Tampere University of Technology
Electrical Engineering

Fundamentals of Electrical and Power Engineering DEE-23106 26.11.2015

Anna Kulmala Programmable calculator allowed 5 questions/ á 6 pts

Question 1: A one-phase voltage source is feeding a load through a one-phase feeder. The source voltage is 155.56cos(377t+10°)V. The feeder impedance is 1+j2 Ω and the load impedance is 10–j4 Ω.

a) Draw the circuit diagram of the network and calculate the current. Draw the phasor diagram of the current and voltage. (2p)

b) Determine the real power, reactive power, apparent power and the power factor of the source. Draw the power triangle. (2p)

c) Determine the real power, reactive power, apparent power and the power factor of the load. Draw the power triangle. (2p)

Question 2: A three-phase power system consisting of one generator, two transformers, a transmission line and a load is represented in Fig. 1. The parameters of the system are the following:

Generator 1 (G1): 50 MVA, 11 kV, X1 = 0.15, X2 = 0.1, X0 = 0.03 pu
Transformer 1 (T1): 50 MVA, 11/110 kV, X = 9 %
Transformer 2 (T2): 25 MVA, 110/20 kV, X = 10 %
Load 1 (L1): P_{nom} = 10 MW, 20 kV
Load 2 (L2): Q_{nom} = 5 MVAr, 20 kV

a) The loads are modeled using a constant impedance load model such that they consume their nominal powers at the nominal voltage. The given power is three-phase power and the voltage 20 kV is the nominal line-to-line voltage. Calculate the impedance values for the loads. (1p)

b) Draw the positive sequence impedance network of the circuit. Use per unit values. (3p)

c) Calculate the current flowing through the transmission line. The internal emf of the synchronous generator G1 can be assumed to be 1.05∠0° pu. (2p)

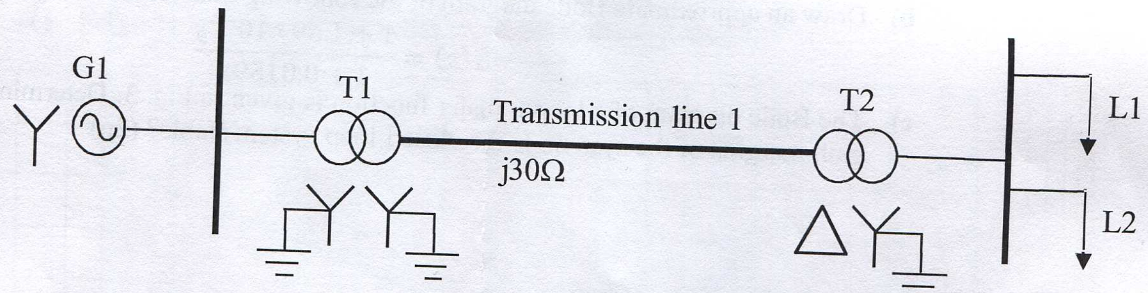

Fig. 1. The power system of question 2.

Question 3: Fig. 2 presents an electric circuit and all the relevant parameter values are given on the figure.

d) Determine the nodal admittance matrix of the electric circuit. (1p)

e) Calculate the voltages at nodes 3 and 4. (2p)

f) Determine the real and reactive powers injected by the two voltage sources at nodes 1 and 2. (2p)

g) Calculate the powers consumed by the resistive loads R_{30} and R_{40}. (1p)

