Solutions to Quiz-1 (Group-A) IEC102

(Q1) Calculate the current gain i_o/i_s in the circuit shown in Fig. Q1

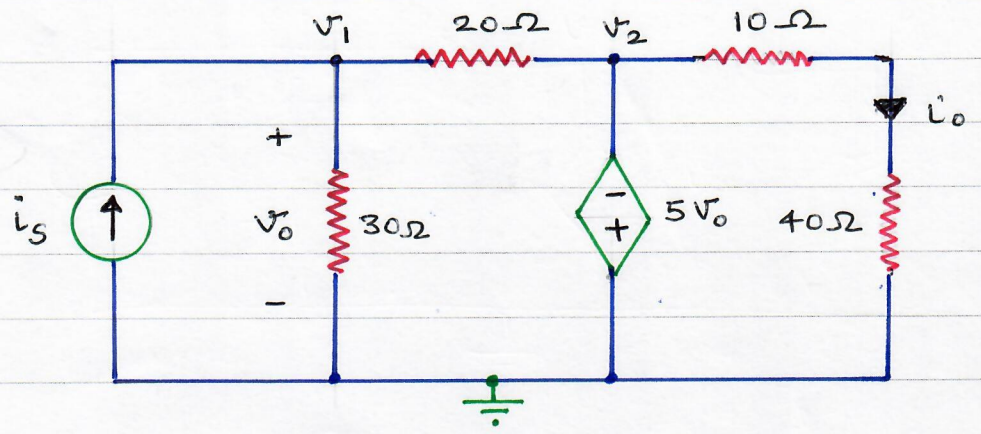


Fig. Q1

Sol. Apply KCL at node ① (v_1)

$$-i_s + \frac{v_1}{30} + \frac{v_1 - v_2}{20} = 0$$

$v_1 = v_o$; $v_2 = -5v_o$

$$\therefore \quad -i_s + \frac{v_o}{30} + \frac{v_o - (-5v_o)}{20} = 0$$

$$\Rightarrow \quad -i_s + \frac{v_o}{30} + \frac{6v_o}{20} = 0 \quad \Rightarrow \quad -i_s + \frac{v_o}{3} = 0$$

$$i_o = \frac{v_2}{10+40} = \frac{-5v_o}{50} = -\frac{v_o}{10} \quad \Rightarrow \quad v_o = -10i_o$$

$$-i_s + \frac{v_o}{3} = 0 \quad \Rightarrow \quad -i_s + \frac{-10i_o}{3}$$

$$\Rightarrow \boxed{\frac{i_o}{i_s} = -0.3}$$

Q2. Use nodal analysis to find I_o in the circuit shown in Fig. Q2

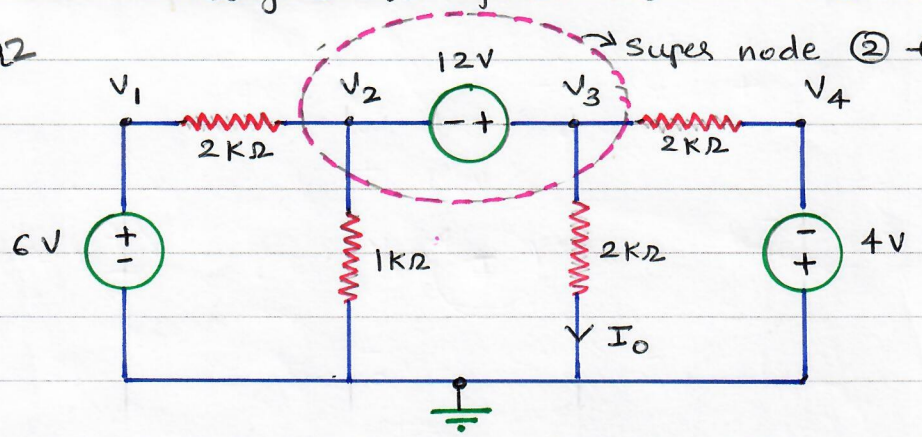


Fig. Q2

$V_1 = 6V$, $V_4 = -4V$

Applying KCL at super node ② - ③

$$\frac{V_2 - V_1}{2K} + \frac{V_2}{1K} + \frac{V_3}{2K} + \frac{V_3 - V_4}{2K} = 0$$

