Course:
ELEC ENG 3110 Electric Power Systems
ELEC ENG 7074 Power Systems PG

(Semester 2, 2021)

Sample Quiz Questions

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Following is a set of sample quiz questions.

This is indicative of the style of questions that will be in the quiz. It is emphasized that the actual quiz may cover material in the notes, tutorials, quiz #1, sample quiz #1 which are not covered in the following questions. Thus, you **<u>should NOT</u>** restrict your revision only to these sample questions.

The material in **<u>Tutorials #1 to #4, quiz #1, sample quiz #1</u>** and the **lecture notes** up to and including those on **<u>Wednesday 13 October</u>** is subject to testing in the quiz.

The duration of quiz 2 will be 60 minutes and will be out of 40 marks. Thus, on average, it is expected each mark will require 60/40 = 1.5 min. The length of this sample quiz is out of 75 marks and is thus almost twice as long as the actual quiz. You should aim to complete the sample quiz questions in 110 min.

1 Power System Operation [8 marks]

1.1 Explain the meaning of power system security [2 marks]

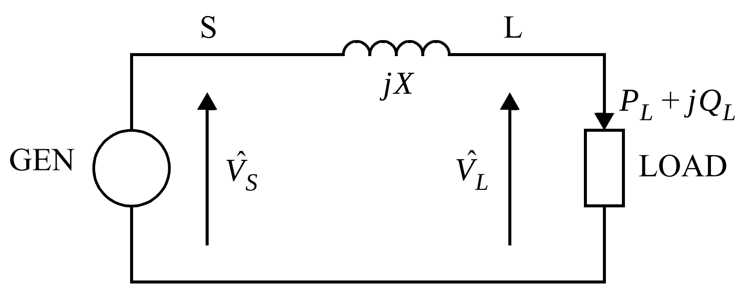
1.2 List four of the main advantages of the per-unit system? [2 marks]

1.3 With reference to the surge impedance load of a transmission line explain under what conditions a transmission line may be a net generator or net consumer of reactive power. [2 marks]

1.4 List three reasons for conducting loadflow analysis. [2 marks]

2 Power transmission limits (A) [10 marks]

Consider the following circuit in which all parameters are in per-unit on a consistent basis. The line reactance is $X = 0.3$ pu and $V_s = |\hat{V}_S| = 1.05$ pu. The load power factor is 0.9 (lag).



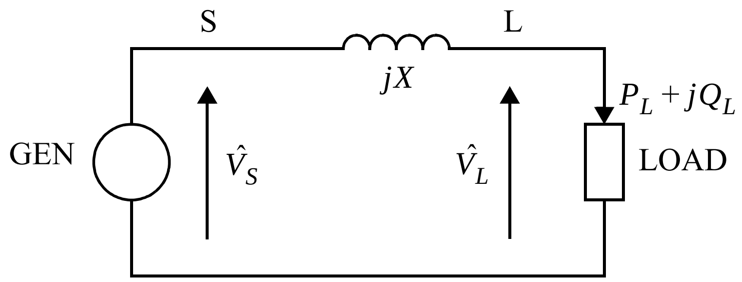
Calculate the load power P_L such that the load voltage magnitude is $V_L = 0.95$ pu.

[Hints: The solutions of the quadratic equation $ax^2 + bx + c = 0$ are $x_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

and $(\cos(x))^2 + (\sin(x))^2 = 1$]

3 Power transmission limits (B) [12 marks]

Consider the following circuit in which all parameters are in per-unit on a consistent basis. The line reactance is $X = 0.3$ pu and $V_s = |\hat{V}_S| = 1.05$ pu. The load power factor is 0.9 (lag).



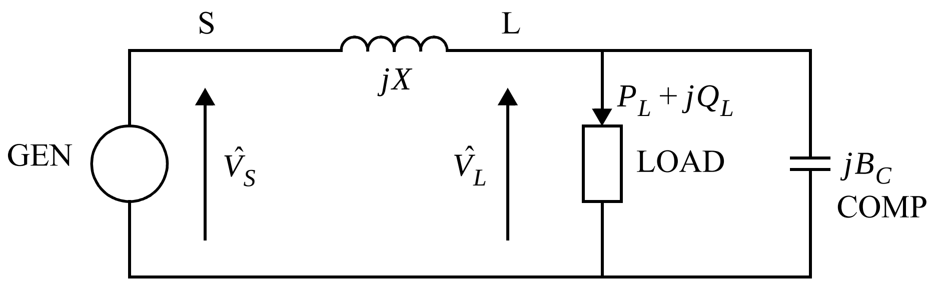
Calculate the maximum load, $P_{L\max}$, that can be supplied and the corresponding load bus voltage V_L when this load is being supplied.

[Hints: The solutions of the quadratic equation $ax^2 + bx + c = 0$ are $x_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

and $(\cos(x))^2 + (\sin(x))^2 = 1$]

4 Reactive power compensation [10 marks]

Consider the following circuit in which all parameters are in per-unit on a consistent basis. The line reactance is $X = 0.4$ pu, $V_s = |\hat{V}_S| = 1.05$ pu, $P_L = 1.2$ pu and $Q_L = 0.6$ pu.



