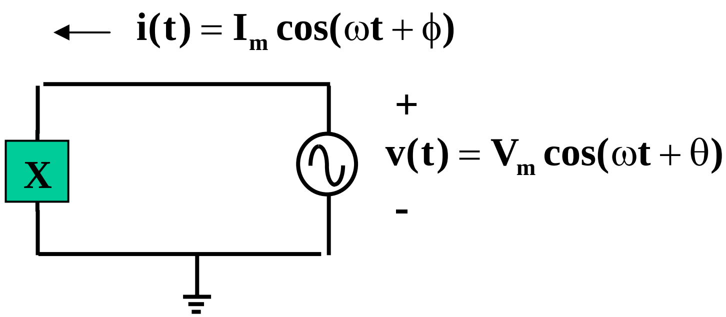
1

In the circuit, X is an unknown element. . (23)

(a) If $V_m = 10V$, $I_m = 5A$, $\theta = \phi = 60^o$, find X in Ω, power factor of X, and power dissipated by X.

(b) If $V_m = 8V$, $I_m = 4A$, $\theta = 0^o$, $\phi = 90^o$, find X in Ω, and power stored by X.



(a)

$$X = R = \frac{V_m}{I_m} = \frac{10V}{5A} = 2\Omega$$

$$PF = 1$$

$$P_R = I^2 * R = \left(\frac{5A}{\sqrt{2}}\right)^2 * 2\Omega = 25W$$

(b)

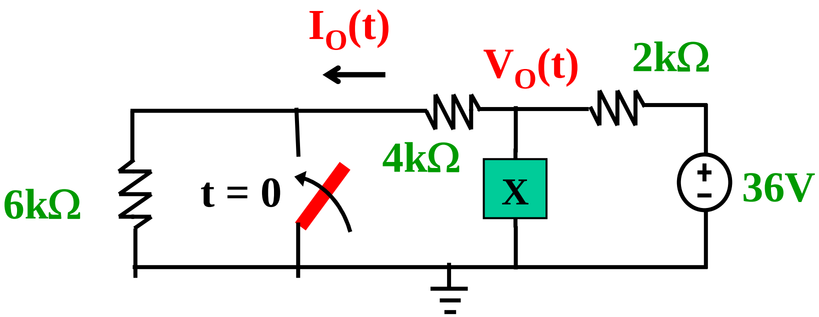
$$X = C = -j2\Omega$$

$$Q_C = I^2 * \frac{1}{\omega C} = \left(\frac{4A}{\sqrt{2}}\right)^2 * 2\Omega = 16VAR(C)$$

2

The circuit is at steady state for $t < 0$. At $t = 0$, the switch is **closed**.
If $X = 0.2\text{mF}$, find $V_O(0)$, $V_O(\infty)$ and time constant τ for $t > 0$. Find also $I_O(t)$ when $t = 0$ and 10τ .
(21)

Given that $\mathbf{V_C(t) = V_C(\infty) + [V_C(0) - V_C(\infty)] * e^{-t/\tau}}$ **and** $\boldsymbol{\tau} = \mathbf{CR}$



(a)

$$\therefore\ V_O(0) = V_O(0-) = 36V\left(\frac{10k\Omega}{12k\Omega}\right) = 30V$$

$$\therefore \tau = CR = 200\mu F * (2k\Omega // 4k\Omega) = 0.267s$$

$$\therefore V_O(\infty) = 36V * \frac{4k\Omega}{6k\Omega} = 24V$$

$$I_O(0) = \frac{30V}{4k\Omega} = 7.5mA$$

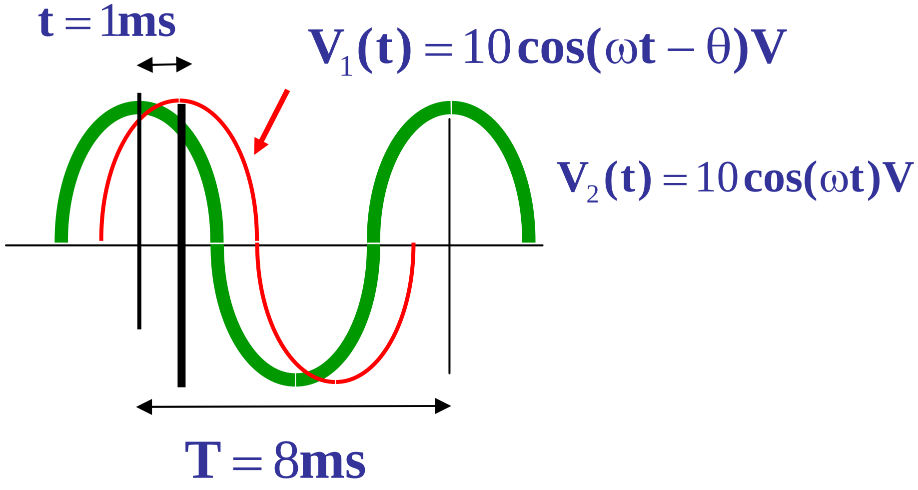
$$I_O(10\tau) \cong \frac{24V}{4k\Omega} = 6mA$$

3

Find ω , θ and $V_1(0)$

Does $V_2(t)$ lag $V_1(t)$?

