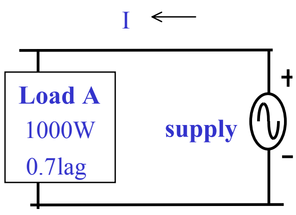
1

1. Load A is connected in parallel to a $200\sqrt{2}\cos(2\pi 50t)$ V supply as shown.
(a) Explain very briefly the physical meaning of apparent power S, reactive power Q and average power P.
(b) Show that Q of load A is 1.02kVAR.
(c) If load A is a resistance R in parallel with an element X, find R and X.
(d) Find the magnitude of current I in Arms. Find also I(t). (35)



[a]

P = real (or average) power dissipated by load
S = power supplied by source to load Z
Q = maximum reactive power stored in Z

[b]

$$\therefore Q = P\tan\theta = 1k\tan(\cos^{-1}0.7) = 1k\tan(45.58^o) = 1.02kVAR(L)$$

[c]

$$\therefore P = \frac{V^2}{R} = \frac{200^2}{R} = 1kW$$

$$\therefore R = \frac{200^2}{1k} = 40\Omega$$

$$\therefore Q = \frac{V^2}{\omega L} = \frac{200^2}{2\pi(50)L} = 1.02kVAR$$

$$\therefore X = L = 124mH$$

[d]

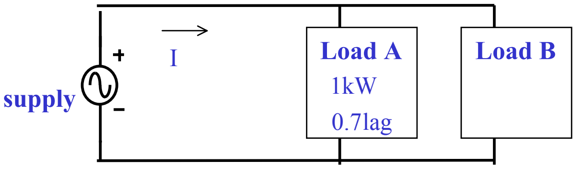
$$\therefore S = \frac{P}{\cos\theta} = \frac{1k}{0.7} = 1.43KVA$$

$$\therefore I = \frac{S}{V} = \frac{1.43k}{200} = 7.14A$$

$$\therefore I(t) = 7.14\sqrt{2}\cos(2\pi 50t - 45.6^o)A$$

2

2. Refer to the circuit in Question 1, a load B is now connected in parallel to load A.
(a) If P of the combined load is 4kW, find the P of load B.
(b) If Q of the combined load is 0.02kVAR inductive, find the Q of load B.
(c) If power factor PF of the combined load is 1, find the element and value of load B. Find also the magnitude of current in load B in Arms.
(21)



[a]

If total P = 4kW, then P of load B = 3kW

[b]

If total Q = 0.02kVAR(L), then Q of load B = 1kVAR(C) or −1kVAR

[c]

$$Q = 1.02kVAR(C) = V^2\omega C$$

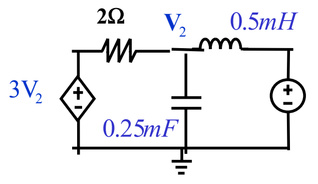
$$\therefore C = \frac{Q}{V^2\omega} = \frac{1.02k}{200^2(2\pi 50)} = 0.082mF$$

$$\therefore I = \frac{Q}{V} = \frac{1.02k}{200} = 5.1Arms$$

(20)

3

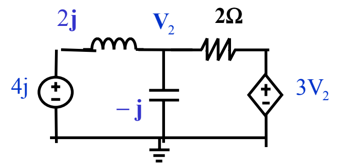
3. In the circuit, if $V_1(t) = 4\cos(4k\,t + 90^o)$ V, use complex method and find $V_2(t)$. The voltage controlled voltage source is in volt and equal to $3V_2(t)$. (20)



$$V(t) = 4\cos(4kt + 90^o)V \Rightarrow V = 4\angle 90^o = 4j$$

$$j\omega L = j(4k)0.5m = 2j\Omega$$

$$\frac{1}{jC\omega} = \frac{1}{j(0.25m)4k} = -j\Omega$$



$$\frac{4j - V_2}{2j} = \frac{V_2}{-j} + \frac{V_2 - 3V_2}{2}$$

$$4j - V_2 = -2V_2 - 2V_2(j)$$

$$4j = V_2(1 - 2 - 2j) = V_2(-1 - 2j)$$

$$V_2 = \frac{4j}{-1 - 2j} = -\frac{4j}{1 + 2j}$$

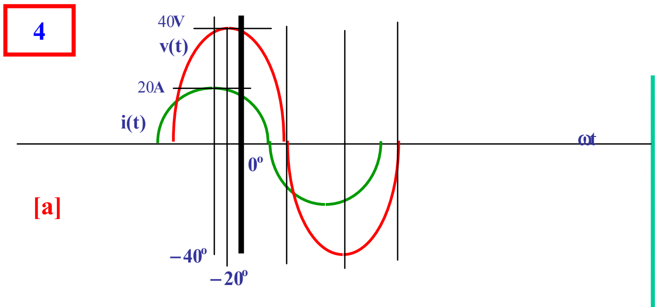
$$= -\frac{4\angle 90^o}{\sqrt{5}\angle 63.4^o} = -\frac{4}{\sqrt{5}}\angle 26.6^o V$$

$$\therefore V_2(t) = \frac{-4}{\sqrt{5}}\cos(4kt + 26.6^o)V$$

(30)