and $V_3 - V_2 = 12$ or $\boxed{V_3 = 12 + V_2}$ ... (A)

$$-\frac{V_1}{2K} + V_2\left(\frac{1}{2K} + \frac{1}{1K}\right) + V_3\left(\frac{1}{2K} + \frac{1}{2K}\right) - \frac{V_4}{2K} = 0$$

$$\Rightarrow -\frac{V_1}{2K} + \frac{3}{2K}V_2 + \frac{V_3}{K} - \frac{V_4}{2K} = 0$$

$$\Rightarrow -V_1 + 3V_2 + 2V_3 - V_4 = 0$$

$$\Rightarrow -6 + 3V_2 + 2V_3 - (-4) = 0$$

$$\Rightarrow 3V_2 + 2V_3 = 2$$

$$\Rightarrow 3V_2 + 2(12 + V_2) = 2 \quad \text{(Using eq (A))}$$

$$\Rightarrow 5V_2 = -22 \text{ or } \boxed{V_2 = -22/5}$$

$$V_3 = 12 + V_2 = 12 - \frac{22}{5} = \frac{38}{5} V$$

$$\boxed{V_3 = \frac{38}{5} V}$$

$$\boxed{I_o = \frac{V_3}{2K} = \frac{38}{10K} A = 3.8 mA}$$

(Q3) Using mesh analysis, calculate I_o in the circuit shown in Fig. Q3

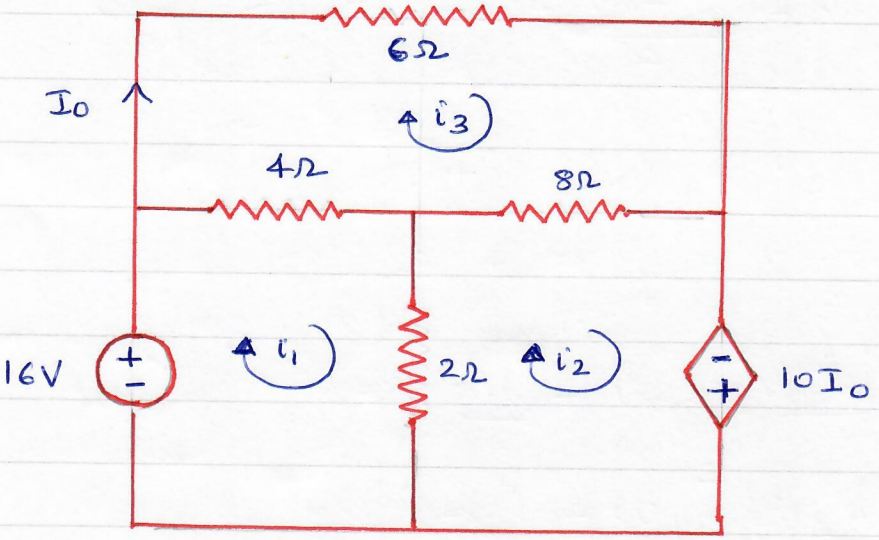


Fig. Q3

Sol.

$$I_o = i_3$$

Applying KVL around loop (1)

$$-16 + 4(i_1 - i_3) + 2(i_1 - i_2) = 0$$

$$\Rightarrow \boxed{6i_1 - 2i_2 - 4i_3 = 16} \quad \ldots (A)$$

Applying KVL around loop (2)

$$2(i_2 - i_1) + 8(i_2 - i_3) - 10I_o = 0$$

but $I_o = i_3$

$$\therefore 2(i_2 - i_1) + 8(i_2 - i_3) - 10i_3 = 0$$

$$\Rightarrow \boxed{-2i_1 + 10i_2 - 18i_3 = 0} \quad \ldots (B)$$

Applying KVL around loop (3)

$$6(i_3) + 8(i_3 - i_2) + 4(i_3 - i_1) = 0$$

$$\Rightarrow \boxed{-4i_1 - 8i_2 + 18i_3 = 0} \quad \ldots (C)$$

Writing eqns (A), (B), and (C) in matrix form

$$\begin{bmatrix} 6 & -2 & -4 \\ -2 & 10 & -18 \\ -4 & -8 & 18 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} \quad \begin{bmatrix} 16 \\ 0 \\ 0 \end{bmatrix}$$

