

Q1 Refer to Figure 1 for this question

8 MARKS

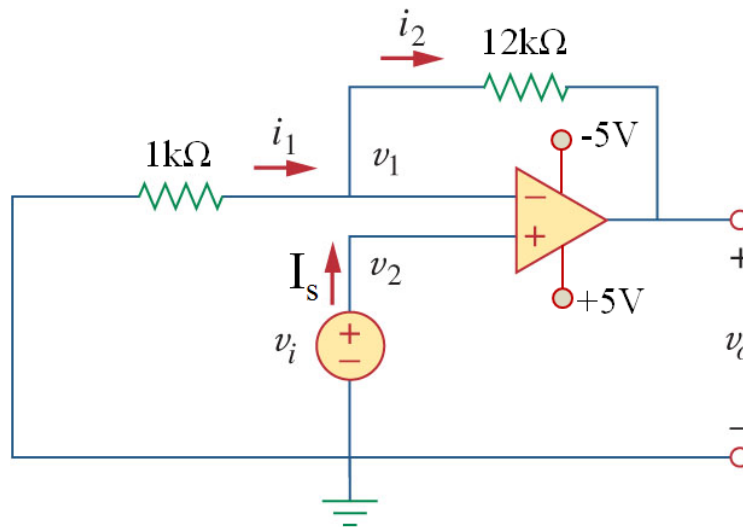


Figure 1

If $v_i = 0.1\text{V}$,a. Find V_1 and V_2 (2 marks)

$$V_1 = 0.1\text{V (1 mark)}$$

$$V_2 = 0.1\text{V (1 mark)}$$

b. Find I_s , I_1 and I_2 (3 marks)

$$I_s = 0 \text{ (1 mark)}$$

$$I_1 = -0.1 \text{ mA (1 mark)}$$

$$I_2 = -0.1 \text{ mA (1 mark)}$$

c. Find v_o (1 mark)

$$\text{Output } v_o = 1.3 \text{ V (1 mark)}$$

d. If v_i is increased to 0.6V , find the new v_o (2 marks)

$$\text{New } v_o = 5 \text{ V due to saturation (2 marks)}$$

Score for Q1: _____ / 8

Q2 Refer to Figure 2 for this question

12 MARKS

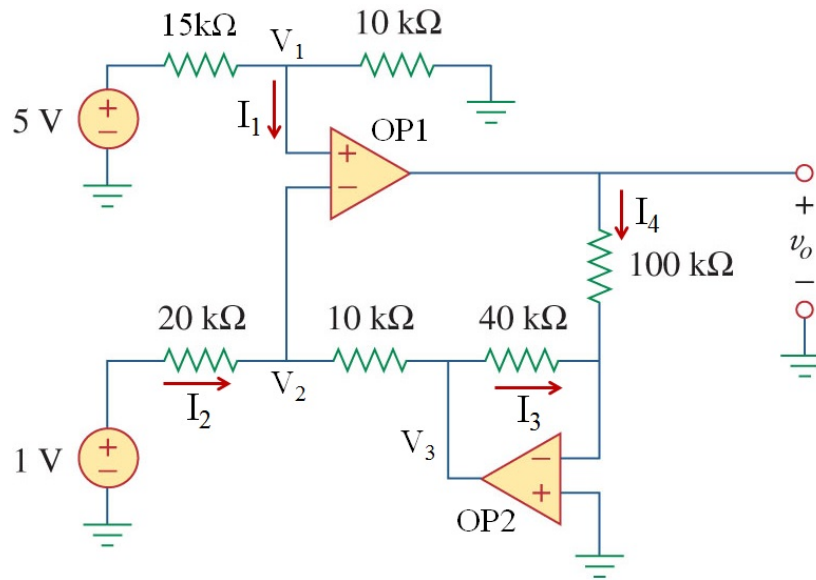


Figure 2

a. Find I_1 and V_1 (2 marks)

$$I_1 = 0 \text{ (1 mark)}$$

$$V_1 = 2 \text{ V (1 mark)}$$

b. Find V_2 (1 mark)

$$V_2 = 2 \text{ V (1 mark)}$$

c. Find I_2 (1 mark)

$$I_2 = -0.05 \text{ mA (1 mark)}$$

d. Find V_3 (2 marks)