Given 2π radian = 360°, period of $V_2(t)$ is 8 ms, and difference between the peaks of $V_1(t)$ and $V_2(t)$ is 1 ms. (14)



$$\omega = \frac{2\pi}{T} = \frac{2\pi}{8ms}$$

$$\theta = \frac{t}{T} * 360^o = \frac{1ms}{8ms} * 360^o = 45^o$$

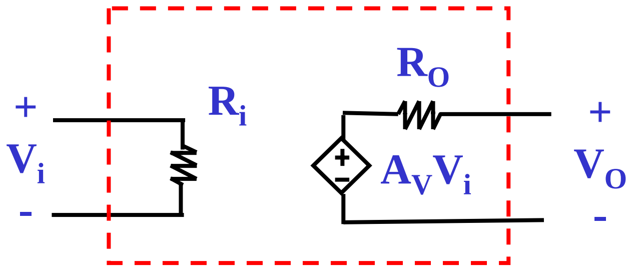
$$\therefore V_1(t) = 10\cos(\frac{2\pi}{8ms}t - 45^o)V$$

$$\therefore V_1(0) = 10\cos(0 - 45^o)V = \frac{10}{\sqrt{2}}V$$

$V_2(t)$ leads $V_1(t)$

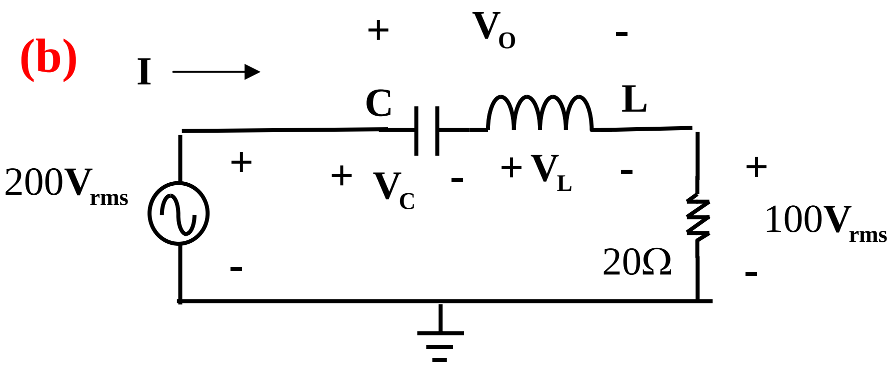
4

(a)



Rin = oo , Ro = 0

(b)



$$\mathbf{I} = \frac{100\mathbf{V}_{\mathbf{rms}}}{20\Omega} = 5\mathbf{A}_{\mathbf{rms}}$$

$$\therefore \mathbf{V}_{\mathbf{O}} = \sqrt{200^2 - 100^2} \cong 173\mathbf{V}_{\mathbf{rms}}$$

. (a) Draw the circuit model for a **voltage amplifier**.
What are the ideal values of the input resistance
and output resistance of the voltage amplifier?

(b) In the circuit, find I in Arms and find V_O in Vrms .
. (19)

5

A load consumes 6kW at power factor (PF) of 0.6 lagging from a $200\angle 0^o$ Vrms 50 Hz line.
(a) Find the real power (dissipated power) P and apparent power (supply power) S of the load. Show that the reactive power (stored power) Q is 8kVAR. ,
(b) Show that the current I in the load is 50Arms. Find also the current I in phasor form.
If the load is a resistance R in series with an inductance L, find L.
(c) An element X is connected in parallel to the load to improve the power factor to 1. Find the element and value of X.
(32)

(a)

$$\mathbf{P} = 6\mathbf{kW}$$

$$\mathbf{Q} = \mathbf{P}\tan\theta = 6\mathbf{kW}\tan(\cos^{-1}0.6) = 8\mathbf{kVAR(L)}$$

$$\therefore \mathbf{S} = \sqrt{\mathbf{P}^2 + \mathbf{Q}^2} = \sqrt{6\mathbf{k}^2 + 8\mathbf{k}^2} = 10\mathbf{kVA}$$

