King Fahd University of Petroleum & Minerals
Electrical Engineering Department
EE205: Electric Circuits II (031)

Final Exam

Jan 18, 2004
7:30 AM-10:00AM
Building 14-108

Serial #

Name: KEY

ID:

Sec. (1) 8:00-8:50 (2) 9:00-9:50

Question	Mark
1	/7
2	/7
3	/6
4	/8
5	/7
Total	/35

Instructions:

1. This is a closed-books/notes exam.
2. The duration of this exam is two 2.5 hours.
3. Read the question carefully. Plan which question to start with.
4. Write explicitly the formulas that you use in your solution (e.g by KVL … by KCL). No credit will be given if you do not show your formulas.
5. Work in your own.
6. Strictly no mobile phones are allowed.

Good luck

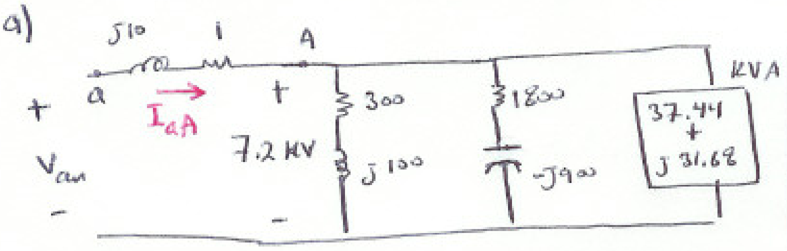
Dr. Ali Muqaibel

Problem 1: (7 points)

Three balanced three-phase loads are connected in parallel. Load 1 is Y connected with an impedance of 300+*j* 100 Ω/Ø; load 2 is Δ connected with an impedance of 5400 -*j* 2700 Ω/Ø; and load 3 is 112.32+ *j* 95.04 kVA (*hint: load 3 is represented by its 3-phase complex power*) . The loads are fed from a distribution line with an impedance of 1+ *j* 10 Ω/Ø. The magnitude of the line-to-neutral voltage at the load end of the line is 7.2kV.

a) Construct a single-phase equivalent circuit. **(1 point)**
b) Using the single phase equivalent circuit, calculate the line current I_{aA} **(2 points)**
c) Calculate the total complex power at the sending end of the line. **(2 points)**
d) What percentage of the average power at the sending end of the line is delivered to the loads? **(2 points)**

a)



Load 2

$\Delta \to Y$ conversion $* \frac{1}{3}$ $\quad \frac{5400 - J2700}{3} = 1800 - J900$

Load 3

Single phase complex power

$\frac{112.32 + J\,95.04 \text{ KVA}}{3} = 37.44 + J\,31.68$ KVA

b) Lets first calculate the individual currents.

$I_1 = \frac{7.2K}{300 + J100} = 21.6 - J7.2 \quad A$

$I_2 = \frac{7.2K}{1800 - J900} = 3.2 + J1.6 \quad A$

$I_3 \qquad S = VI^* \Rightarrow I_3^* = \frac{S}{V}$

$I_3^* = \frac{37.44 + J31.68}{7.2} \frac{K}{K} = 5.2 + J4.4 \quad A$

$\Rightarrow I_3 = 5.2 - J4.4 \quad A$

$I_{aA} = I_1 + I_2 + I_3 = 30 - J10 \quad A$

c) $S_T = 3S_\phi = 3(V_{an} \; I_{aA}^*)$

$V_{an} = 7.2K + (30 - J10)(1 + J10)$

$= 7.33 + J\,0.29 \text{ KV}$

$S_T = 3((7.33 + J0.29)(30 + J10))K$
same.
$= 651 + J246 \quad \text{KVA}$

d) $S_{1\phi} = V_1 I_1^* = 7200(21.6 + J7.2)$

$= 155.52 + J\,51.84 \text{ KVA}$

$S_{2\phi} = V I_2^* = 7200(3.2 - J1.6)$

$= 23.4 - J\,11.52 \text{ KVA}$

$S_{3/\phi} = 37.44 + J\,31.68 \text{ KVA}$

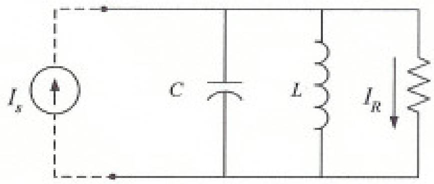
$S_{load/\phi} = S_{1/\phi} + S_{2/\phi} + S_{3/\phi}$

