Tampere University
Electrical Engineering

EE.EES.430 ELECTRIC POWER SYSTEMS

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Attempt ALL questions

The numbers in square brackets after the assignments indicate the marks allotted to the part of the question against which the mark is shown. These marks are for guidance only.

An electronic calculator may be used provided that it does not have a facility for either textual storage or display, or for graphical display. If a calculator is used, intermediate steps in the calculation should be indicated.

Q1 A 50 Hz transmission line 300 km long has a total series impedance of 40 + j125 Ω and total shunt admittance of 0.001 1/Ω, both for positive sequence. The shunt admittance is a pure capacitive susceptance, shunt conductance being zero. The receiving-end load is 50 MW at 220 kV ($\underline{U}_R$ line-to-line voltage) with 0.8 lagging power factor. Determine the *ABCD* parameters using nominal π equivalent. Find the receiving end current $\underline{I}_R$, sending end voltage $\underline{V}_S$, sending end current $\underline{I}_S$ and sending end active power. [6]

Q2 (a) For the circuit shown in Figure 1, determine the nodal voltage solution using one iteration round of the power flow Newton-Raphson method. Select bus 1 to be the slack bus, with a voltage magnitude of 1.0 p.u. and 0 phase angle. The voltage magnitude at bus 2 is also kept at 1 p.u. To start the iterative solution, assume 0 voltage phase angle at bus 2. Notice that synchronous generator at bus 2, is injecting 0.5 p.u. of active power at bus 2. [4]

(b) Describe briefly, how the current and power flow according to solution of Newton-Raphson method (no need to calculate) can be determined? [2]

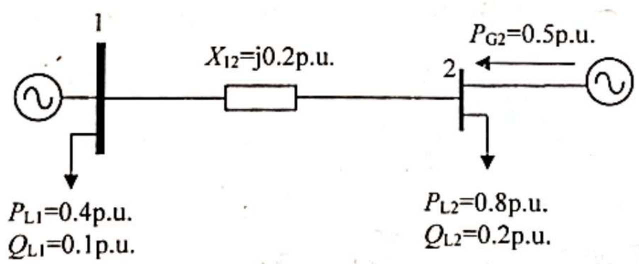

Figure 1. Electrical circuit for Question 2a).

Tip: Nodal active (P_l) and reactive (Q_l) power equations in a generic node l, have the following form:

$$P_l = V_l \sum_{m=1}^{n} V_m \left(G_{lm}\cos(\theta_l - \theta_m) + B_{lm}\sin(\theta_l - \theta_m)\right)$$

$$Q_l = V_l \sum_{m=1}^{n} V_m \left(G_{lm}\sin(\theta_l - \theta_m) - B_{lm}\cos(\theta_l - \theta_m)\right)$$

where V_l and V_m are the nodal voltage magnitudes at nodes l and m, θ_l and θ_m are their corresponding phase angles, and G_{lm} and B_{lm} are the conductance and susceptance of a transmission line linking nodes l and m.

Q3 The power circuit of Figure 2 undergoes a single-phase-to-ground fault (conductor in phase A) in Bus 4.

(a) Calculate the fault current at bus 4 assuming a flat voltage profile of 1.05 p.u. in all four buses just before the fault occurs and zero fault impedance at bus 4, i.e. $Z_f = 0 + j0$ p.u. [2].

(b) Determine the nodal voltages during a fault in all buses, in sequence quantities. Express briefly, how the nodal phase voltages could be determined according to nodal sequence voltages. [2]

(c) Determine the currents in sequence quantities just after the fault occurs, flowing through the two transmission lines and the transformer [2].

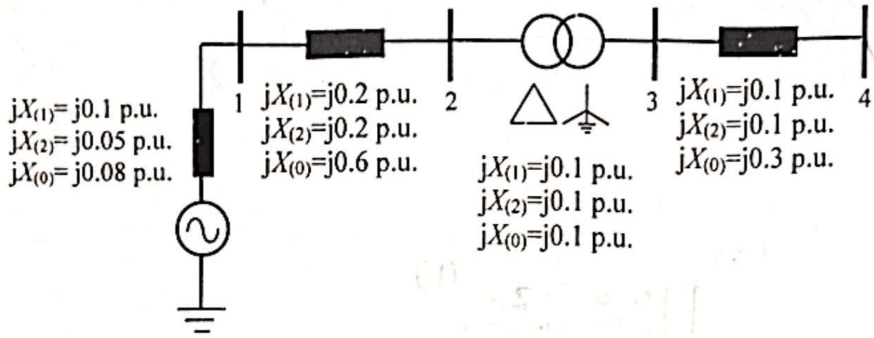

Figure 2. Electrical circuit for Question 3.

Q4

a) Find the maximum power that can be transferred when another parallel line of the network (Figure 3) is disconnected. Generator emf voltage E' = 1.075∠33.9°. All impedances and voltages are in p.u. [2]

b) Write the swing equation upon the disconnection of the line (situation of Section a)) and determine the initial angular acceleration. H = 4 MJ/MVA [2]

c) If this acceleration can be assumed to remain constant for Δt = 0.05 s, find the rotor angle at the end of this time interval and the new acceleration. [2]

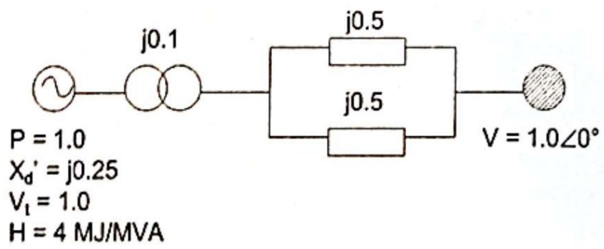

Figure 3. Electrical circuit for Question 4.

Q5 Provide a brief explanation and/or calculation model for the following terms:

(a) Characteristic impedance and propagation constant of transmission line [1]
(b) Earth fault factor [1]
(c) V-P characteristics of the system (VP-curve) [1]
(d) SVC devices [1]
(e) Speed droop with a frequency control [1]
(f) List some factors, how to improve transient stability [1]