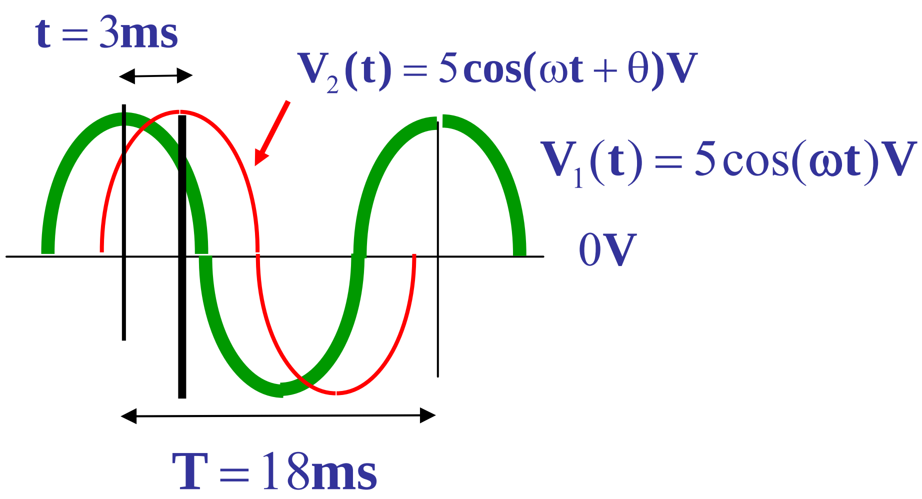
 (12) (210)

1

Find ω and θ. Does $V_2(t)$ lag $V_1(t)$? Given period of $V_2(t)$ is 18ms, and difference between the peaks of $V_1(t)$ and $V_2(t)$ is 3 ms. (12)



$$\omega = \frac{2\pi}{T} = \frac{2\pi}{18ms}$$ (3.5)

$$\theta = -\frac{t}{T} * 360^{o} = -\frac{3ms}{18ms} * 360^{o} = -60^{o}$$ (5)

$V_2(t)$ lags $V_1(t)$ (3.5)

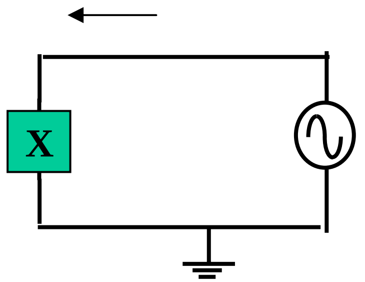
(20)

2 (20)

(a) If $X = 2k\Omega$, $I_m = 5mA$, $\theta = 60^o$, find V_m, ϕ, power factor of X, power stored in X.

(b) If $X = -j4\Omega$, $V_m = 8V$, $\theta = -10^o$, find I_m, ϕ, power factor of X.

$i(t) = I_m \cos(\omega t + \phi)$



+

$v(t) = V_m \cos(\omega t + \theta)$

-

(a) $V_m = 10\,V$ (2.5)

$\phi = 60^o$ (2.5)

$PF = 1$ (2)

$Q_R = 0$ (2.5)

(b) $I_m = 2A$ (3.5)

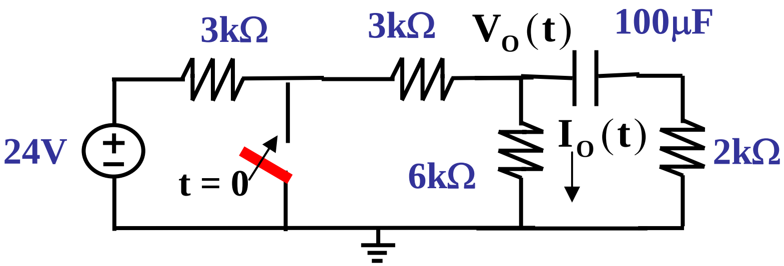
$\phi = 80^o$ (5)

