DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
HONG KONG UNIVERSITY OF SCIENCE OF TECHNOLOGY

ELEC 101 BASIC ELECTRONICS
TEST 2

1810 - 1932 9 November 2000 LTA

Name:

Student ID :

Department:

1. This is a closed book examination. No additional sheet is allowed.
2. Answer all questions in the space provided.
3. Show all your calculations clearly. No marks will be given for unjustified answers.
4. Do your own work. Any form of cheating is a violation of academic integrity, and will be dealt with accordingly.

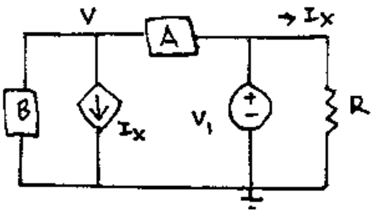
Questions	Maximum Scores	Scores
1	29	
2	33	
3	35	
4	31	
5	24	
Total	152	

1. In the following circuit, $V_1(t) = 4\cos(1000t)$ V.

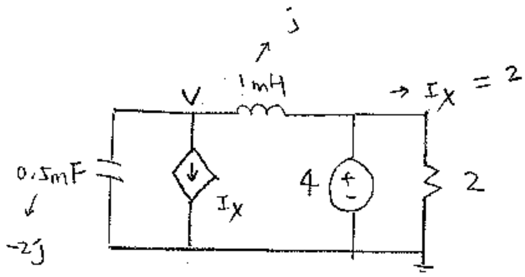
(a) If element A = 1mH, element B = 0.5mF, R = 2 Ω, show that $V(t) = \mathbf{4\sqrt{5}\cos(1000t - 26.6^\circ)V}$.

(b) Does V(t) lead $V_1(t)$?

(c) If R = 2 Ω, V(t) = 1 cos (1000t) V, suggest the elements and values of A and B.



(29 marks)



(a) $j\omega L = j(1k)(1m) = j$

$$\frac{1}{j\omega C} = \frac{1}{j(1k)(0.5m)} = -2j$$

$4\cos 1kt \rightarrow 4\angle 0 \rightarrow 4$ V

$I_x = 2\angle 0 = 2$ A 8

Using KCL : (node V)

$$\frac{4 - V}{j} = I_x + \frac{V}{-2j}$$

$\therefore 8 - 2V = 2(2j) - V$

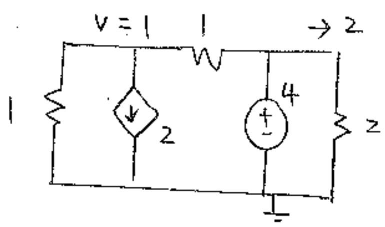
$V = 8 - 4j = 4(2 - j)$

$= 4\sqrt{5}\angle -26.6^\circ$

$\therefore V(t) = 4\sqrt{5}\cos(1000t - 26.6^\circ)$ V 11

(b) v(t) lags $v_1(t)$ 2

(c)



$\therefore A = 1\Omega$

$B = 1\Omega$ 8

2. In the following parallel LCR circuit, $i(t) = \sqrt{2}\cos\omega t$ mA, L = 50 mH, C = 10 μF, R = 10kΩ.

(a) Find the resonant frequency in rad/s.

(b) Find the Q factor. $\frac{10}{2\pi}$

(c) Show that the bandwidth is ~~2π10~~ Hz .

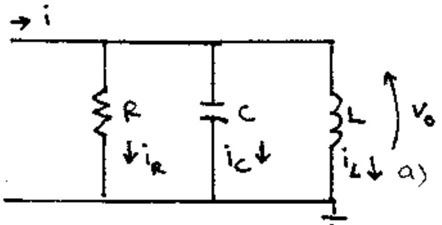
(d) Find the upper and lower cut-off frequencies.

(e) Find the maximum Vo(t).

(f) Sketch Vo (in Vrms) versus ω. Label clearly all intercepts

(g) Find the maximum i_C (in mA rms).

(h) Explain briefly two advantages if R is changed to 20kΩ.