(b)

$$\mathbf{I} = \frac{\mathbf{S}}{\mathbf{V}} = \frac{\mathbf{10k}}{\mathbf{200}} = \mathbf{50A_{rms}}$$

$$\textbf{phasor } \mathbf{I} = 50\mathbf{A_{rms}}\angle -\cos^{-1}0.6 = 50\mathbf{A_{rms}}\angle -53^o$$

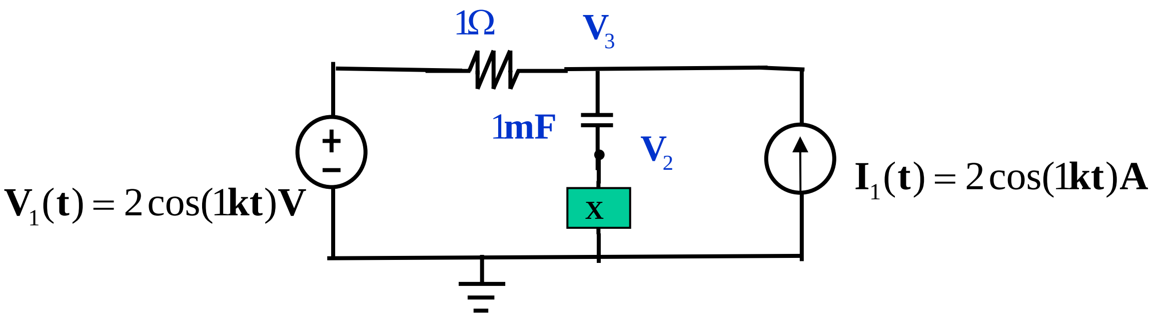
$$\mathbf{L} = \frac{\mathbf{Q}}{\omega \mathbf{I}^2} = \frac{\mathbf{8k}}{\mathbf{2\pi 50(50^2)}} = \mathbf{10.2mH}$$

(c) Connect a C parallel to the load

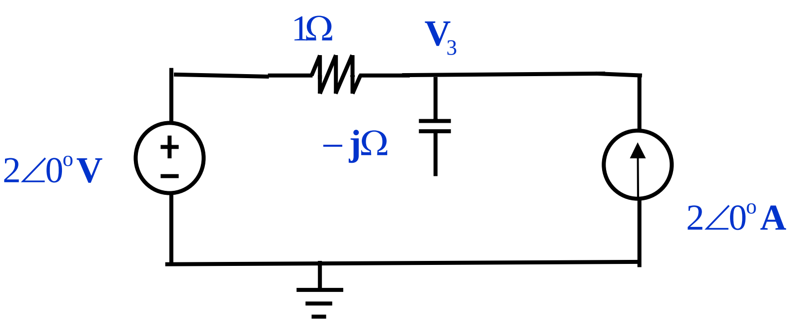
$$\therefore\ \mathbf{C} = \frac{|\mathbf{Q_C}|}{\mathbf{V}^2\omega} = \frac{8\mathbf{kVAR}}{(200\mathbf{V_{rms}})^2 * 2\pi 50\mathbf{rad/s}} = 0.64\mathbf{mF}$$

6

(a) If X is an open circuit, find V_3 in phasor form.
(b) If X = 1mH, find V3(t).
(c) If X = 1ohm , find V2 in phasor form.
Draw also V_1 and V_2 in a **phasor diagram**. (30)



(a)



$$\therefore \mathbf{V}_3 = 4\angle 0^{\mathbf{o}}\,\mathbf{V}$$

(b)

$$\frac{1}{\mathbf{j}\omega\mathbf{C}} = \frac{1}{\mathbf{j}(1\mathbf{k})1\mathbf{mF}} = -\mathbf{j}\Omega$$

$$\mathbf{j}\omega\mathbf{L} = \mathbf{j}(1\mathbf{k})1\mathbf{mH} = \mathbf{j}\Omega$$

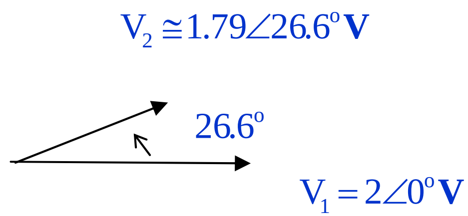
$$\therefore \mathbf{V}_3 = 0\mathbf{V}$$