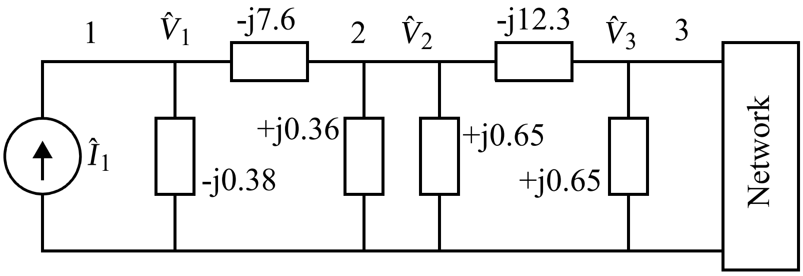
4.1 Calculate the compensation susceptance B_C required such that the load bus voltage magnitude is $V_L = 1.05$ pu. [6 marks]

4.2 Explain why reactive power compensation is required. [2 marks]

4.3 It is required to reduce the voltage at a node. Will you connect a reactor or capacitor to the bus? Explain your choice. [2 marks]

5 Nodal current equations [12 marks]

5.1 Consider the following network. Form the nodal current equation for node 2 only. The equation must be expressed in the form $\hat{I}_2 = c_1\hat{V}_1 + c_2\hat{V}_2 + c_3\hat{V}_3$ and the numerical value of $\hat{I}_2$ must be specified. All network elements are per-unit admittances. [5 marks]



5.1 For a particular operating condition $\hat{V}_1 = 1.0\angle 30°$ and $\hat{V}_2 = 1.05\angle 20°$. Calculate the reactive power Q_1 supplied by the source. [4 marks]

5.2 List two reasons for conducting power flow analysis [2 marks]

5.3 Describe what is meant by a PV bus in loadflow analysis [1 marks]

6 Transmission line performance [15 marks]

Consider transmission line of length 300 km and nominal voltage $V_0 = 500$ kV (rms, ph-ph). The series reactance of $X_L = 0.271$ ohm / phase / km and shunt susceptance of $B_C = 4.332 \times 10^{-6}$ S / phase / km. The system nominal frequency is 50 Hz. Transmission line losses are to be neglected.

6.1 Show that the surge impedance load of a transmission line is:

$$\mathrm{SIL} = \frac{V_0^2}{Z_0}\ \mathrm{MW} \tag{1}$$

(*You must clearly show the steps in your derivation.*) [3 marks]

6.2 Calculate the surge impedance load of the transmission line. [2 marks]

6.3 The transmission line receiving end voltage is $\hat{V}_R = 500$ kV (rms, ph-ph) and the three-phase power supplied by the transmission line is 500 MW at unity power factor. Calculate the source voltage $\hat{V}_S$ (in kV, rms, ph-ph) and the three-phase reactive power supplied by the source, Q_S (in MVAr).
[10 marks]

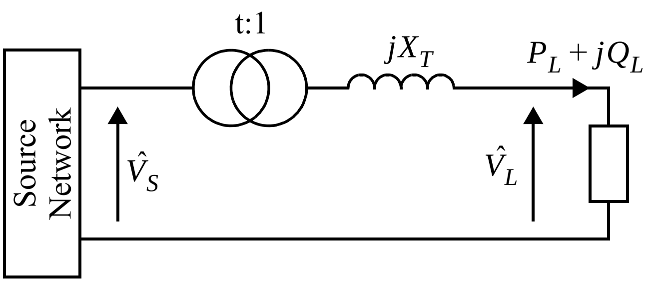
[Hints: Relevant transmission line related equations:

$$\hat{V}(x) = \hat{V}_S\cos(\beta x) - \boxed{j}Z_0\hat{I}_S\sin(\beta x) \quad \text{and} \quad \hat{I}(x) = \hat{I}_S\cos(\beta x) - \boxed{j}\left(\frac{\hat{V}_S}{Z_0}\right)\sin(\beta x), \quad Z_0 = \sqrt{L/C}$$

and $\beta = \omega\sqrt{LC} = \dfrac{2\pi}{\lambda}$.]

7 Transformer voltage control [8 marks]

Consider a transformer equipped with an on-load tap-changer (OLTC) as shown in the following power circuit diagram. All quantities are in per-unit on a consistent basis. The transformer leakage reactance is $X_T = 0.12$ pu. The load is $P_L = 0.8$ pu with power factor 0.98 (lag), the load bus voltage magnitude is $V_L = 1.02$ pu and the source voltage is $V_S = 0.98$ pu.



7.1 Calculate the transformer off-nominal tap-position t required to satisfy the given operating conditions. (Note: the tapped winding is on the source side of the transformer). [4 marks]

7.2 Calculate the reactive power supplied by the source network. [4 marks]