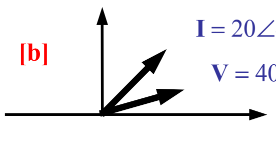
4

[a]



i(t) leads v(t) by 20°

[b]



$\mathbf{I} = 20\angle 40^o$ **A**

$\mathbf{V} = 40\angle 20^o$ **V**

[c] **Capacitive element (C in parallel with R)**

$$\therefore Z = \frac{V}{I} = \frac{40\angle 20^o V}{20\angle 40^o A}$$

$$= 2\angle -20^o \Omega$$

$$Y = \frac{1}{2}\angle 20^o S = \frac{1}{R} + j\omega C$$

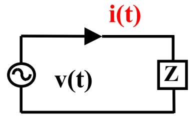
$$Y = 0.5(\cos 20^o + j\sin 20^o)$$

$$= 0.47 + j0.17 = \frac{1}{R} + jC\omega$$

$$\therefore R = \frac{1}{0.47} = 2.13\Omega$$

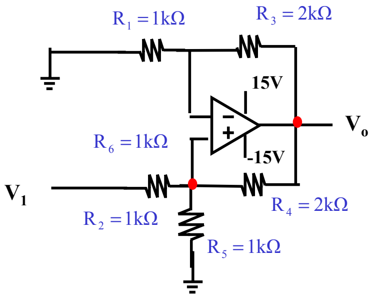
$$\therefore C = \frac{0.17}{\omega} = \frac{0.17}{10} = 0.017F$$

4. In the following circuit, $v(t) = 40\cos(10t + 20^o)$ V, $i(t) = 20\cos(10t + 40^o)$ A.
(a) Sketch v(t) and i(t) together. Show clearly the phase angles and amplitudes. Does v(t) lead i(t) ? Find also the phase angle between v(t) and i(t).
(b) Plot v and i in a phasor diagram.
(c) If Z is composed of two elements connected in parallel, find the two elements and the values. (30)



5

5. Given the ideal op amp circuit. (a) Find V_o/V_1. (b) Sketch Vo(t) when V_1 = 6sin 1kt V. (c) If $R_4 = R_5 = \infty$, V_1 = 2V, find Vo. (33)



[a]

$$V_- = V_+ = v$$

$$\frac{V_1 - v}{1k} = \frac{v}{1k} + \frac{v - V_O}{2k}$$

$$\therefore 2V_i - 2v = 2v + v - V_O$$

$$\therefore 2V_i = 5v - V_O$$

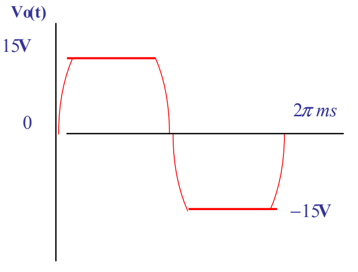
$$\frac{v}{1k} = \frac{V_O - v}{2k} \qquad \therefore 2v = V_O - v$$

$$\therefore v = \frac{V_O}{3}$$

$$\therefore 2V_i = 5\frac{V_O}{3} - V_O = \frac{2}{3}V_O$$

$$\therefore A_V = \frac{V_O}{V_i} = 3$$

[b] **If Vi = 6V, Vo = 15V**



[c]

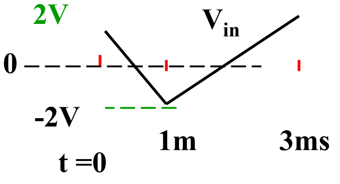
If $R_4 = R_5 = \infty, V_1 = 2V$

$$then\ Vo = (1 + \frac{R_3}{R_1})V_1 = (1 + \frac{2k}{1k})2V = 6V$$

6

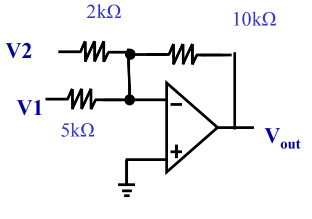
6. (a) Design an op amp circuit that can perform the function: Vo = - $2V_1 - 5V_2$ where V_1, V_2 are input and Vo is output of the circuit. Use 1k to 10k ohm resistors in your circuit.
(b) Draw the circuit of an op amp differentiator.
(c) The following graph shows the Vin of a differentiator. If RC = 1msec, plot Vo on the same graph.
(d) Sketch the circuit of an op amp voltage follower. What are the values of the input and output resistances? (26)

