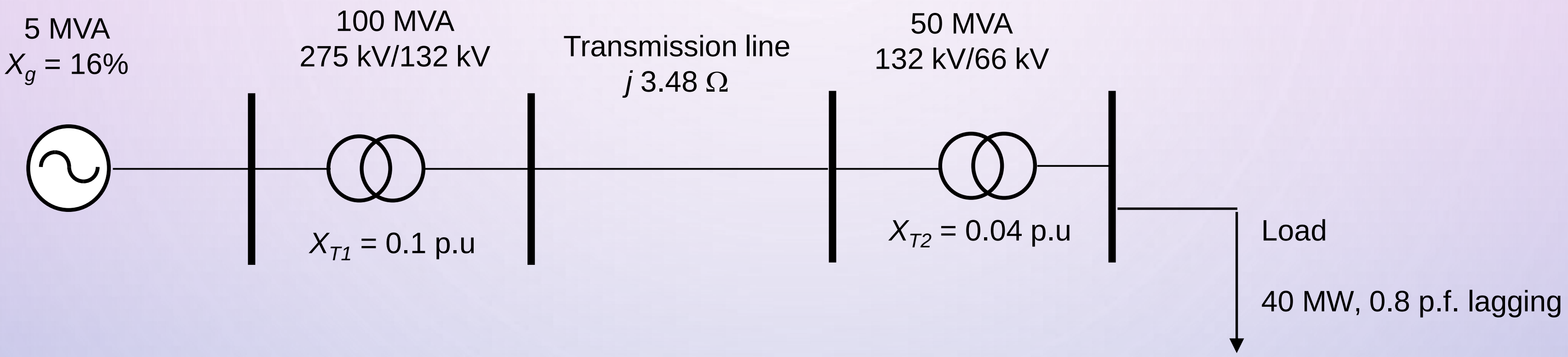
Changing the base of per unit quantities

For a connected circuit, it is obvious that the same bases should be used for the whole network such that the normal circuit theorems would also apply to per unit values, e.g

$$Z_{p.u,new} = Z_{p.u,old} * \frac{\left(kV_{b,old}\right)^2}{\left(kV_{b,new}\right)^2} * \frac{MVA_{b,new}}{MVA_{b,old}}$$

Example 1

Determine the per-unit values of the following single-line diagram and draw the impedance diagram.



Solution:

Chosen base: Always choose the largest rating, therefore S_{base} = 100 MVA, V = 66 kV, 132 kV and 275 kV

Per-unit calculations:

Generator G1:

$$\boxed{Z_{NEW}\left(pu\right) = Z_{OLD} \times \frac{\left[kV_{base\ OLD}\right]^2}{\left[kV_{base\ NEW}\right]^2} \times \frac{MVA_{base\ NEW}}{MVA_{base\ OLD}}}$$

$$X_g(pu) = 0.16 \times \frac{100}{50} = 0.32 \quad \text{p.u.}$$

Transformer T1:

$$X_{T1}(pu) = 0.1 \quad \text{p.u.}$$

Transmission line TL:

$$\boxed{Z_{base} = \frac{[kV_{base}]^2}{MVA_{base}}} \quad \boxed{Z_{pu} = \frac{Z_{actual}}{Z_{base}}}$$

$$X_{TL}(pu) = \frac{3.4 \times 100}{132^2} = 0.0195 \quad \text{p.u.}$$

Inductive load:

