Department of Electrical Engineering
Final Assignment
Date: 22/06/2020

Course Details

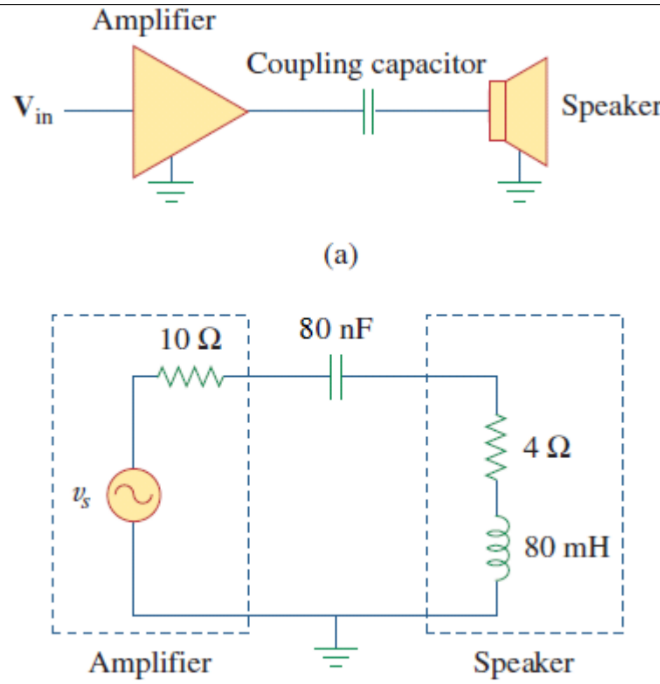
Course Title: Electrical Network Analysis
Instructor: **Dr Shehryar Shafique Qureshi**
Module: 4th
Total Marks: 50

Student Details

Name: M.Salman shahid
Student ID: 15006

Student Signature: ____________________

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} = $180\angle -20^\circ$ V. If the source is connected to a -connected load of $20\angle 40^\circ\ \Omega$, find the phase and line currents.	Marks 10 CLO 02
Q3.		Consider a load with value of, $V = 110\angle 85^\circ$ V , $I = 0.4\angle 15^\circ$ 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


Amplifier
Coupling capacitor
V_{in}
Speaker
(a)
10 Ω
80 nF
4 Ω
v_s
80 mH
Amplifier
Speaker

Q1:-

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

Sol:-

Given data:-

$P_1 = 2000\,kW \quad , \quad \cos\alpha_1 = 0.85$

$S_1 = \dfrac{P_1}{\cos\alpha_1} = 2352.94\,kVA$

$Q_1 = \sqrt{S_1^2 - P_1^2} = 129.49\,kVAr$

Additional load

$P_{add} = 300\,kW \quad , \quad \cos\alpha_{add} = 0.8$

$S_{add} = \dfrac{P_{add}}{\cos\alpha_{add}} = 375\,kVA$

$Q_{add} = \sqrt{S_{add}^2 - P_{add}^2} = 225\,kVAr$

Total load

$P_2 = P_1 - P_{add} = 2300\,kW$

$Q_2 = Q_1 + Q_{add} = 1464.49\,kVAr$

$S_2 = S_1 + S_{add} = 2727.94\,kVA$

turbine

being overloaded, total generator from has to be equal complex power to the complex power of a rated load.

$S_2' = S_1$

We have to add capacitor with reactive power Q_c

$S_2 + jQ_c = S_1$

$P_2 + jQ_2 + jQ_c = S_1$

$Q_2' = \sqrt{S_1^2 - P_2^2} = 496.37$ KVAr where Q_2' is $Q_2 + Q_c$

$Q_c = Q_2' - Q_2 = -968.18$ KVAr

we need capacitor with reactive power of 968.18 KVar

Q2.		A balanced *abc* sequence, one line voltage of a balanced Y-connected source is $V_{AB} = 180\angle -20°$ V. If the source is connected to a Δ-connected load of $20\angle 40°\ \Omega$, find the phase and line currents.	Marks 10 CLO 02