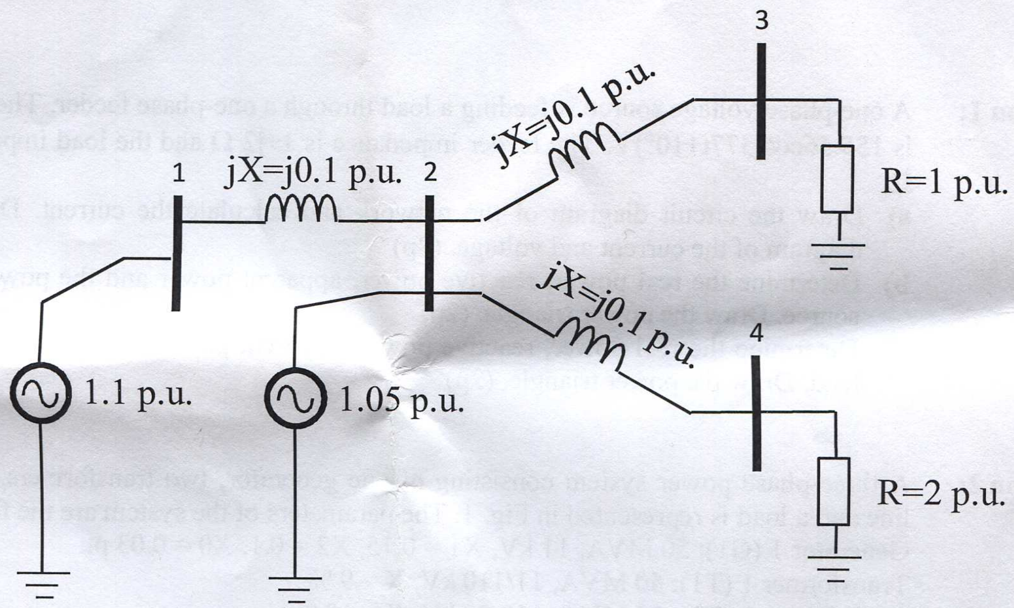

Fig. 2. The electric circuit of question 3.

Question 4:

a) Find symmetrical components of the following three-phase voltage. Draw the phasor diagrams of the original voltage phasors and the symmetrical components. (2p)

$$\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} = \begin{bmatrix} 1.05\angle 10^\circ \\ 0.8\angle -20^\circ \\ 1.2\angle 190^\circ \end{bmatrix}$$

b) Draw an approximate Bode diagram of the following transfer function. (2p)

$$G(s) = \frac{1 + 1.59 \cdot 10^{-4} s}{1 + 0.0159 s}$$

c) The Bode diagram of a loop transfer function is given in Fig. 3. Determine the phase and gain margins of the system. Is the closed-loop system stable? (2p)

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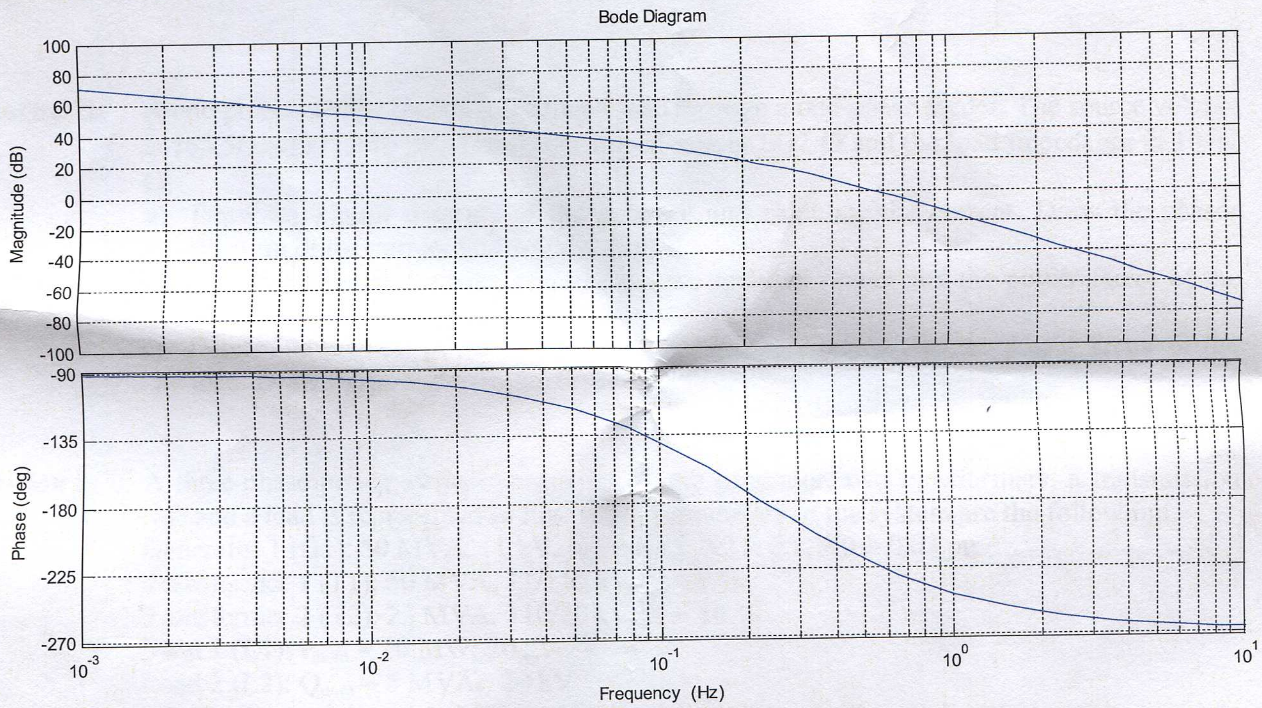

