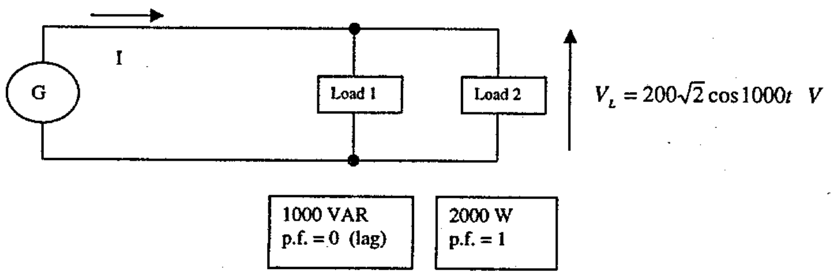
1. Referring to the following diagram :

a) What are the elements of load 1 & load 2 ? (4 marks)
b) Calculate their values. (9 marks)
c) Calculate the total current I. (10 marks)
d) Prove that the minimum size (in KVA) of the generator G is 2.24 KVA. (3 marks)
e) Calculate the total power factor. (3 marks)
f) The total power factor is improved to be unity when Load 3 is connected. Show the connection in the following figure. What is the reactive power of Load 3 ? (4 marks)
g) After improving the power factor, an additional Load 4 is added. Show the connection in the following figure. What kind of this Load 4 is ? What is the max. power consumption of this Load 4 ? (5 marks)



a) load 1 : L 2

load 2 : R 2

b) $R = \dfrac{V^2}{P} = \dfrac{200^2}{2k} = 20\,\Omega$ 4

$L = \dfrac{V^2}{Q\omega} = \dfrac{200^2}{1k \cdot 1k} = 40\,mH$ 5

c) $I = \dfrac{200}{40j} + \dfrac{200}{20}$ 6

$= 10 - 5j$

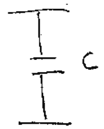
$= \sqrt{125}\ \angle -0.5$

$= 11.2\ \angle -26.6\ A_{rms}$ 4

d) $S = 200\,(11.2) = 2240\ VA$ 3

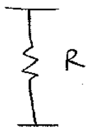
e) $PF = \cos(-26.6) = 0.89$ 3

f)



$Q_C = -1k\ VAR$ 4

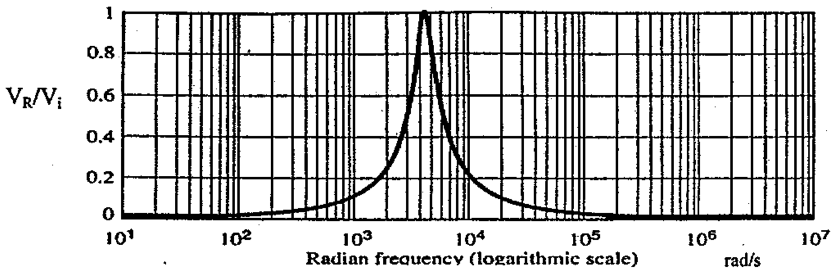
g)



$P = 2240 - 2k$ 5

$= 240\ W$

2. A series RLC circuit has the following magnitude plot.



a) Estimate the resonant frequency. (2 marks)
b) Estimate the bandwidth. (2 marks)
c) Estimate the lower cut-off and higher cut-off frequencies. (4 marks)
d) Calculate the Q factor. (3 marks)
e) Calculate the value of the inductor if the value of the resistor is 1kΩ. (4 marks)
f) Calculate the value of the capacitor. (4 marks)
g) Calculate the power consumption at resonance if the input voltage $V_i(t) = 10\cos\omega t$ V. (5 marks)
h) What is the ratio of V_c/V_i ? (2 marks)
i) Calculate the resistance of another parallel RLC circuit that has the same magnitude plot. (6 marks)

a) $\omega_0 \sim 4.5k$ rad/s   2

b) $BW \sim 2k$ rad/s   2

c) $\omega_2 \sim 5.5k$ rad/s   2

$\omega_1 \sim 3.5k$ rad/s   2

d) $Q = \frac{\omega_0}{BW} = \frac{4.5k}{2k} = 2.25$ 3

e) $L = \frac{QR}{\omega_0} = \frac{2.25(1k)}{4.5k}$ 4

$= 0.5H$

f) $C = \frac{1}{\omega_0^2 L} = \frac{1}{(4.5k)^2(0.5)}$ 4

$= 0.1\ \mu F$

g) $P = \frac{V^2}{R} = \left(\frac{10}{\sqrt{2}}\right)^2 \frac{1}{1k}$ 5

$= \frac{1}{20}$ W

h) $\frac{V_c}{V_i} = Q = 2.25$ 2

i) $R = Q\omega_0 L$ 6

$= 2.25(4.5k)0.5$

$= 5.06k\Omega$

4. Given a resistor (R) , a capacitor (C) and an inductor (L).

a) Show how to connect the resistor and the inductor to form a low-pass filter. Show the location of the output. (3 marks)

b) Roughly sketch the frequency response of the low-pass filter (magnitude plot only). (2 marks)