$= 216 + J72 \text{ KVA}$

$S_{load} = 3(S_{load/\phi}) = 648 + J216 \text{ KVA}$

% delivered $= \left(\frac{648}{651}\right)(100) = 99.54\ \%$

Problem 2: (7 points)



For the parallel *RLC* circuit shown:

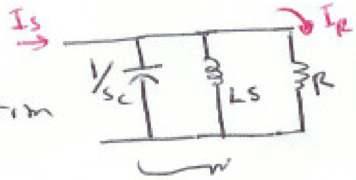
a) Find the transfer function $H(s) = \dfrac{I_R}{I_s}$. **(3 points)**

b) If R=10Ω, C=0.1F ,and L=8, H, draw the pole-zero plot for *H(s)* **(2 points)**

c) For the same values of *R,L,* and *C*, what type of response will the parallel *RLC* circuit have (Under-damped, Critically damped, Over-damped)? Why? **(1 point)**

d) Find the Neper frequency α , and the resonant radian frequency ω_0 **(1 point)**

a) By CDR



the parallel combination of L & C

$$\frac{LS \cdot \frac{1}{SC}}{LS + \frac{1}{SC}}$$

$$\frac{L/C}{\frac{CLS^2+1}{SC}} = \frac{SL}{CLS^2+1}$$

again by current divider rule (CDR)

$$\frac{I_R}{I_s} = \frac{\frac{SL}{CLS^2+1}}{\frac{SL}{CLS^2+1} + R} = \frac{SL}{CLRS^2+SL+R}$$

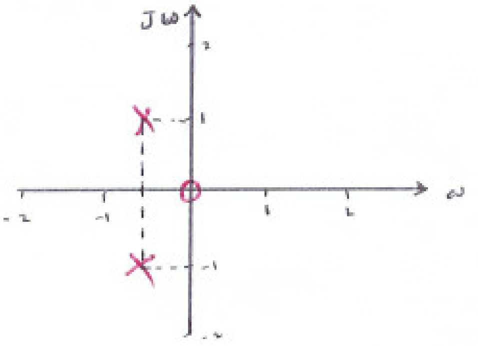
$$= \frac{\frac{1}{RC}S}{S^2 + \frac{1}{RC}S + \frac{1}{LC}}$$

b) $H(S) = \dfrac{S}{S^2 + S + 1.25}$

sigle zero at $S=0$

Poles

$$S_{1,2} = \frac{-1 \pm \sqrt{1-4(1)(1.25)}}{2} = -\frac{1}{2} \pm J$$



c) Under damped, because it has two complex poles ≡ the characteristic Equation have two complex roots.

d) for parallel RLC circuit the characteristic Equation or roots

$$S_{1,2} = -\alpha \pm \sqrt{\alpha^2 - \omega_0^2}$$

⇒ $\alpha = 1/2$ rad/s (neper).

$\omega_0 = \sqrt{5}/2$ rad/s $= 1.118$ rad/s

or for parallel RLC

$$\alpha = \frac{1}{2RC} = \frac{1}{2RC} = \frac{1}{2(10)(0.1)} = \frac{1}{2} \text{ rad/s}$$

&

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8 \times 0.1}} = \sqrt{\frac{1}{0.8}}$$

$$= \sqrt{1.25} = \sqrt{\frac{5}{4}} = \frac{\sqrt{5}}{2} \text{ rad/s}$$

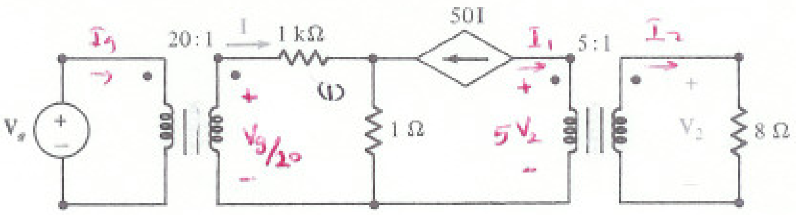
(Same answer).