(33 marks)

a) $\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{50m \cdot 10\mu}} = 1414$ rad/s 4

b) $Q = \frac{R}{\omega_0 L} = \frac{10K}{1414(50m)} = 141.4$ 4

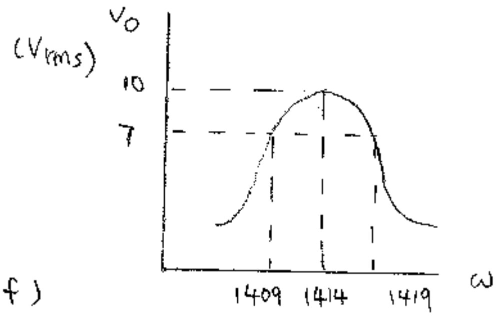
c) $BW = \frac{\omega_0}{Q} = \frac{1414}{141.4} = 10 = \frac{10}{2\pi}$ Hz 3

d) $\omega_2 = \omega_0 + \frac{BW}{2} = 1414 + 5$ rad/s

$\omega_1 = \omega_0 - \frac{BW}{2} = 1414 - 5$ rad/s 4

e) max $V_0(t) = iR = 10\sqrt{2}\cos 1414t$ V 5

f)



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g) max $i_C = Q\,i$

$= 141.4$ mA rms 4

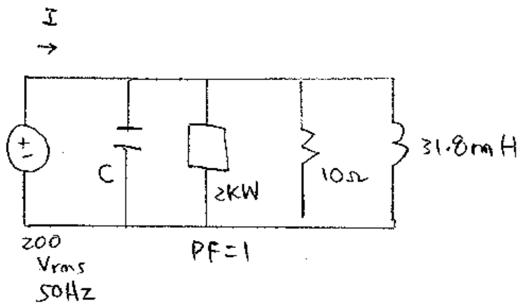
h) R = 20K

Q increases

BW decreases 4

3. (a) Load A is connected in parallel to a 200 ∠0° Vrms 50Hz power supply. If load A is a 10 Ω resistor in parallel with a 31.8 mH inductor, find the apparent power S, reactive power Q, average power P and power factor PF of load A.
(b) A load B of 2kW and PF = 1 is connected in parallel with load A, find the total Q of the combined load.
(c) A load C is now connected in parallel to the combined load in (b) to make the total power factor = 1, show that load C is a 0.318 mF capacitor. Find also the apparent power and current (in Arms) supplied by the power supply.

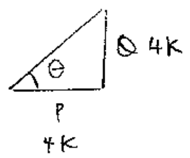
(35 marks)



(a)

$$P = \frac{V^2}{R} = \frac{200^2}{10} = 4\text{KW}$$ 4

$$Q = \frac{V^2}{\omega L} = \frac{200^2}{2\pi 50(31.8m)} = 4\text{KVAR}$$ 4



$$S = \sqrt{P^2 + Q^2} = 4\sqrt{2}\ \text{KVA}$$ 4

$$PF = \cos\theta = \cos 45° = 0.707$$ lagging 4

(b) total $Q = 4\text{KVAR}$ 4

(c)

$$Q = \frac{V^2}{\frac{1}{\omega C}} = V^2 \omega C$$

$$\therefore C = \frac{Q}{V^2 \omega} = \frac{4K}{200^2\ 2\pi 50} = 0.318\ mF$$ 6

$$S = 2K + 4K = 6\ kVA$$ 5

$$I = \frac{S}{V} = \frac{6K}{200} = 30\ A_{rms}$$ 4

(4) In the following circuit, $R_1 = R_2 = R$.

(a) Find the complex transfer function G (= Vo/Vi) as a function of jω, C and R.

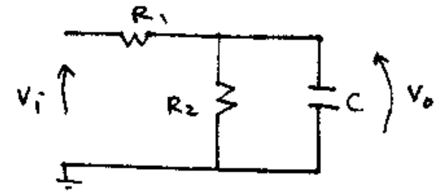
(b) Find the pole and zero of G.

(c) If C = 2mF and R = 1kΩ, find the cut-off frequency.

(d) Sketch the magnitude of G versus angular frequency ω. Label clearly the intercepts.