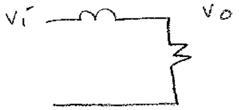
c) Show the relation between the half-power voltage gain and the bandwidth in your sketch. (2 marks)

d) What is the relation between the resistance and the inductance to obtain the cut-off frequency to be 10kHz ? (4 marks)

e) How to add a capacitor to your circuit shown in (a) so that it can still be a low-pass filter. (3 marks)

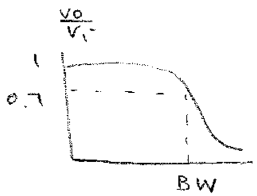
f) Derive the transfer function according to your circuit shown in (e). (5 marks)

a)



3

b)



2

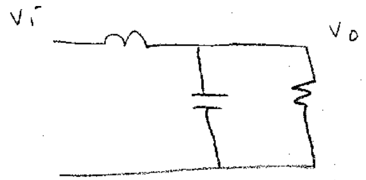
c) 2

d) $\omega = \frac{L}{R} = 2\pi f$

$= 2\pi (10K)$

4

e)



3

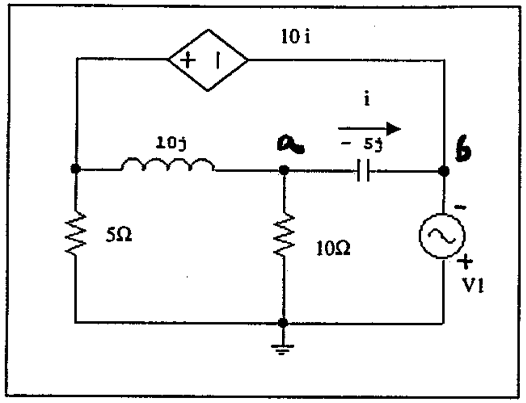
f) $\frac{V_o}{V_i} = \frac{R \parallel \frac{1}{j\omega C}}{j\omega L + R \parallel \frac{1}{j\omega C}}$

$= \frac{\frac{R}{1+j\omega CR}}{j\omega L + \frac{R}{1+j\omega CR}}$

$= \frac{1}{1 + \frac{1+j\omega CR}{R} j\omega L}$

5

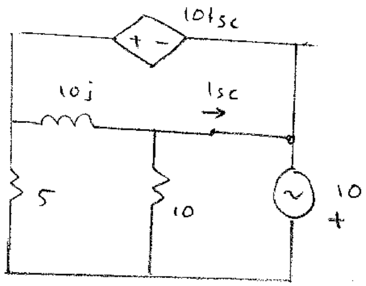
5. Given : V1(t) = 10 cosωt V.



at ab

a) Calculate Isc. (10 marks)
b) Calculate Voc. (9 marks)
c) Prove the total impedance Zth = Voc / Isc = 10j Ω. (3 marks)
d) Calculate i(t). (8 marks)
e) Does i(t) lead V1(t) ? (2 marks)

a)

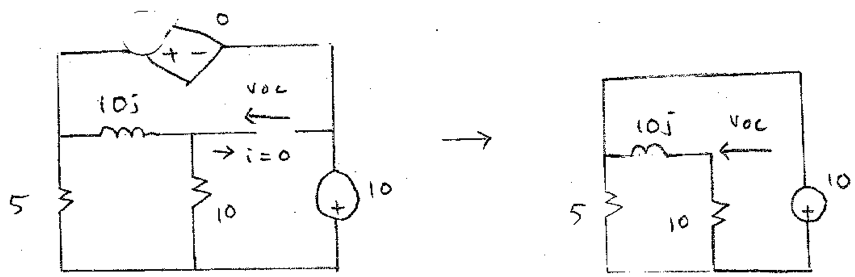


$$I_{sc} = \frac{10 I_{sc}}{10j} + \frac{10}{10}$$

$$\therefore I_{sc} = \frac{1}{1 - \frac{1}{j}} = \frac{1}{1+j}$$

10

b)



$$\therefore V_{oc} = \frac{10j}{10 + 10j} \, 10$$

$$= \frac{10j}{1+j}$$

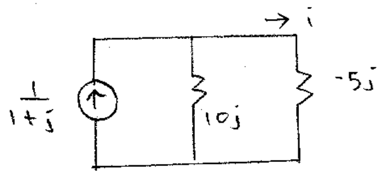
9

c)

$$\therefore Z_{th} = \frac{V_{oc}}{I_{sc}} = \frac{\frac{10j}{1+j}}{\frac{1}{1+j}} = 10j$$

3

d)



$$\therefore i = \frac{1}{1+j} \, \frac{10j}{10j - 5j} = \frac{2}{1+j}$$

$$= \frac{2}{\sqrt{2}\angle 45} = \sqrt{2}\angle -45$$

6

$$\therefore i(t) = \sqrt{2}\cos(\omega t - 45^\circ) \ \text{A}$$

2

e) i(t) lags v(t)

2

END