Problem 3: (6 points)

For the circuit shown in the figure which uses IDEAL transformers.

a) Find the voltage gain V_2/V_g. **(4 points)**

b) If p_g is the power supplied by the voltage source and p_2 is the power absorbed by the 8Ω load resistor, find the power gain p_2/p_g. **(2 points)**



By finding the voltage at the midle circuit using the voltage relation for ideal transformer.

$$\frac{V_1}{N_1} = \frac{V_2}{N_2}$$

By KVL in the left loop. (1)

$$-\frac{V_g}{20} + 1000I + (50+1)I\,(1) = 0$$

$$-\frac{V_g}{20} + 1051\,I = 0 \quad \text{—(1)}$$

By KVL at loop Second Transformer

$$I_2 = \frac{V_2}{8} \text{ —(2)} \quad \text{But} \quad N_1 I_1 = N_2 I_2$$

$$5I_1 = I_2$$

$$5(-50I) = I_2 \quad \text{—(3)}$$

$\Rightarrow$ From (2) & (3)

$$V_2 = 8I_2 = 8(5)(-50)I$$

$$\Rightarrow I = \frac{V_2}{-2000} \quad \text{substitute in (1)}$$

$$-\frac{V_g}{20} + 1051\left(\frac{V_2}{-2000}\right) = 0$$

$$\Rightarrow \boxed{\frac{V_2}{V_g} = -0.095}$$

$$P_2 = V_2^2/R$$

assume RMS values (ratio).

$$P_g = V_g I_g$$

$$I_g N_1 = I N_2 \qquad \text{first Transformer}$$

$$20 I_g = I$$

$$\Rightarrow I_g = \frac{I}{20}$$

$$\text{from (1)} \qquad I = \frac{1}{20 \times 1051} V_g$$

$$I_g = \frac{1}{20 \times 20 \times 1051} V_g$$

$$P_g = \frac{1}{420400} V_g^2$$

$$P_2 = \frac{(-0.095)^2 \cancel{V_g^2}/8}{\frac{1}{420400}\cancel{V_g^2}} \simeq 474.26$$

Problem 4: **(8 points)**

For the given transfer function: $H(s) = \dfrac{s^2 + 13s + 30}{3s(s+100)}$

Make Straight-Line amplitude and phase angle plots for the given transfer function.
Show your steps