(e) Find the magnitude of G in dB at the half-power frequency.

(f) What is the type and order of the filter?



(31 marks)

$$R//C = \frac{R\left(\frac{1}{j\omega C}\right)}{R + \frac{1}{j\omega C}} = \frac{R}{1 + j\omega CR}$$

a) $$\therefore G = \frac{V_o}{V_i} = \frac{\frac{R}{1+j\omega CR}}{R + \frac{R}{1+j\omega CR}} = \frac{1}{1 + 1 + j\omega CR}$$

$$= \frac{1}{2 + j\omega CR}$$ 8

b) No Zero

pole : $2 + j\omega CR = 0$

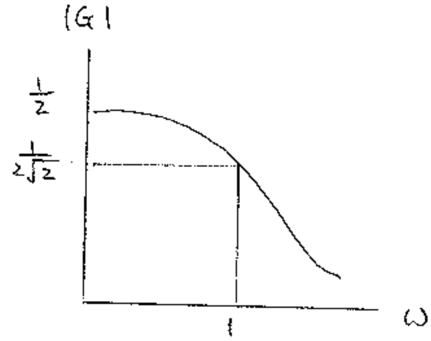
$$j\omega = \frac{-2}{CR}$$ 5

c) cut off : $2 + j\omega CR = 2 + 2j$

$\omega CR = 2$

$$\therefore \omega_{co} = \frac{2}{CR} = \frac{2}{2m \cdot 1k} = 1 \text{ rad/s}$$ 5

d)



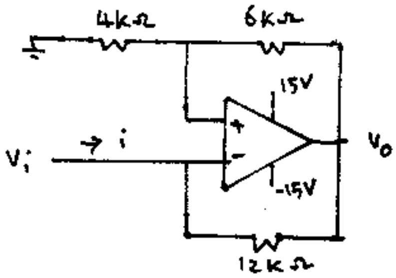
$$|G| = \frac{1}{\sqrt{4 + (\omega CR)^2}}$$ 5

e) $$20 \log \frac{1}{2\sqrt{2}} = -9 \text{ dB}$$ 4

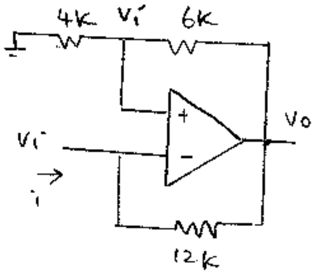
f) 1st order low pass filter 4

5. (a) In the following circuit, assume op amp is ideal. (i) Show that i = - 0.5mA if Vi = 4V. (ii) Find i if Vi = - 8V.

(b) A voltage amplifier (with input resistance R_{in}, voltage gain A and output resistance R_{out}) is connected between a source (with voltage V_s and source resistance R_s) and a load (R_L). Sketch the circuit model of the whole circuit and explain briefly why an ideal voltage amplifier should have infinite input resistance and zero output resistance.



(24 marks)



(a)

$$V_o = V_i + \frac{V_i}{4K} 6K$$
$$= 4 + 6 = 10\,V$$
$$\therefore i = \frac{V_i - V_o}{12K} = \frac{4-10}{12K}$$
$$= -0.5\ mA$$

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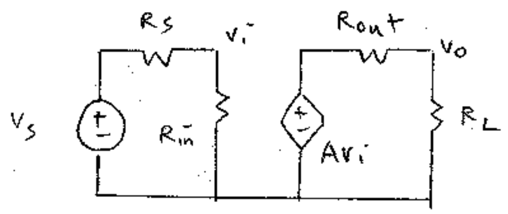
$$V_o = V_i + \frac{V_i}{4K} 6K$$
$$= -8 - 12 = -20\,V \quad \text{op amp saturates!}$$
$$\therefore V_o = -15\,V$$
$$\therefore i = \frac{V_i - V_o}{12K} = \frac{-8+15}{12K} = \frac{7}{12}\ mA$$

6

(b)



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$R_{in} \to \infty \qquad v_i \to V_s$

$R_{out} \to 0 \qquad V_o \to Av_i \to AV_s$