Solving the above simultaneous eqns.

$$\boxed{i_3 = I_0 = -4A}$$

Q4 Use superposition to find v_x in the circuit shown in Fig. Q4

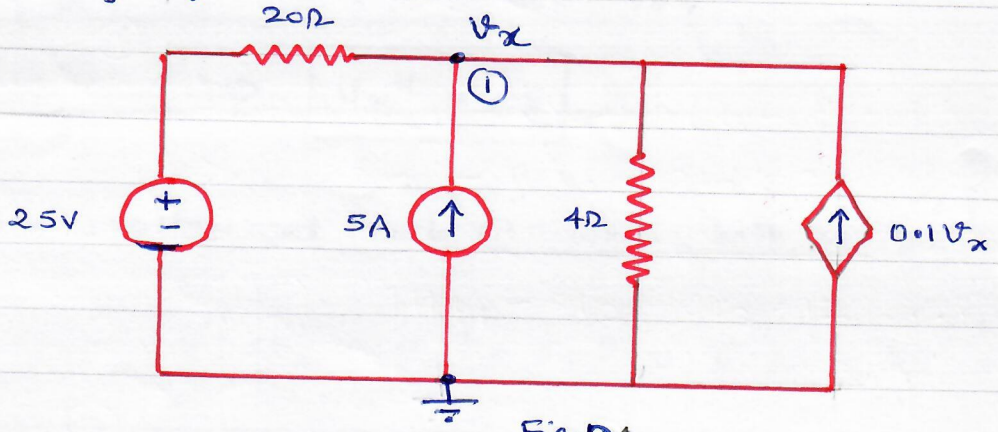
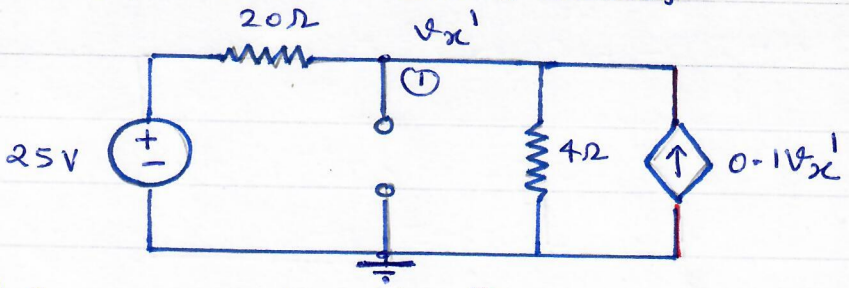


Fig. Q4

Sol.

Let node ① voltage be v_x' due to voltage source alone. (open circuit the current source)



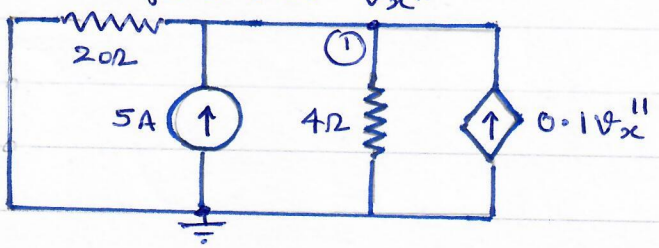
Applying KCL at node ①

$$\frac{v_x' - 25}{20} + \frac{v_x'}{4} - 0.1v_x' = 0$$

$$\Rightarrow \frac{v_x'}{20} + \frac{v_x'}{4} - \frac{v_x'}{10} = \frac{25}{20}$$

$$\Rightarrow \boxed{v_x' = \frac{25}{4} = 6.25\,V}$$

Let node ① voltage be v_x'' due to the current source alone (short circuit the voltage source)



Applying KCL at node ①

$$\frac{v_x''}{20} - 5 + \frac{v_x''}{4} - 0.1v_x'' = 0$$

$$\Rightarrow v_x'' \left(\frac{1}{20} + \frac{1}{4} - \frac{1}{10} \right) = 5$$

$$\Rightarrow \boxed{v_x'' = 25}$$

The voltage at node ① when both sources are present is

$$v_x = v_x' + v_x'' = 6.25 + 25 = 31.25\,V$$