$$V_3 = 2 + 0.05 \times 10 = 2.5 \text{ V (2 marks)}$$

e. Find I_3 (2 marks)

$$I_3 = 2.5/40 = 0.0625 \text{ mA (2 marks)}$$

f. Find I_4 (2 marks)

$$I_4 = -0.0625 \text{ mA (2 marks)}$$

g. Find v_o (2 marks)

$$\text{Output } v_o = -0.05 \times 100 = -6.25 \text{ V (2 marks)}$$

Score for Q2: _____ / 12

Q3 Refer to Figure 3 for this question

7 MARKS

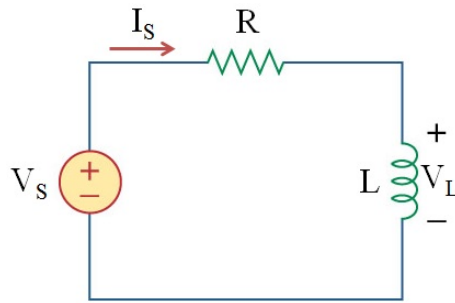


Figure 3

- a. Under DC conditions, the inductor appears as a **SHORT** circuit. (1 mark)
- b. When the amplitude of V_s is fixed and its frequency as a sinusoid is increased:
- i) The amplitude of I_s will increase/decrease/remain the same. Circle your choice. (2 marks)
- ii) The amplitude of V_L will increase/decrease/remain the same. Circle your choice. (1 mark)
- c. The phase of I_s relative to V_L is **-90** degrees. (1 mark)
- d. Given $V_L = 5 \cos(1000t + 30^\circ)$, $L = 20 \text{ mH}$ and $I_s = I_m \cos(1000t + \Psi)$, where I_m is positive and Ψ is in degrees, find I_m and Ψ . (2 marks)

$$I_m = \underline{0.25} \text{ A (1 mark)}$$

$$\Psi = \underline{-60} \text{ degrees}$$

Score for Q3: _____ / 7

Q4 Refer to Figure 4 for this question

9 MARKS

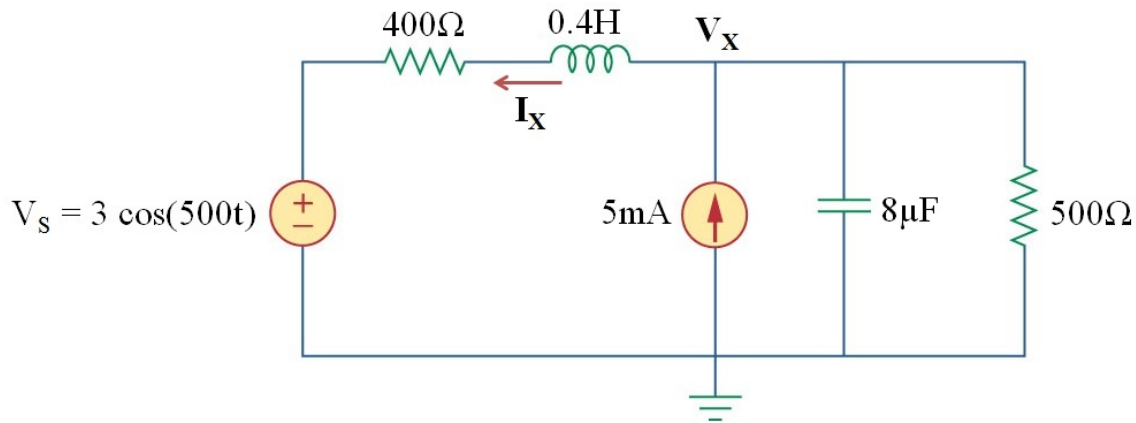


Figure 4

- a. Under DC conditions, find V_x . (2 marks)

$$V_x = (2000/9) * 0.005 = 10/9 = 1.11V \text{ (2 marks)}$$

- b. At rad/s, find V_x in the **time domain**. (4 marks)

$$V_x(t) = 1.3416 \cos(500t - 63^\circ) \text{ (4 marks; Give 3 marks if answer is a phasor)}$$

- c. Find I_x at all frequencies, expressed in the **time domain**. (3 marks)

$$I_x(t) = 6 \cos(500t - 180^\circ) + 3 \text{ mA}$$

3 marks;