Fig. 3. Bode diagram of question 4c.

Question 5: The frequency response of impedance of a system is shown in Fig. 4. The system is composed of two passive components with their corresponding equivalent series resistances (ESRs).

a) What is the circuit? Draw the circuit and write its s-domain impedance equation. (2p)

b) Estimate the values of its main passive components. (2p)

c) Estimate the value of the ESRs involved in the system. (2p)

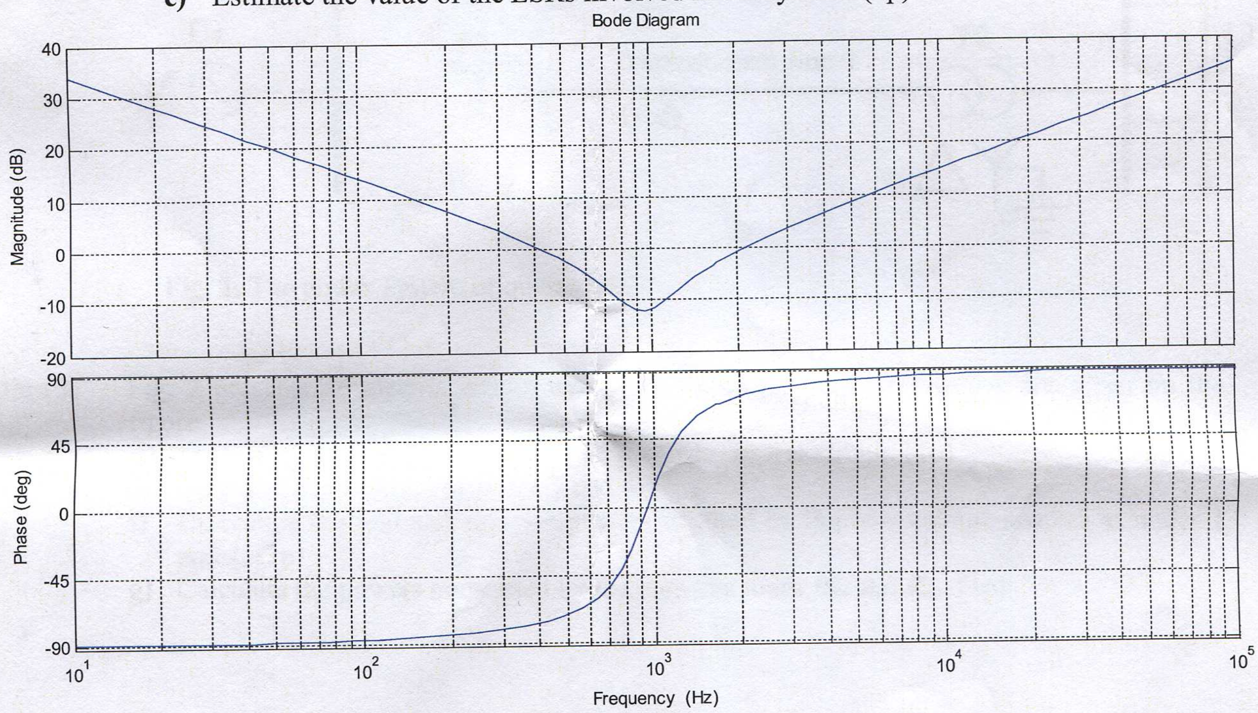

Fig. 4. Impedance plot of question 5.