Department of Electrical Engineering
Final Assignment
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Course Details

Course Title: Electrical Network Analysis **Module:** 4th

Instructor: Dr. Shehryar Shafique **Total Marks:** 50

Student Details

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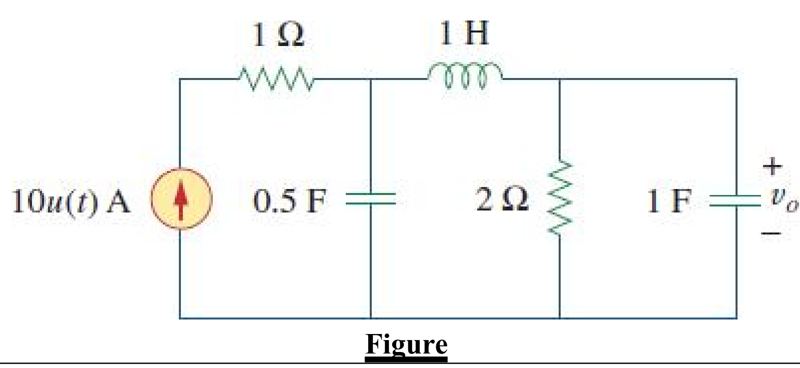
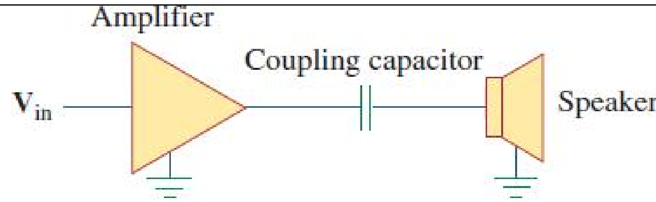
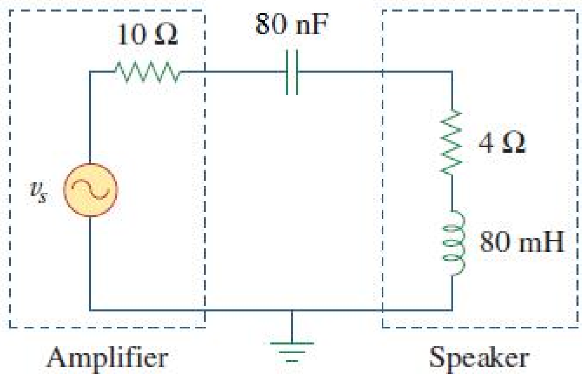
Q1.		Assume that a 2000-kW turbine-generator of 0.85 power factor operates at the rated load. An additional load of 300 kW at 0.8 power factor is added. What kVAR of capacitors is required to operate the turbine generator but keep it from being overloaded?	Marks 10 CLO 03
Q2.		A balanced *abc* sequence, one line voltage of a balanced Y-connected source is $V_{AB} = 180\angle-20^o$ V. If the source is connected to a Δ-connected load of $20\angle40^o\ \Omega$, find the phase and line currents.	Marks 10 CLO 02
Q3.		Consider a load with value of, $V_{rms} = 110\angle85^o$ V , $I_{rms} = 0.4\angle15^o$ A. Calculate the following: a) The complex and apparent powers b) The real and reactive powers, and c) The power factor and the load impedance.	Marks 10 CLO 01
Q4.		Apply Laplace transform and calculate the output voltage $v_o(t)$ in the circuit of figure below:  **Figure**	Marks 10 CLO 01
Q5.		For the circuit given in figure below, the speaker works as load while the amplifier and the capacitor act as the source. To block dc current from an amplifier, a coupling capacitor of 80 nF is used (see figures below). Calculate the following: a) At what frequency is maximum power transfer to the speaker? b) If Vs = 5 V_{rms}, how much power is delivered to the speaker at that	Marks 10 CLO 03

		 (a)  **Figure**	

Q1 :-

sol :-

orignal load :-

$P_1 = 2000\ KW$

$\cos\theta_1 = 0.85 \rightarrow \theta_1 = 31.79^\circ$

$S_1 = \dfrac{P_1}{\cos\theta_1} = 2352.94\ KVA$

$Q_1 = S_1 \sin\theta_1 = 1239.5\ KVAR$

Additional load:

$P_2 = 300\ KW$

$\cos\theta_2 = 0.8 \rightarrow \theta_2 = 36.87^\circ$

$S_2 = \dfrac{P_2}{\cos\theta_2} = 375\ KVA$

$Q_2 = S_2 \sin\theta_2 = 225\ KVAR$

Total load:

$S = S_1 + S_2 = (P_1 + P_2) + j(Q_1 + Q_2) = P + jQ$

$P = 2000 + 300 = 2300\ KW$

$Q = 1239.5 + 225 = 1464.5\ KVAR$

minimum operating pf for a 2300 KW load not exceeding the KVA rating of the generator is.

$$\cos\theta = \frac{P}{S_2} = \frac{2300}{2352.94} = 0.9775$$

or $\theta = 12.177^\circ$

maximum KVAR for this condition

$$Q_n = S_2 \sin\theta = 2352.94 \sin(12.277^\circ)$$

$$Q_n = 496.323 \text{ KVAR}$$

The capacitor apply the difference between total load KVAR (i.e Q) and the generatar KVAR i.e (Q_n) Thus,

$$Q_c = Q - Q_n$$

$$Q_c = 968.2 \text{ KVAR}$$

Q2 :-

sol

line voltage $V_{AB} = 180 \angle -20° \, V$

$Z_\Delta = 20 \angle 40° \, \Omega$

using formula $V_L = \sqrt{3} \, V_P \angle 30° \Rightarrow V_P = \frac{V_L}{\sqrt{3} \angle 30°}$

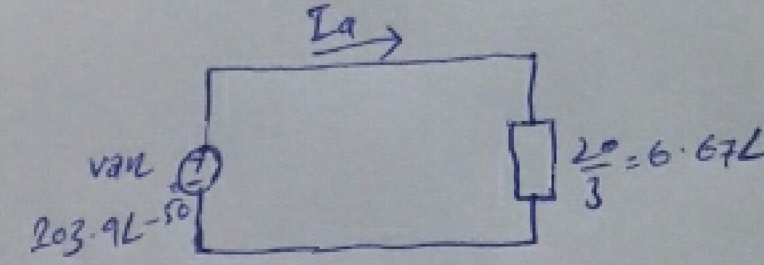
phase voltage

$$V_{an} = \frac{180 \angle -20°}{\sqrt{3}} \cdot \angle -30° = 103.9 \angle -50° \, V \quad \text{— (i)}$$

$$Z_Y = \frac{Z_\Delta}{3} = \frac{20 \angle 40°}{3} = 6.67 \angle 40° \, \Omega \quad \text{— (ii)}$$

Line current

$$I_a = \frac{V_{an}}{Z_\Delta / 3} = \frac{103.9 \angle -50°}{6.67 \angle 40°}$$



$I_a = 15.57 \angle -90° \, A$

$I_b = I_a \angle -120° = 15.59 \angle +150° \, A$

$I_c = I_a \angle +120° = 15.59 \angle 30° \, A$

phase current

$$I_{AB} = \frac{15.57 \angle -90°}{\sqrt{3}} \cdot \angle 30° = 9 \angle -60° \, A$$

$I_{BC} = I_{AB} \angle -120 = 9 \angle -180° \, A$

$I_{CA} = I_{AB} \angle +120 = 9 \angle 60° \, A.$

Q3:-

Sol
}

Given data

$V_{rms} = 110 \angle 85^\circ V$

$I_{rms} = 0.4 \angle 15^\circ A$

(a) The complex power

$S = V_{rms} I_{rms}^*$

$S = (110 \angle 85^\circ)(0.4 \angle -15^\circ)$

$S = 110 \times 0.4 \angle (85^\circ - 15^\circ)$

$S = 44 \angle 70^\circ VA$

The appearent power

$S = |S|$

$S = 44 VA$

(b) The real and reactive power

$S = 44 \angle 70^\circ$

$S = 44 [\cos(70^\circ) + j \sin(70^\circ)]$

$S = 44 [0.3420 + j0.9397]$

$S = 15.05 + j41.35$

Since

$S = P + jQ$

$P = 15.05\ W$

$Q = 41.35\ VAR$

(c) The power factor

$pf = \cos(70^\circ)$

$pf = 0.342$ (lagging)