(c) **using Thevenin's Theorem, Z = 1-j**

$$\therefore \mathbf{V}_2 = \frac{1}{1+1-\mathbf{j}\Omega} * 4\angle 0^{\mathbf{o}}\,\mathbf{V}$$

$$= \frac{4\angle 0^{\mathbf{o}}}{\sqrt{5}\angle -26.6^{\mathbf{o}}}$$

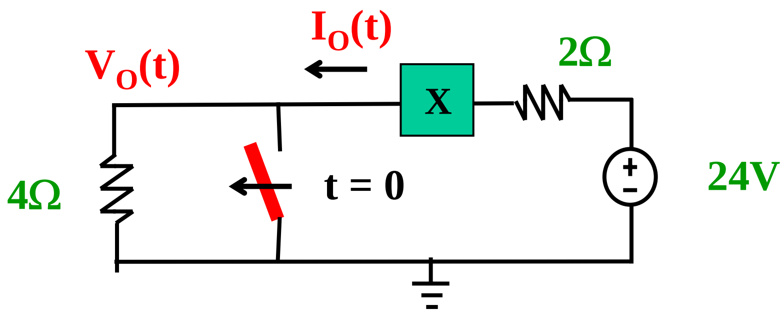
$$\cong 1.79\angle 26.6^{\mathbf{o}}\,\mathbf{V}$$



7

The circuit is at steady state for $t < 0$. At $t = 0$, the switch is **opened**. If X = 0.4H, find $I_O(0)$, $I_O(\infty)$, and time constant τ. Plot also $V_O(t)$ versus t for $\infty \geq t \geq 0$ and label clearly the intercepts. (22) (22)

Given that $\mathbf{I_L(t) = I_L(\infty) + [I_L(0) - I_L(\infty)] * e^{-t/\tau}}$ **and** $\mathbf{\tau = L/R}$

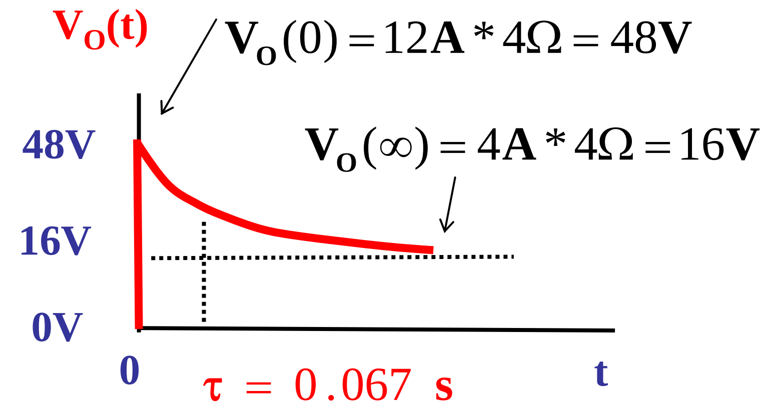


$$\therefore\ I_O(0) = I_O(0-) = \frac{24V}{2\Omega} = 12A$$

$$\therefore \tau = \frac{L}{R} = \frac{0.4H}{6\Omega} \cong 66.7ms$$

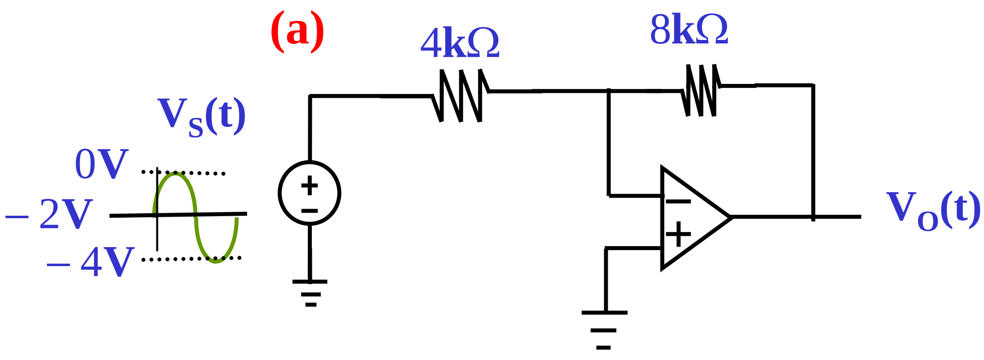
$$\therefore I_O(\infty) = \frac{24V}{6\Omega} = 4A$$

(b)



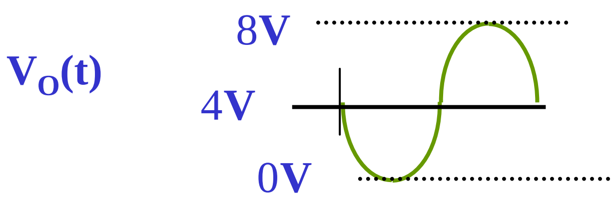
8

(a) Find the voltage gain A (=Vo/Vs) and draw the Vo(t) waveform. Assume an ideal op amp. (9)