a) $H(s) = \dfrac{(s+3)(s+10)}{3s\,(s+100)}$

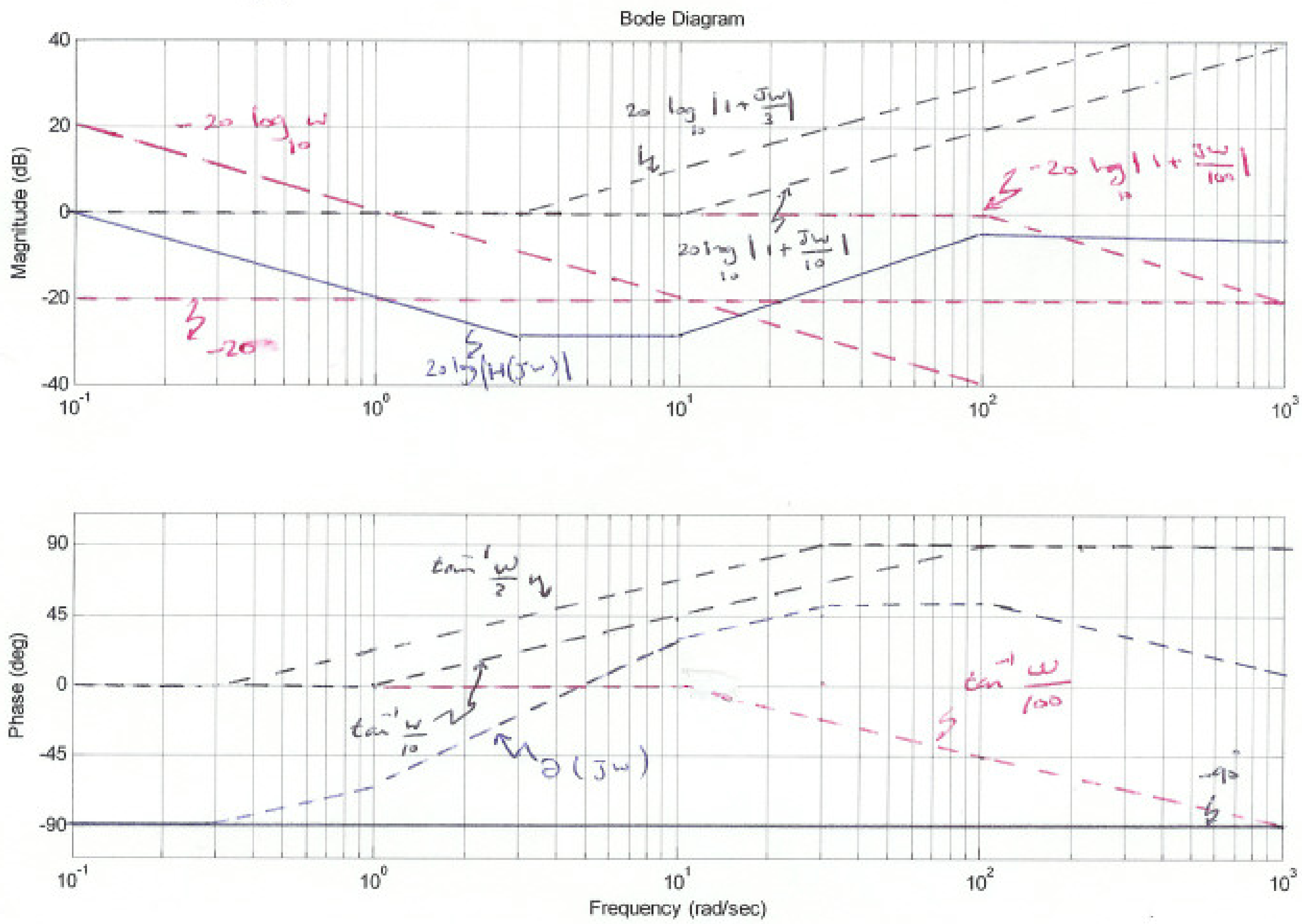
$H(j\omega) = \dfrac{(j\omega+3)(j\omega+10)}{3j\omega\,(j\omega+100)}$

$H(j\omega) = \dfrac{30\,(1+\frac{j\omega}{3})(1+\frac{j\omega}{10})}{300\,j\omega\,(1+\frac{j\omega}{100})}$

$= \dfrac{(1+\frac{j\omega}{3})(1+\frac{j\omega}{10})}{10\,j\omega\,(1+\frac{j\omega}{100})}$

$20\log_{10}|H(j\omega)| = 20\log_{10}|1+\frac{j\omega}{3}| + 20\log_{10}|1+\frac{j\omega}{10}| \overbrace{-20\log_{10}10}^{-20} - 20\log_{10}\omega - 20\log_{10}|1+\frac{j\omega}{100}|$

$\theta(j\omega) = \tan^{-1}\frac{\omega}{3} + \tan^{-1}\frac{\omega}{10} - 90^\circ - \tan^{-1}\frac{\omega}{100}$