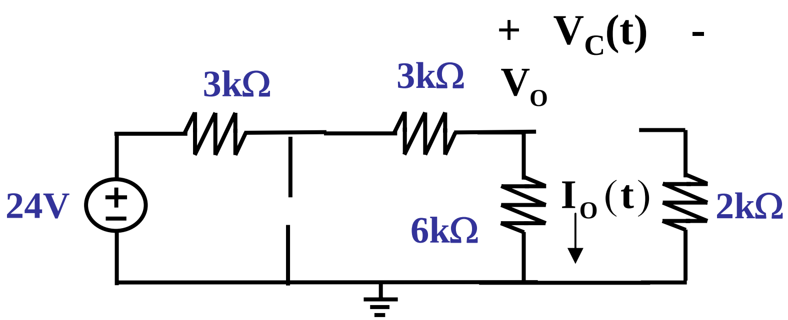
$PF = 0$ (2)

3

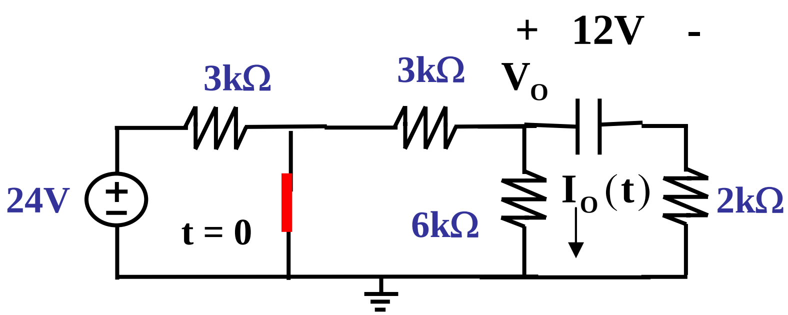
Explain briefly why the voltage of capacitor is continuous with time.

(b) circuit is at steady state for $t < 0$. At $t = 0$, the switch is **closed.** Find $I_O(0)$. (17)





$$\therefore V_C(0) = 12\text{V}$$



(a)

$$E_C = \frac{CV_C(t)^2}{2}$$

(8)

E_C (hence V_C) must be continuous with time

(b)

$$\therefore I_O(0) = \frac{12\text{V}}{3\text{k}\Omega // 6\text{k}\Omega + 2\text{k}\Omega} * \frac{3\text{k}\Omega}{3\text{k}\Omega + 6\text{k}\Omega} = 1\text{mA}$$

(9)

(13)

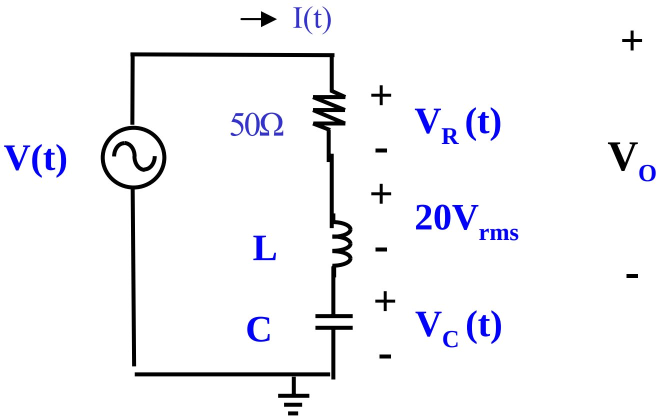
4

In the circuit, $\mathbf{V(t)} = 2\sqrt{2}\cos(1\mathbf{kt})\mathbf{V}$

$\mathbf{I(t)} = 40\sqrt{2}\cos(1\mathbf{kt})\mathbf{mA}$

Find Vo **in Vrms**

. (13)



$$\therefore \mathbf{I} = 40\mathbf{mA}_{\mathbf{rms}}$$ (3)

$$\therefore \mathbf{V}_{\mathbf{R}} = 40\mathbf{mA}_{\mathbf{rms}} * 50\Omega = 2\mathbf{V}_{\mathbf{rms}}$$ (4.5)