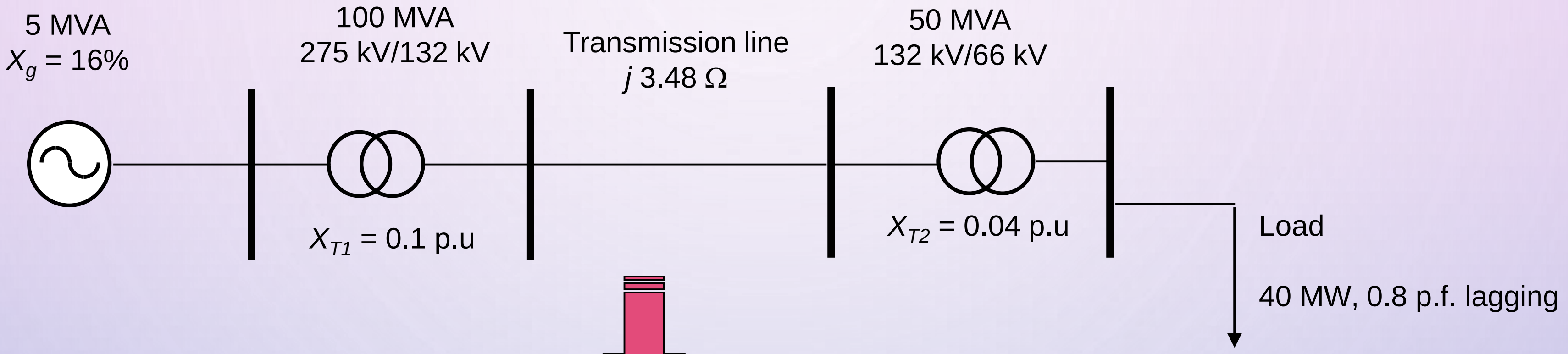
$$Z_{actual} = \frac{66 \times 10^3 / \sqrt{3}}{40 \times 10^6 / \sqrt{3} \times 66 \times 10^3 \times 0.8} = 87.12\angle 36.87^o \quad \Omega$$

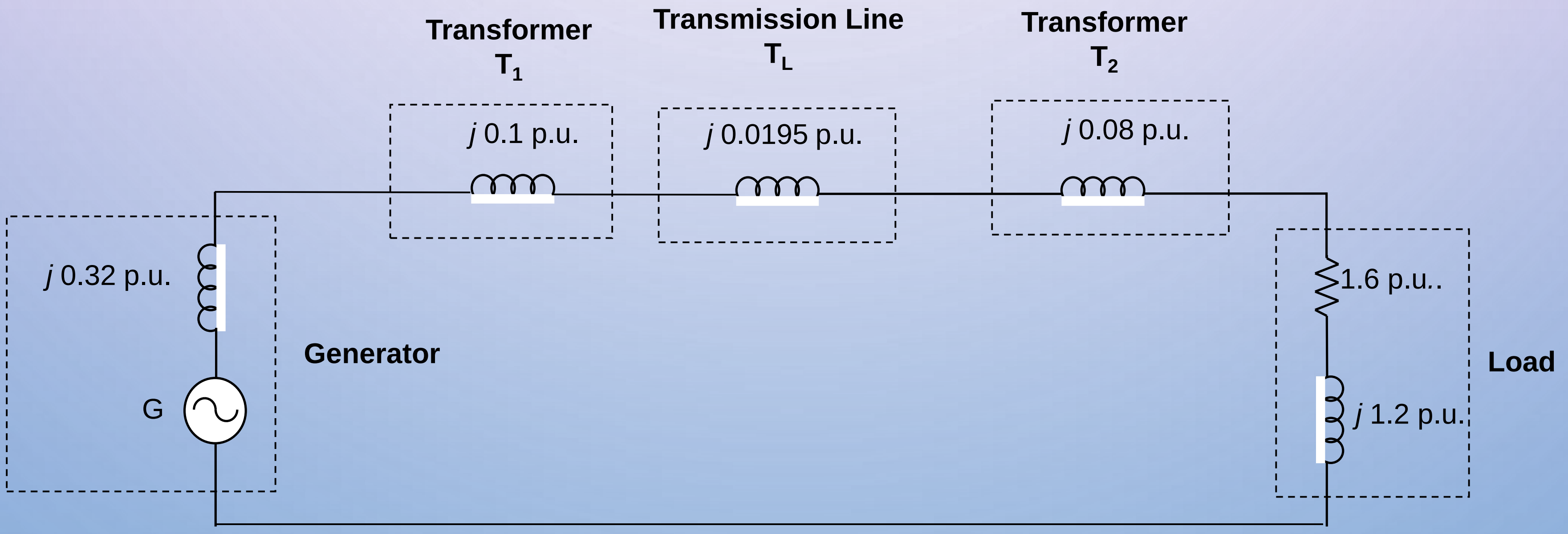
$$Z_L(pu) = \frac{87.12\angle 36.87^o \times 100}{66^2} = 2\angle 36.87^o \; or \; (1.6 + j1.2) \quad \text{p.u.}$$

Transformer T2:

$$X_{T2}(pu) = 0.04 \times \frac{100}{50} = 0.08 \quad \text{p.u.}$$

Now, we have all the impedance values in per-unit with a common base and we can now combine all the impedances and determine the overall impedance.