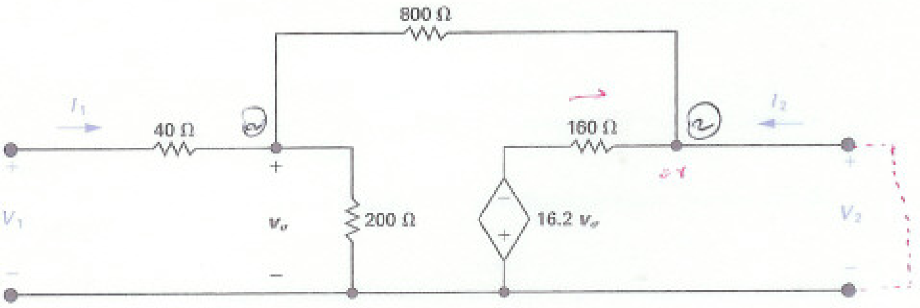


Problem 5: (7 points)

a) **Find the *h* parameters for the given circuit** which is equivalent to an operational amplifier. **(6 points)**

(Hint: h_{21}=16, you only need to find the other three parameters)

b) If port 1 is connected to a dc voltage source with a no-load voltage of 10V and an internal resistance 9Ω, and port 2 is connected to a resistive load, Calculate the load resistance that will result in maximum power delivered to the load. **(1 points)**



h parameters

$$V_1 = h_{11} I_1 + h_{12} V_2$$
$$I_2 = h_{21} I_1 + h_{22} V_2$$

Terminated 2-Port Equations

$$Z_{in} = h_{11} - \frac{h_{12} h_{21} Z_L}{1 + h_{22} Z_L}$$
$$I_2 = \frac{h_{21} V_g}{(1 + h_{22} Z_L)(h_{11} + Z_g) - h_{12} h_{21} Z_L}$$
$$V_{Th} = \frac{-h_{21} V_g}{h_{22} Z_g + \Delta h}$$
$$Z_{Th} = \frac{Z_g + h_{11}}{h_{22} Z_g + \Delta h}$$

$h_{11} = \frac{V_1}{I_1} \Big|_{V_2=0}$ $\qquad h_{21} = \frac{I_2}{I_1} \Big|_{V_2=0}$

short circuit

$h_{11} = \frac{V_1}{I_1} = 40 + 800 \,//\, 200$

$= 200 \,\Omega$

$I_2 + \left(\frac{-16.2\, V_a}{160} \right) + \frac{V_a}{800} = 0$

$I_2 - 0.1\, V_a = 0 \Rightarrow V_a = 10\, I_2$

By KCL at node (a)

$I_1 = \frac{V_a}{200} + \frac{V_a}{800}$

$I_1 = \left(\frac{1}{200} + \frac{1}{800} \right) (10\, I_2)$

$I_1 = 0.0625\, I_2$

$\Rightarrow \frac{I_2}{I_1} = 16$ Confirmed.

$h_{12} = \frac{V_1}{V_2} \Big|_{I_1=0}$, $\quad h_{22} = \frac{I_2}{V_2} \Big|_{I_1=0}$

$V_1 = V_a$

By voltage divider VDR

$V_a = \frac{200}{200+800} V_2 \Rightarrow \frac{V_1}{V_2} = 0.2$

$h_{22} = \frac{I_2}{V_2} \Big|_{I_1=0}$

By KCL at (2)

$I_2 = \frac{V_2 - V_1}{800} + \frac{V_2 + 16.2\, V_a}{160}$

$\frac{I_2}{V_2} = \frac{1 - 0.2}{800} + \frac{1 + 16.2(0.2)}{160}$

$= 0.0275 = 27.5 \text{ mS}$

b) The load that will result in maximum power

$= Z_{Th}^*$

$\Delta h = h_{11} h_{22} - h_{12} h_{21} = 2.3$

$Z_{Th} = \frac{Z_g + h_{11}}{h_{22} Z_g + \Delta h} = \frac{9 + 200}{(0.0275)(9) + 2.3} = \frac{209}{2.5475} = 82\, \Omega$