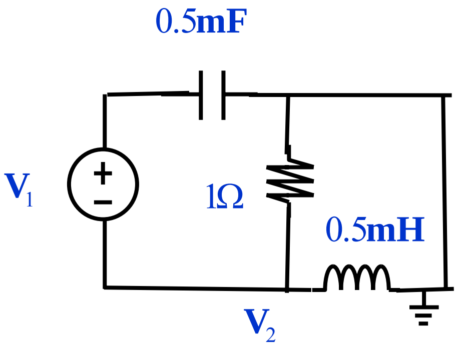
$$\therefore \mathbf{V}_{\mathbf{O}} = \sqrt{2^2 + 20^2} \cong 20.1\mathbf{V}_{\mathbf{rms}}$$ (5.5)

$$\therefore \mathbf{V}_{\mathbf{C}} = -20\mathbf{V}_{\mathbf{rms}}$$

(23)

5

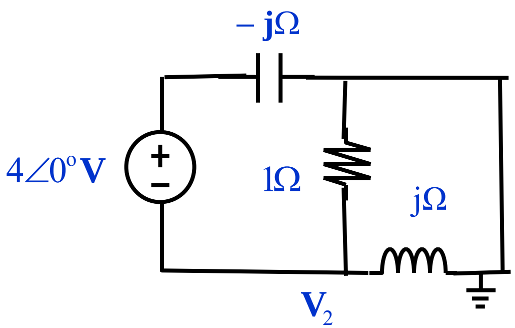
In the circuit, $V_1(t) = 4\cos(2kt)V$ find V_2 in **phasor form**. (23)



$$\therefore V_1 = 4\angle 0^o V \quad (3)$$

$$\frac{1}{j\omega C} = \frac{1}{j(2k)0.5mF} = -j\Omega \quad (3)$$

$$j\omega L = j(2k)0.5mH = j\Omega \quad (3)$$



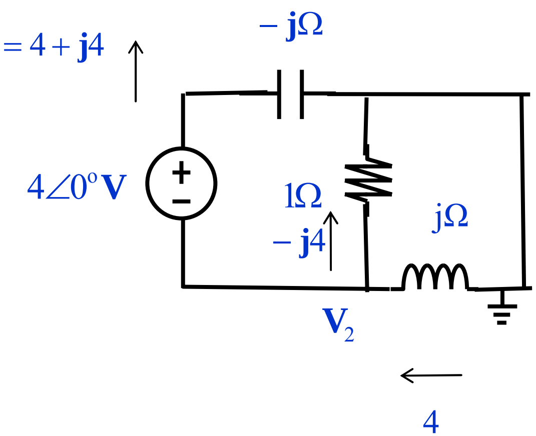
$$\frac{0 - V_2}{j\Omega} = \frac{V_2}{1\Omega} + \frac{V_2 + 4}{-j\Omega} \quad (6.5)$$

$$-V_2 = jV_2 - (V_2 + 4)$$

$$V_2 = -j4V = 4\angle -90^o V \quad (7.5)$$

$$\therefore V_2(t) = 4\cos(2kt - 90)V$$

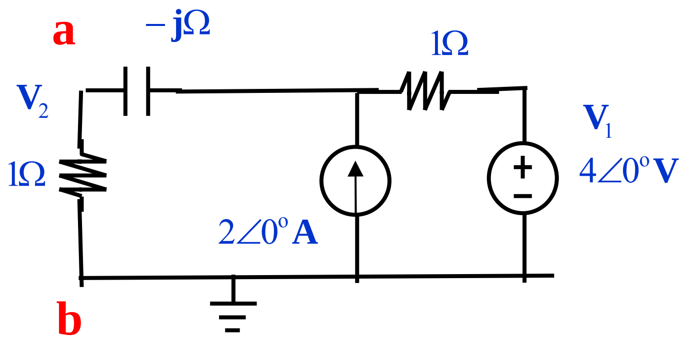
$$\frac{-j4+4}{-j} = 4 + j4$$

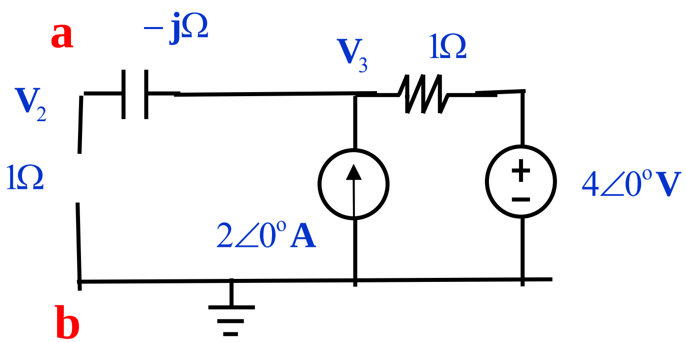


(25)