Line voltage $V_{AB} = 180\angle 20° V$

$Z_\Delta = 20\angle 40° \Omega$

$V_L = \sqrt{3} V_p \angle 30° \Rightarrow V_p = \frac{V_L}{\sqrt{3}\angle 30°}$

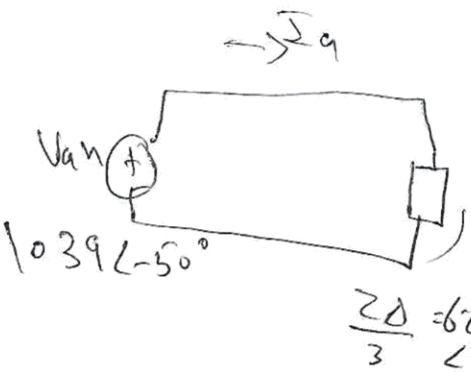
Phase voltage

$$V_{an} = \frac{180\angle -20°}{\sqrt{3}} \angle -30° = 103.9\angle -$$

$$Z_Y = \frac{Z_\Delta}{3} = \frac{20\angle 40°}{3} = 6.67\angle 40° \Omega$$

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

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

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

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

Q3.		Consider a load with value of, $V_{rms} = 110\angle 85^\circ$ V , $I_{rms} = 0.4\angle 15^\circ$ 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

Q3:-

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

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

step 2

a) complex power is

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

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

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

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

apparent power is

$S = |S|$

$S = 44$ VA

step 3

Express in complex power in Rectangular form

$S = 44\angle 70^\circ$

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

$S = 44(0.3420 + j0.9397)$

~~$S = 15.05 + j\,41.35$~~

$S = 15.05 + j\,47.35$

since $S = P + jQ$

real Power is

$P = 15.05$ W

reactive power is

$Q = 41.35$ VAR

Step 4 :- The power factor is

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

$P_f = 0.342$ (lagging

power factor is lagging as the reactive power is +ive

The load impedance is

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

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

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

Step 5

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

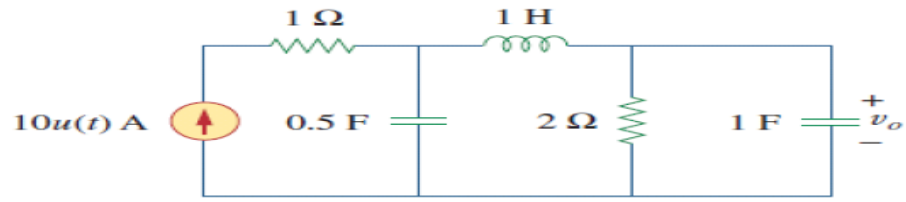
$Z = 275 \angle 70^\circ\ \Omega$

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

$Z = 275\,(0.342 + j\,0.9337)$

$Z = (94.05 + j\,258.4)\ \Omega$

Q4.		Apply Laplace transform and calculate the output voltage $v_o(t)$ in the circuit of figure below:	Marks 10 CLO 01



Figure

1. Since there is nothing said about the initial charge on the inductor and the capacitor before $t=0$ we assum that the initial condition on both of them is 0

2) Converting the element of the circuit from time domain to the s-domain.