[c]

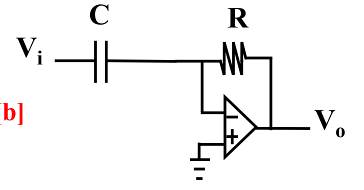


$\boxed{Vo = -2V_1 - 5V_2}$

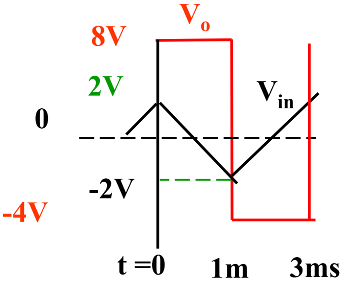
[a]



[b]

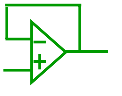


[c]



$$\therefore V_O = -CR\frac{dV_i}{dt} = -2m\frac{-2-2}{1m} = 8V$$

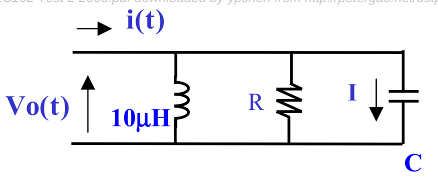
[d]



$R_i \sim \infty$
$R_o \sim 0$

(27)

7



[a] $f_O = 101.8MHz$

$BW = 2MHz$

$$\therefore upper\ f = f_O + \frac{BW}{2} = 101.8 + 3.255 = 105.055MHz$$

$$\therefore lower\ f = f_O - \frac{BW}{2} = 101.8 - 3.255 = 98.545MHz$$

[b] **Maximum Vo when tuner is at resonance**

$$\omega_O = \frac{1}{\sqrt{LC}}$$

$$\therefore C = \frac{1}{\omega_O{}^2 L} = \frac{1}{(2\pi 101.8M)^2 10\mu H} = 2.44x10^{-13} F$$

Maximum Vo =

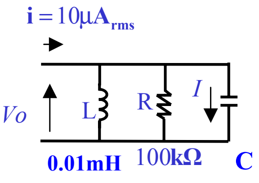
$$Vo = iR = 0.01mArms * 100k\Omega = 1Vrms$$

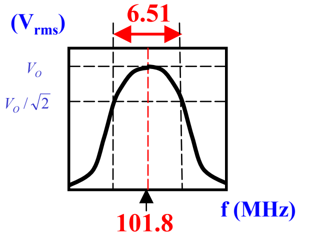
[c]

$$\therefore QF = \frac{R}{\omega_O L} = \frac{100k}{(2\pi 101.8M)10\mu H} = 15.63$$

$$I = QF*i = 15.63(0.01mArms) = 0.1563mArms$$

7. A parallel LCR radio tuner circuit is used to receive radio stations as shown in the tuner curve.
(a) Find in Hz the resonant frequency, bandwidth, upper and lower frequencies of the tuner.
(b) Find value of C so that the output voltage Vo of the tuner is maximum. Find also the maximum Vo in Vrms.
(c) Find the quality factor QF of the tuner. Find also the magnitude of I in Arms. (27)

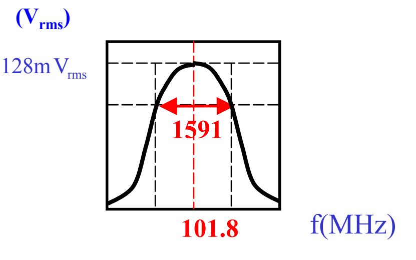




(21)

8

8. Refer to the circuit in Q5, if the LCR are now connected in series and voltage across the LCR is 2Vrms, sketch the tuner curve. On the curve, show clearly the resonant frequency, the bandwidth, and the magnitude of maximum voltage across C in Vrms. (21)



[a]

Same resonant frequency

$$\therefore QF = \frac{\omega_O L}{R} = \frac{1}{15.63} = 0.064$$

$$\therefore BW = \frac{\omega_O}{QF} = \frac{101.8M}{0.064} = 1591MHz$$

$$\therefore V_C = \frac{V}{R}\frac{1}{\omega_O C} = \frac{2V}{100k}\frac{1}{(2\pi 101.8M)0.244p} = 128mV$$