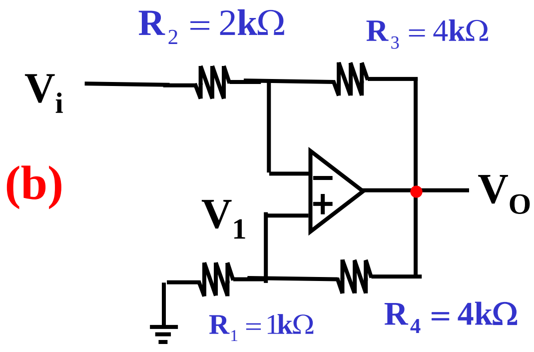


(a)

$$A = -\frac{8k\Omega}{4k\Omega} = -2$$



(b) Show that V1 = Vo/5. Hence find the voltage gain A (=Vo/Vi). Assume an ideal op amp. (17)



(b)

$$\because V_- = V_+ = V_1$$

$$\therefore \frac{V_1}{1k} = \frac{V_O - V_1}{4k}$$

$$\therefore V_1 = \frac{V_O}{5}$$

$$\therefore \frac{V_i - V_1}{2k} = \frac{V_1 - V_O}{4k}$$

$$\therefore 2V_i - 2V_1 = V_1 - V_O$$

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

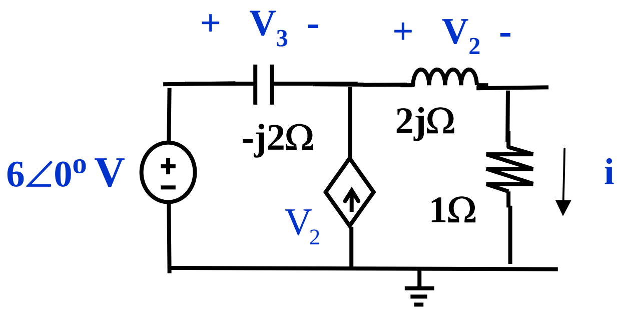
$$\therefore 2V_i = -\frac{2}{5}V_O$$

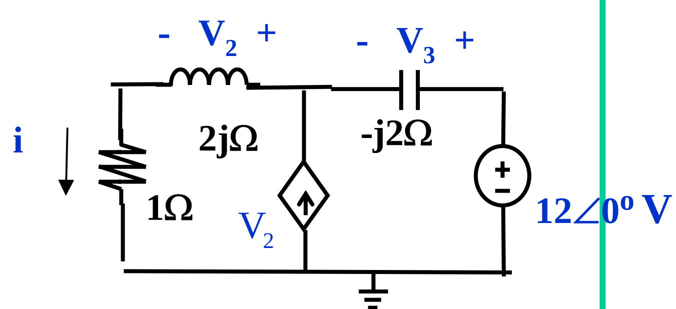
$$\therefore A_V = \frac{V_O}{V_i} = -5$$

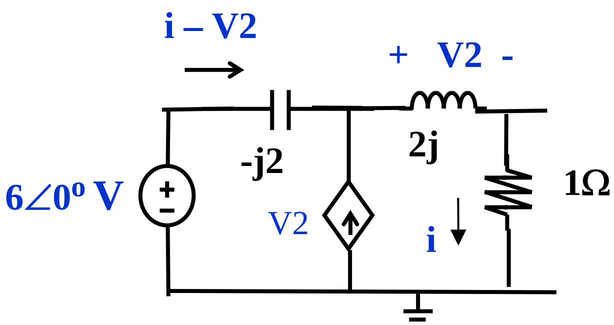
(20)

9

In the circuit, the dependent source is a **voltage controlled current source** and is in A.
Find i , V_2 and V3 in phasor form.
(20)







$$\because i*1\Omega + V2 + (i - V2)(-2j\Omega) = 6V$$

$$\because V2 = i*2j\Omega = 2ijV$$

$$\therefore i*1\Omega + 2ijV + (i - 2ij)(-2j\Omega) = 6V$$

$$i*1\Omega + 2ijV - 2ijV - 4iV = 6V$$

$$-3\mathbf{i}\mathbf{V} = 6\mathbf{V}$$

$$\therefore i = -2A$$

$$\therefore V2 = 2jiV = -4jV$$

$$\therefore \mathbf{V}_3 = (\mathbf{i} - \mathbf{V}_2)*-2\mathbf{j} = (-2+4\mathbf{j})*-2\mathbf{j} = 4\mathbf{j}+8\mathbf{V}$$