$1\Omega \Rightarrow 1\Omega$

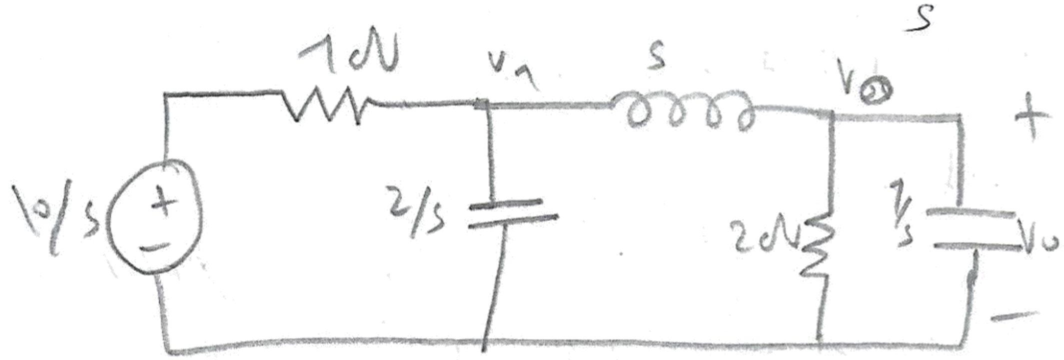
$2\Omega \Rightarrow 2\Omega$

$1H \rightarrow s$

$1f \rightarrow \frac{1}{s}$

$0.5f \Rightarrow \frac{2}{s}$

$10u(t)V \Rightarrow \frac{10}{s}$



to the s domain will look like the one show in the above fig

5. At node 1, applying KCL & ohm's law gives.

$$\frac{V_1}{2/s} + \frac{V_1 - V_0}{s} + \frac{V_1 - \frac{10}{s}}{1} = 0$$

Multiplying by 2s and simplifying

$$(s^2 + 2s + 2) V_1 - 2V_0 = 20$$

Applying KCL to node 0

$$\frac{V_0}{2} + \frac{V_0 - V_1}{s} + \frac{V_0}{1/s} = 0$$

Multiplying by s & simplifying

$$V_1 = (s^2 + 0.5s + 1) V_0$$

Substitut Eq (2) in Eq 1 yield

$$(s^2 + 2s + 2)(s^2 + 0.5s + 1) V_0 - 2V_0 = 20$$

$$V_o = \frac{20}{s(s^3+2.5s^2+4s+3)}$$

$$= \frac{20}{s(s+1.2306)(s^2+1.2694s+2.4377)}$$

Now break down $V_o(s)$

$$\frac{20}{s(s+1.2306)(s^2+1.2694s+2.4377)} = \frac{A}{s} + \frac{B}{s+1.2306} + \frac{Cs+D}{s^2+1.2694s+2.4377}$$

By residue method

$$A = (s)\left(\frac{20}{s(s+1.2306)(s^2+1.2694s+2.4377)}\right)\Bigg|_{s=0}$$

$$= 6.667$$

$$B = (s+1.2306)\left(\frac{20}{s(s+1.2306)(s^2+1.2694s+2.4377)}\right)$$

$$= -6.8$$

By algebric method find C & D

$$20 = A(s+1.2306)(s^2+1.2694s+2.4377)$$
$$+B(s)(s^2+1.2694s+2.4377)$$
$$s+1.2306) + (Cs+D)(s)($$

$$20 = 6.667(s+1.2306)(s^2+1.2694s+2.4377)$$
$$-6.8(s)(s^2+1.2694s+2.4377)$$
$$(s+1.2306) + (Cs+D)(s)$$

s^3

coefficien

$$0 = 6.667 - 6.8 + C = C = 0.133$$

s^2

$$= \quad D = -8.199$$

hence

$$V_o(s) = \frac{6.667}{s} - \frac{6.8}{s+1.2306} + \frac{0.133s - 8.199}{s^2+1.2694s + 2.4377}$$

$$V_o(s) = \frac{6.667}{s} - \frac{6.8}{s+1.2306} + \frac{0.1333 - 8.199}{s^2+1.2694s+2.4372}$$

$$= \frac{6.667}{s} - \frac{6.8}{s+1.2306} + \frac{0.133(s+0.6347)}{(s+0.6347)^2+(1.4265)^2} - \frac{8.2834}{(s+0.6347)^2+(1.4265)^2}$$

taking inverse laplace

$$V_o(t) = L^{-1}\{V_o(s)\}$$

$$= L^{-1}\left[\frac{6.667}{s}\right] - L^{-1}\left[\frac{6.8}{s+1.2306}\right] + L^{-1}\left[\frac{0.133(s+0.6347)}{(s+0.6347)^2+(1.4265)^2}\right]$$

$$- L^{-1}\left[\frac{8.2834}{(s+0.6347)^2+(1.4265)^2}\right]$$

$$= 6.667u(t) - 6.8e^{-1.2306t}u(t) + 0.133e^{-0.6347}\cos(1.4265)u(t)$$

$$- 5.80608e^{-0.6347}\sin(1.4265)u(t)\ V$$

Result

$$\cancel{V_o(t) = 6.6667 - 6.8e^{-1.2306t} + e^{-0.6347t}(0.133\cos 1.4265}$$

Result

$$v_o(t) = \left(6.667 - 6.8e^{-7.2306t} + e^{-0.6347t}\left(0.133\cos(1.4985t) - 5.8068\sin(1.4985t)\right)\right)u(t)\ (V)$$

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

Q5) Source impedance $Z_b = R_s - jX_c$

Load impedance $Z_L = R_L + jX_L$

for maximum load transfer

$Z_L = Z_s \rightarrow R_s = R_L, \; X_c = X_L$

$X_c = X_L \rightarrow \omega L = \frac{1}{\omega C} \rightarrow \omega = \frac{1}{\sqrt{LC}} = 2\pi f$

$$f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(80\times10^{-3})(40\times10^{-9})}}$$

$$= 2.8145 \text{ Hz}$$

b) $P = \left(\frac{V_s}{(10+4)}\right)^2 4 = \left(\frac{4.6}{14}\right)^2 4 = 437.8 \text{ mW}$

since Vs is in rms