Algorithm for GS method

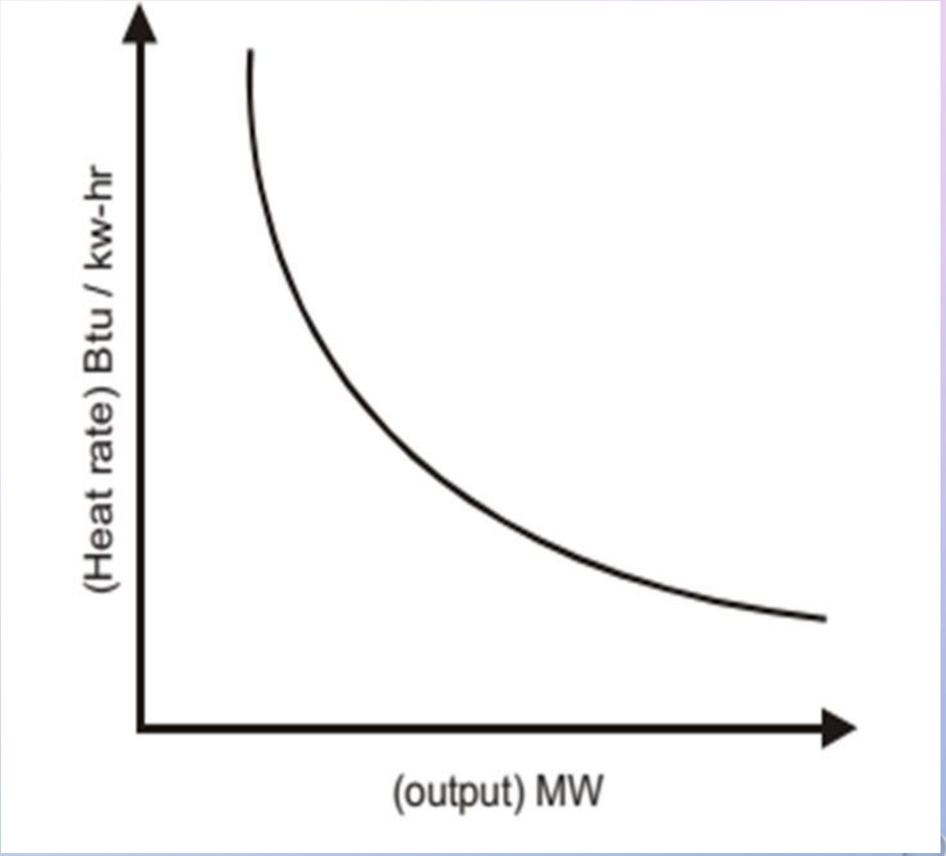
1. Prepare data for the given system as required.
2. Formulate the bus admittance matrix YBUS. This is generally done by the rule of inspection.
3. Assume initial voltages for all buses, 2,3,…n. In practical power systems, the magnitude
of the bus voltages is close to 1.0 p.u. Hence, the complex bus voltages at all (n-1) buses (except slack bus) are taken to be 1.0 0^0. This is normally refered as the flat start solution.
4. Update the voltages. In any (k +1)st iteration, from (17) the voltages are given by

$$V_i^{(k+1)} = \frac{1}{Y_{ii}}\left[\frac{P_i - jQ_i}{(V_i^{(k)})^*} - \sum_{j=1}^{i-1} Y_{ij} V_j^{(k+1)} - \sum_{j=i+1}^{n} Y_{ij} V_j^{(k)}\right] \forall \text{ i=2,3,…n}$$

Economic Operation Of Power Systems

HEAT RATE CURVE

The heat rate is the ratio of fuel input in Btu to energy output in KWh. It is the slope of the input – output curve at any point. The reciprocal of heat – rate is called fuel – efficiency. The heat rate curve is a plot of heat rate versus output in MW



