Tampere University
Electrical Engineering

EE.EES.300 Fundamentals of Electrical and Power Engineering 14.10.2024

Ari Nikander   Programmable calculator allowed   5 questions/ à 6 pts

Q1:

a) Find Thevenin equivalent for the circuit shown in Figure 1. The rms voltage of the sinusoidal voltage source $V_g = 230\ \angle 0°$ V and frequency 50 Hz. R1 = 27 Ω, R2 = 8 Ω, L1 = 150 mH, L2 = 60 mH and C = 67 μF. [3 pts]

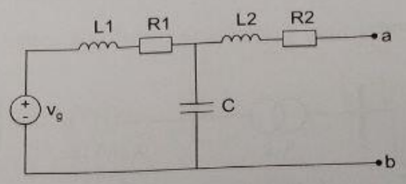

Figure 1. Electric circuit of Question 1 a).

b) Below are presented unbalanced three-phase voltages for Phases a, b and c. Find the symmetrical components for the voltage of Phase a. Draw the phasor diagram which includes the original voltage phasor V_a and its symmetrical components. [3 pts]

$$\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} = \begin{bmatrix} 1.1\angle 9° \\ 0.8\angle 130° \\ 1.2\angle -70° \end{bmatrix} p.u.$$

Q2: Three-phase synchronous generator has a rated power 25 MVA and a rated voltage 11 kV. It has a synchronous reactance of 1.2 Ω. The generator is feeding full load 25 MVA (1 pu) at 0.9 power factor lagging at rated voltage. Calculate the excitation emf (E_f) and power angle δ, when

a) power factor is 0.9 lagging [2 pts]
b) power factor is 0.9 leading [2 pts]
c) Calculate reactive power drawn by the load with power factor 0.9 lagging. [2 pts]

Q3: The electric circuit in Figure 3 comprises three nodes in addition to the reference node 0 (ground), two voltage sources, 5 reactive branches, one of which is capacitive, connected as shown in Figure 3. All the relevant parameter values are given on the figure (2pts/sub-question).

a) Determine the nodal admittance matrix of the electric circuit.
b) Calculate the voltage at Node 2.
c) Determine the real (P) and reactive (Q) powers injected by two voltage sources at Nodes 1 and 3.

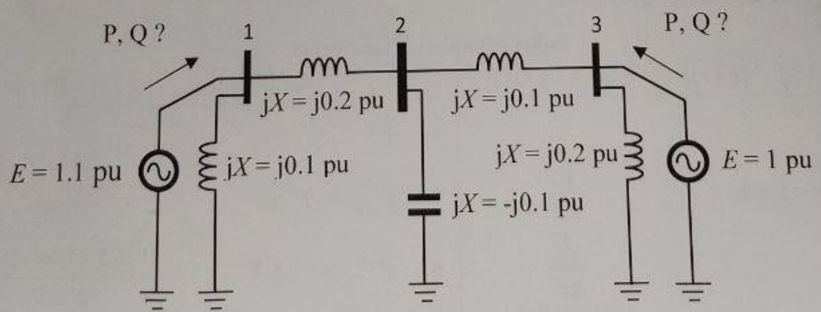

Figure 3. The electric circuit of Question 3.

Tampere University
Electrical Engineering

EE.EES.300 Fundamentals of Electrical and Power Engineering 14.10.2024

Ari Nikander

Programmable calculator allowed 5 questions/ á 6 pts

Q4: The one-line diagram shown in Figure 3 represents a three-phase power network, for which per-unit values of positive, negative and zero sequence parameters, are available (2 pts/sub-question).

a) Draw the sequence networks and determine the positive-sequence (1), negative-sequence (2) and zero-sequence (0) Thevenin impedances, as seen from node 4.

b) Calculate the fault current when three phase short-circuit occurs at Node 3. Fault impedance $Z_f = 0.1$ pu.

c) Calculate the fault current when single line-to-ground fault occurs at Node 4. Fault impedance $Z_f = 0.1\ \Omega$.

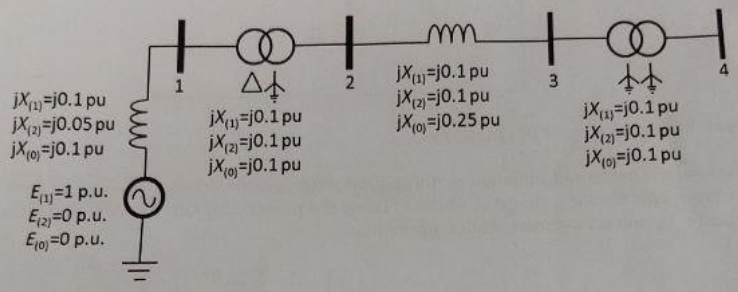

Figure 3. The electric circuit of Question 4.

Q5: Figure 4 presents a first order RC circuit. A step change of 10 V is applied to the input voltage u_{in}. Initial conditions are zero, i.e. u_{in} and u_o are zero.

a) Determine transfer functions for determining u_o and i_{in}. [3 pts]

b) Apply Laplace transform and determine the responses for u_o and i_{in} in a time domain. Utilize the table of Laplace Transforms below. The mathematical expressions as a function of time are acceptable, the graphs are not required. [3 pts]

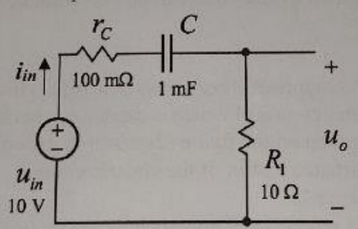

Figure 4. RC circuit of Question 5.

Table of Laplace Transforms

	$f(t)=\mathcal{L}^{-1}\{F(s)\}$	$F(s)=\mathcal{L}\{f(t)\}$		$f(t)=\mathcal{L}^{-1}\{F(s)\}$	$F(s)=\mathcal{L}\{f(t)\}$
1.	1	$\frac{1}{s}$	2.	e^{at}	$\frac{1}{s-a}$
3.	$t^n,\ n=1,2,3,\ldots$	$\frac{n!}{s^{n+1}}$	4.	$t^p,\ p>-1$	$\frac{\Gamma(p+1)}{s^{p+1}}$
5.	$\sqrt{t}$	$\frac{\sqrt{\pi}}{2s^{\frac{3}{2}}}$	6.	$t^{n-\frac{1}{2}},\ n=1,2,3,\ldots$	$\frac{1\cdot3\cdot5\cdots(2n-1)\sqrt{\pi}}{2^n s^{n+\frac{1}{2}}}$
7.	$\sin(at)$	$\frac{a}{s^2+a^2}$	8.	$\cos(at)$	$\frac{s}{s^2+a^2}$