6

Show that the **open circuit voltage** at terminal ab is $6\angle 0^o$ V. Find the Thevenin impedance and hence use Thevenin's Theorem to find V2. Draw also V_1 and V_2 in a **phasor diagram**. (25)





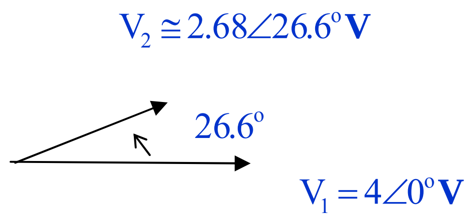
$$\therefore \mathbf{V_{OC}} = \mathbf{V_3} = 4\angle 0^o + 2\angle 0^o * 1\Omega = 6\angle 0^o \mathbf{V}$$ **(4.5)**

Thevenin impedance, Z = 1- j Ω **(5.5)**

$$\therefore \mathbf{V_2} = \frac{1}{1+1-\mathbf{j}\Omega} * 6\angle 0^o \mathbf{V}$$ **(5)**

$$= \frac{6\angle 0^o}{\sqrt{5}\angle -26.6^o}$$

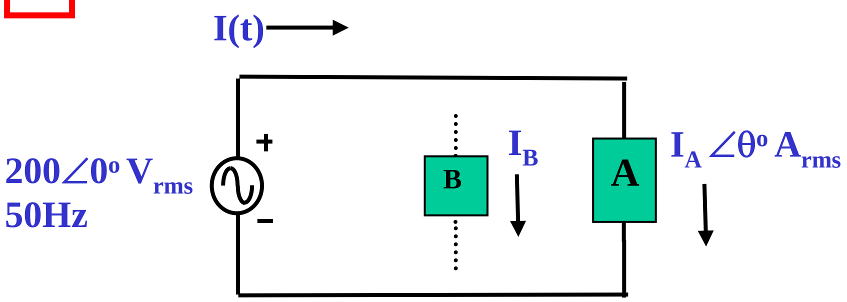
$$\cong 2.68\angle 26.6^o \mathbf{V}$$ **(5)**



(5)

(47)

7



(a)

P = real (or average) power dissipated by load **(3)**

S = power supplied by source to load Z **(3)**

Q = power stored in Z **(3)**

(b)

$$Q = S\sin\theta = 5k\sin(\cos^{-1}0.8) = 3kVAR(L)$$ **(6)**

(c)

$$I_A = \frac{S}{V} = \frac{5k}{200} = 25A_{rms}$$ **(6.5)**

$$L = \frac{Q}{\omega I^2} = \frac{3k}{2\pi 50(25^2)} \cong 15.3mH$$ **(6)**

$$\theta = -\cos^{-1}0.8 \cong -37^o$$ **(6)**

(d)

$$\therefore C = \frac{|Qc|}{V^2\omega} = \frac{3k}{(200^2)2\pi 50} \cong 0.24mF$$ **(7)**

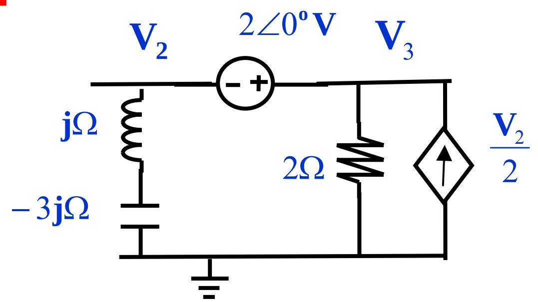
$$I = \frac{S}{V} = \frac{4k}{200} = 20A_{rms}$$