Give 1 mark if DC term is correct

Give 2 marks if AC term is correct and in time domain (1 mark if correct by in phasor form, no marks otherwise)

Working for Part (b)

Impedance of capacitor in parallel with 500Ω : $Z_1 = 100 - j200$

Impedance of inductor in series with 400Ω : $Z_2 = 400 + j200$

$$V_x = 0.6 - j1.2 = 1.3416 \angle -63^\circ$$

Working for Part (c)

AC term: $(1.3416 \angle -63^\circ - 3)/(400 + j200) = -0.006 = 0.006 \angle -180^\circ$

DC term: $1.1/400 = 2.78 \text{ mA}$

Score for Q4: _____ / 9

5 Refer to Figure 5 for this question

14 MARKS

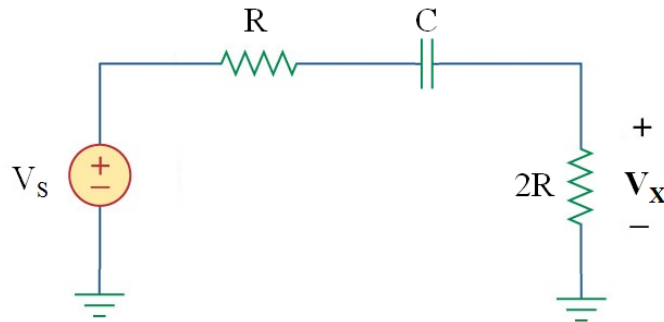


Figure 5

- a. Derive the transfer function in following form: $\frac{V_x}{V_s} = \frac{A}{1 + \omega_c / j\omega}$

Find the value of A and derive the expression for ω_c in terms of the component symbols (e.g. R, L).

A = 2/3 (2 marks), $\omega_c = 1/3RC$ (2 marks)

- b. Determine $\angle(V_x/V_s)$ when $\omega = 0$, $\omega = \omega_c$ and $\omega \rightarrow \infty$ (3 marks)

At $\omega = 0$: $\angle(V_x/V_s) = 90^\circ$ (1 mark)

At $\omega = \omega_c$: $\angle(V_x/V_s) = 45^\circ$ (1 mark)

At $\omega \rightarrow \infty$: $\angle(V_x/V_s) = 0^\circ$ (1 mark)

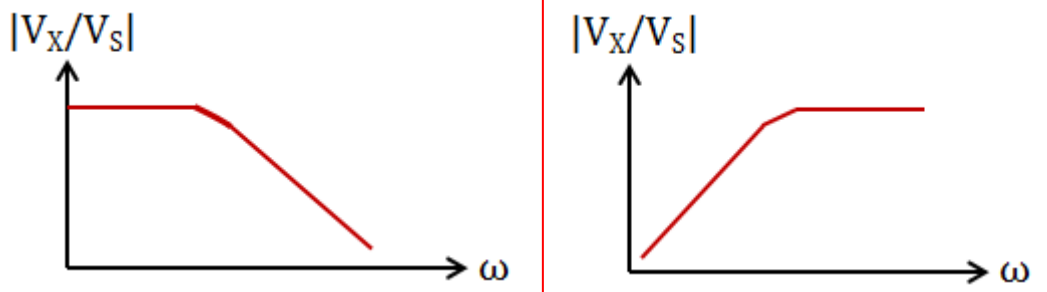
- c. Determine $|V_x/V_s|$ when $\omega = 0$, $\omega = \omega_c$ and $\omega \rightarrow \infty$ (3 marks)

At $\omega = 0$: $|V_x/V_s| = 0$ (1 mark)

At $\omega = \omega_c$: $|V_x/V_s| = 2/(3\sqrt{2})$ (1 mark)

At $\omega \rightarrow \infty$: $|V_x/V_s| = 2/3$ (1 mark)

- d. Circle the corresponding plot of $|V_x/V_s|$ vs ω from the following choices. (2 marks)



- e. On the graph, label the value of $|V_x/V_s|$ at the flat band and the cut off frequency. (2 marks)

Flat band: A OR 2/3 (1 mark), Cut off: A/ $\sqrt{2}$ OR 2/(3 $\sqrt{2}$) (1 mark)

Score for Q4: _____ / 9