The power factor is lagging as the reactive power is positive

The load impedance is

$$Z = \frac{V}{I}$$

$V = \sqrt{2} V_{rms}$

$I = \sqrt{2} I_{rms}$

$$Z = \frac{110\sqrt{2}\angle 85^\circ}{0.4\sqrt{2}\angle 15^\circ}$$

$Z = 275 \angle 70^\circ\ \Omega$

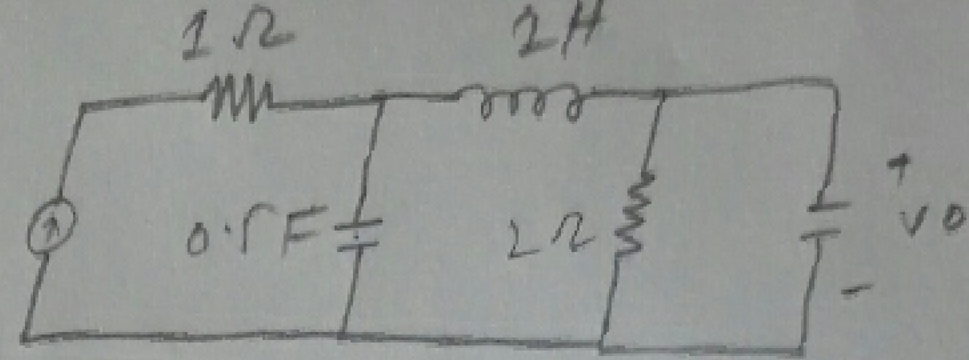
$Z = 275[\cos(70^\circ) + j\sin(70^\circ)]$

$Z = 275[0.342 + j0.9397]$ $\therefore Z = (94.05 + j258.4)\Omega$

(b)

Q4:-

Sol



At node 1

$$\frac{\frac{20}{s} - v_1}{1} = \frac{v_1 - v_o}{s} + \frac{s}{2} v_o \rightarrow 20 = (s+1) v_1 + \left(\frac{s^2}{2} - 1\right) v_o \rightarrow (1)$$

At nod 2

$$\frac{v_1 - v_o}{s} = \frac{v_o}{2} + s\, v_o \rightarrow v_1 = v_o \left(\frac{s}{2} + s^2 + 1\right) \rightarrow (2)$$

Subsituting (2) into (1) gives

$$20 = (s+1)\left(s^2 + s/2 + 1\right) v_o + \left(\frac{s^2}{2} - 1\right) v_o = s\left(s^2 + 2s + 1.5\right) v_o$$

$$v_o = \frac{10}{s(s^2 + 2s + 1.5)} = \frac{A}{s} + \frac{Bs + C}{s^2 + 2s + 1.5}$$

$$10 = A(s^2 + 2s + 1.5) + Bs^2 + Cs$$

s^2 : $0 = A + B$

s : $0 = 2A + C$

constant $10 = 1.5A$

$\rightarrow$ $A = 20/3$, $B = -20/3$, $C = -40/3$

$$V_o = \frac{20}{3}\left[\frac{1}{s} - \frac{s+2}{s^2+2s+1.5}\right]$$

$$= \frac{20}{3}\left[\frac{1}{s} - \frac{s+1}{(s+1)^2+0.7071^2} - 2.424\frac{0.7071}{(s+1)^2+0.7071^2}\right]$$

Taking the inverse laplace transform finally yields

$$v_o(t) = \frac{20}{3}\left[1 - e^{-t}\cos 0.7071t - 2.424e^{-t} \ldots \sin 0.7071\right] u(t)\ V.$$

Ans

Q5 :-

Sol :-

Given

coupling capacitor = 80 nF

$V_S = 5 V_{rms}$

Source Impedance = $Z_S = R_S - jX_1$

Load impedance = $Z_L = R_L + jX_2$

For maximum load transfor

$Z_L - Z_S \rightarrow R_S - R_L, \; X_C - X_L$

$X_C = X_L \rightarrow \frac{1}{\omega C} = \omega L$

or $\omega = \frac{1}{\sqrt{LC}} = 2\pi F$

$f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(80 \times 10^{-3})(80 \times 10^{-9})}}$

$f = 2.055$ KHz

$P = \left[\frac{V_S}{(10+4)}\right]^2 4 = \left(\frac{5}{14}\right)^2 4 = \frac{25}{196} \cdot 4$

$P = 8.51$ mW