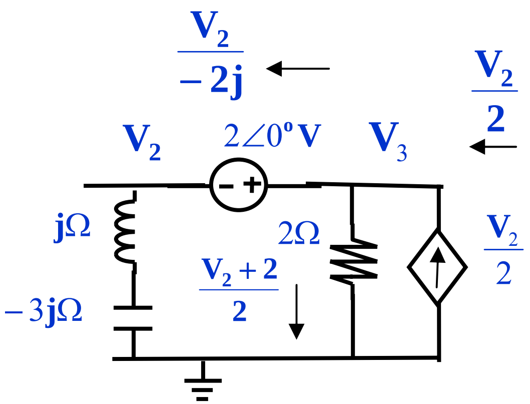
$$I_B = \frac{Q}{V} = \frac{3k}{200} = 15A_{rms}$$ **(6.5)**

Load A is connected in parallel to a 200Vrms, 50 Hz supply as shown. Power factor PF of load A is 0.8 lagging. S = 5kVA.
(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 = 3kVAR.
(c) If load A consists of R and L in series, find IA (in Arms), L and θ.
(d) If load B is connected in parallel to load A such that the power factor (PF) of the combined load is 1, find the element and value of load B. Find also I_B in Arms. (47)

8

Find V2 (15)



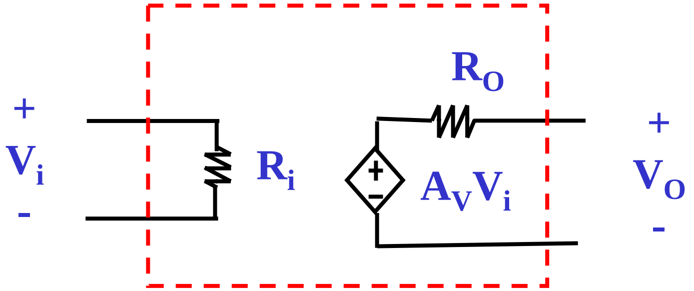


$$\frac{V_2}{2\Omega} = \frac{V_2 + 2V}{2\Omega} + \frac{V_2}{-2j\Omega} \qquad (8)$$

$$0 = 1 - \frac{V_2}{2j}$$

$$\therefore V_2 = 2j \qquad (7)$$

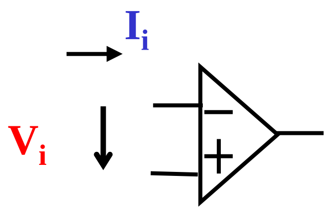
9



(7)

Ro = 0 (3)

(b)



$$V_i = \frac{V_O}{A} \cong \frac{\pm 15V}{\infty} = 0V \qquad (6)$$

$$I_i = \frac{V_i}{R_i} \cong \frac{0V}{\infty\Omega} = 0A \qquad (5)$$

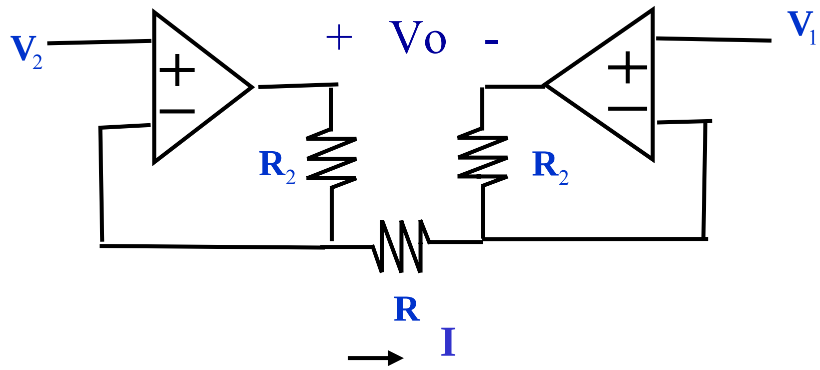
(a)
Draw the circuit model for a **voltage amplifier**.
What is the ideal value of the output resistance?

(b) Explain briefly why for ideal op amp,
the Vi and Ii are ~ 0. (21)

(17)

10

In the instrumentation amplifier,
find Vo/ (V2 - V1) in terms of R2 and R .
Name also two advantages of this amplifier.
Assume the op amps are ideal. (17)



$$\therefore V_O = I*(2R_2 + R) = \frac{V_2 - V_1}{R}(2R_2 + R)$$

(10)

High input resistance
Change voltage gain by only 1 R

(7)