Tampere University of Technology
Electrical Engineering

Fundamentals of Electrical and Power Engineering DEE-23106

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Programmable calculator allowed

5 questions/ á 6 pts

Question 1: The impedance of a system composing of two passive components with ohmic loss elements is shown in Fig. 1. Define the circuit based on the questions below. Each of the following subquestions yields 2 pts.

a) What is the circuit? **b)** Estimate the values of its main passive components, and **c)** Estimate the value of the ohmic losses involved in the system.

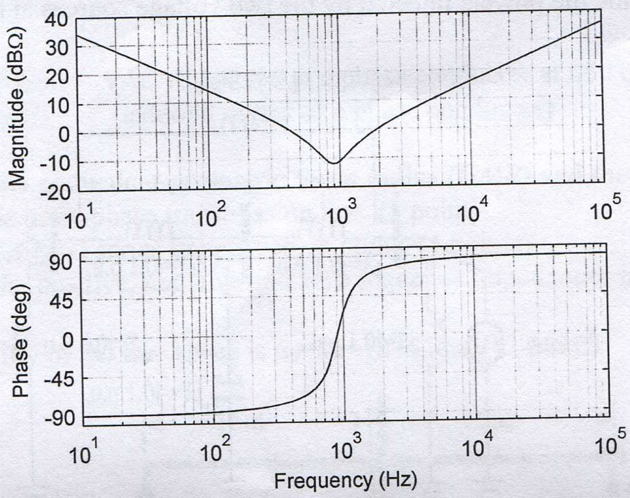


Fig. 1

Question 2: The two-port network representation of a certain linearized system is presented in Fig 2 inside the dashed line corresponding to

$$\begin{cases} \hat{i}_{in} = Y_{in}\hat{v}_{in} + \hat{i}_{out} \\ \hat{v}_{out} = \hat{v}_{in} - Z_o\hat{i}_{out} \end{cases} \quad (1)$$

where the ideal source condition is shown in Fig. 2b and the ideal load condition in Fig. 2a, respectively. It is well known that the impedances of the source (Fig. 2a) and load (Fig. 2b) will affect the system dynamic behavior. a) Compute the source-affected system description according to Fig. 2a based on (1) (Hint: $\hat{v}_{in}$ will change) (3pts), and b) Compute the load-affected system description according to Fig. 2b based on (1) (Hint: $\hat{i}_{out}$ will change) (3 pts).

Fig. 2a

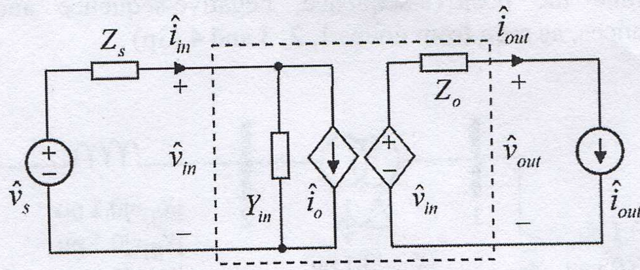
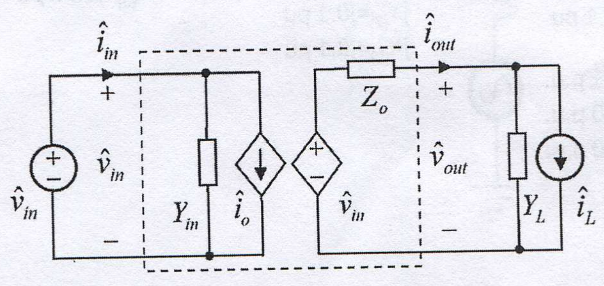


Fig. 2b



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Question 3: The electric circuit in Fig. 3 comprises three nodes in addition to the reference node 0 (ground), two voltage sources, six reactive branches, one of which is capacitive, connected as shown in the figure. All the relevant parameter values are given on the figure (2p/sub-question).

a) Determine the nodal admittance matrix of the electric circuit.
b) Calculate the voltages at node 2.
c) Determine the powers injected by the two voltage sources at nodes 1 and 3

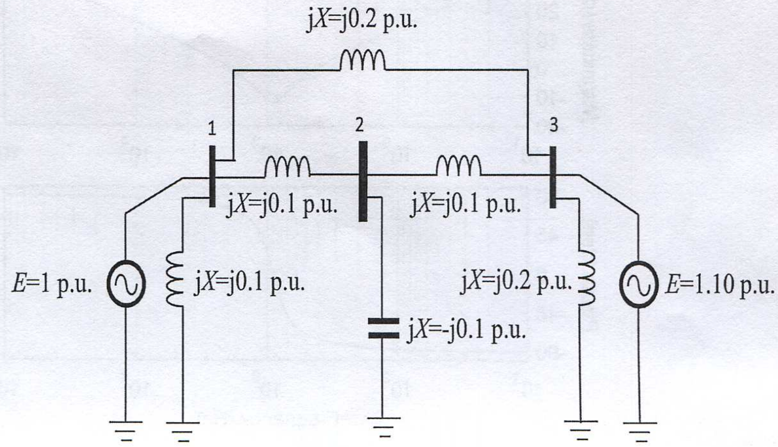

Fig. 3

Question 4: The one-line diagram shown in Fig. 4 represents a three-phase power network, for which per-unit values of positive, negative and zero sequence parameters, are available:

a) Built the positive-sequence, negative-sequence and zero-sequence nodal impedance matrices (3p)
b) Determine the positive-sequence, negative-sequence and zero-sequence Thevenin impedances, as seen from nodes 1, 2, 3 and 4 (3p)

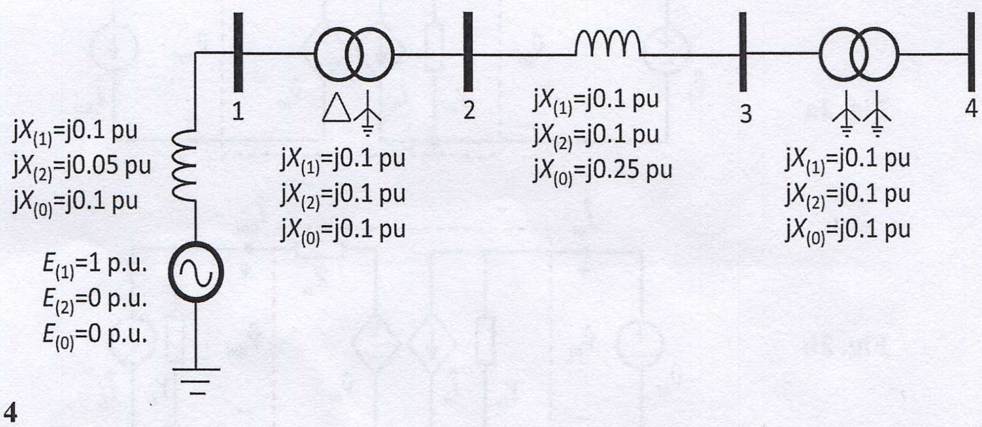

Fig. 4

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Question 5: A single-circuit, three-phase transmission line operating at 60 Hz has the dimensions shown in Fig. 5. It contains 3 bundled conductors per phase and no earth-wires (also termed ground wires or shielding wires). The separation between two adjacent conductors in a bundle is 30 cm. The transmission line is 200 km long and is rated at 230 kV. The conductivity of the ground is σ_g=0.01 S/m. The following additional information exists for the phase conductors:

R_{AC}=0.0798 $\Omega \cdot km^{-1}$ (AC resistance of a phase conductor at 60 Hz)
r_{ext}=1.4597 cm (external radius of a phase conductor)

a) Calculate the equivalent geometric mean radius (*GMR*) and the equivalent resistance per phase of the three-phase transmission line. (1 point)
b) Calculate the total series impedance, in ohms. (4 points)
c) Calculate the positive, negative and zero sequence impedances in ohms.

The permeability of the free space is $\mu_0=4\pi\times10^{-7}$ H·m^{-1}. (1 point)

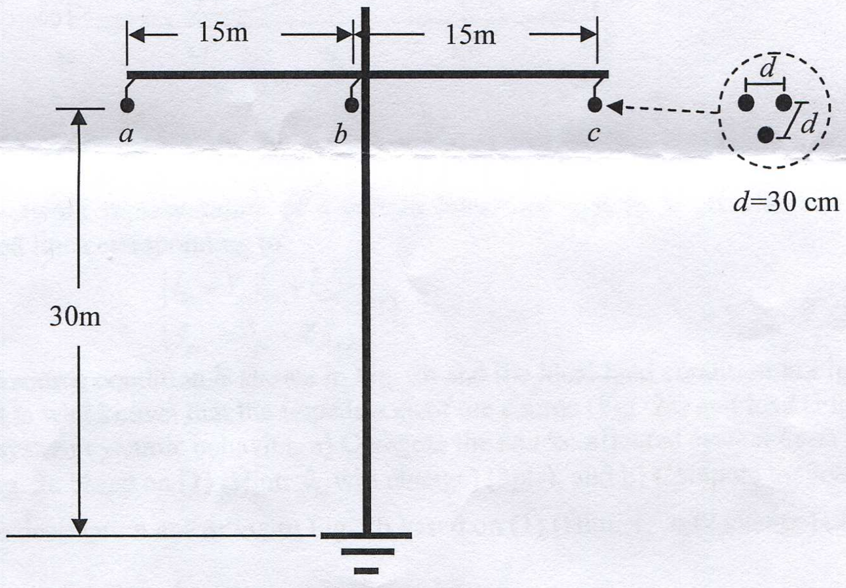

Fig. 5