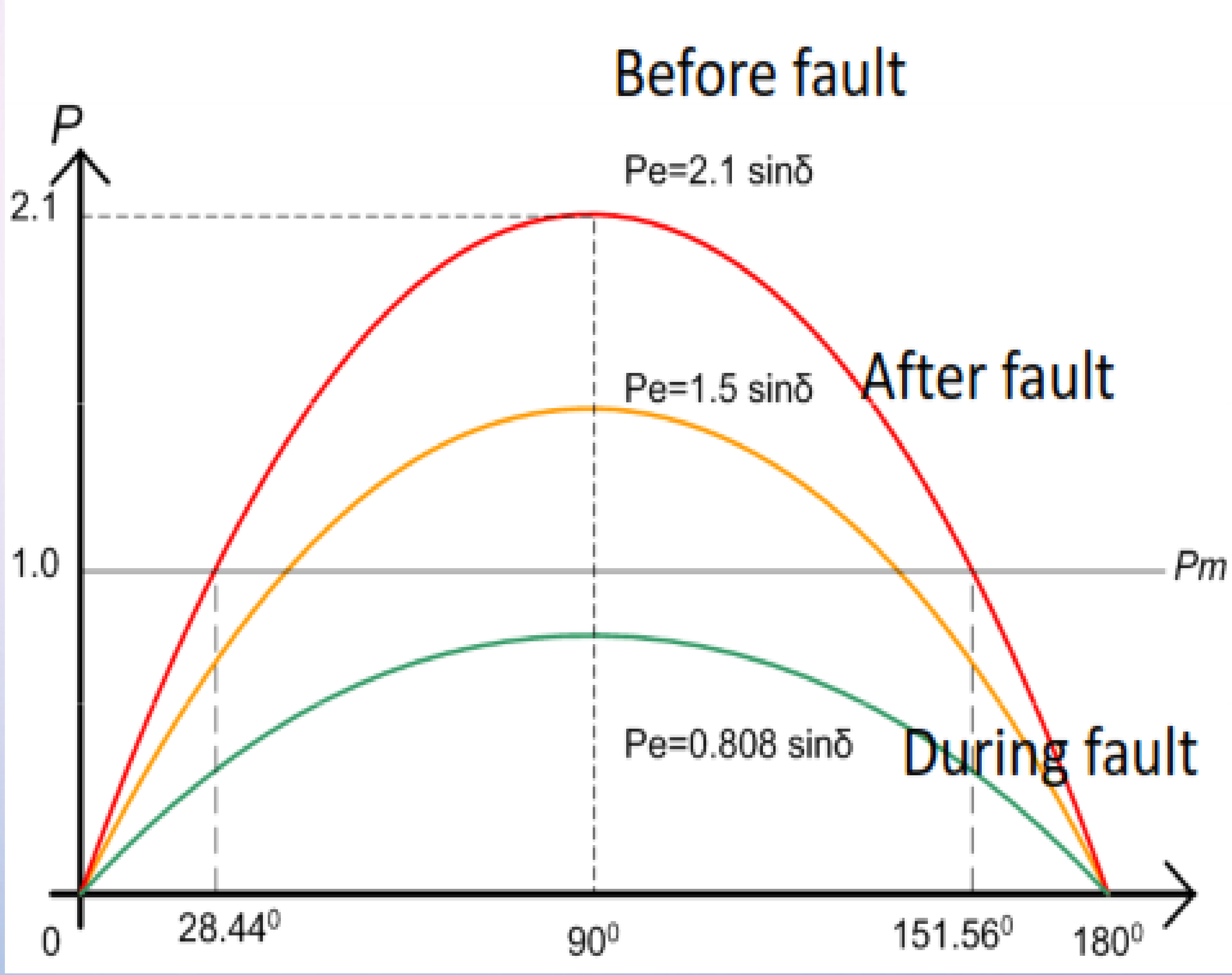
Power System Stability

Power system stability involves the study of the dynamics of the power system under disturbances. Power system stability implies that its ability to return to normal or stable operation after having been subjected to some form of disturbances.
From the classical point of view power system instability can be seen as loss of synchronism (i.e., some synchronous machines going out of step) when the system is subjected to a particular disturbance. Three type of stability are of concern: Steady state, transient and dynamic stability.

From the power-angle curve, two values of angle satisfied the mechanical power i.e at 28.44 and 151.56

However, only the 28.440 is acceptable operating point.

Acceptable operating point is that the generator shall not lose synchronism when small temporary changes occur in the electrical power output from the machine.



TEXTBOOK OR REFERENCES

- 1- POWER SYSTEM ANALYSIS by William D. Stevenson
- 2- POWER SYSTEM ANALYSIS and design by Glover

Useful Links

Description	Links
Video Lecture	https://www.youtube.com/channel/UCBdVgVQSlct8BF35_fn09pg
Power System Analysis Course	https://www.youtube.com/watch?v=UlZx6xJxFZw&list=PLk_us2kvnmO4dCDWZ_Oi1pcRGO6W1On1K&ab_channel=Dr.AhmadAl-Subhi