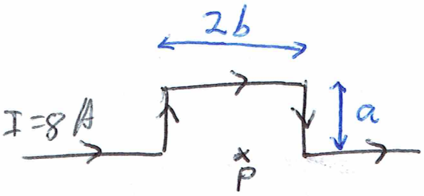
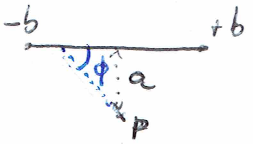
FFT: Maratón Navidad

1



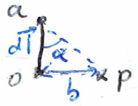


$$B_1 = \frac{\mu_0 I}{4\pi}\cdot\int_{-b}^{b}\frac{d\vec{l}\times r}{r^3} = \frac{\mu_0 I\, a}{4\pi}\int_{-b}^{b}\frac{dl}{(\sqrt{a^2+l^2})^3} = \frac{\mu_0 I\cdot a}{4\pi}\left[\frac{L}{a^2\sqrt{b^2+a^2}}\right]_{-b}^{b} =$$

$d\vec{l}\times r = d\vec{l}\cdot \operatorname{sen}\phi \cdot |\vec{r}|$

$d\vec{l}\times r = d\vec{l}\,\frac{a}{\sqrt{a^2+l^2}}$ *

$$= \frac{\mu_0 I}{4\pi\cdot a}\cdot\frac{2b}{\sqrt{b^2+a^2}} = \boxed{\frac{\mu_0\cdot I}{2\pi\sqrt{a^2+b^2}}\cdot\frac{b}{a}}$$



$$B_2 = \frac{\mu_0 I\, b}{4\pi}\int_0^a \frac{1}{(\sqrt{b^2+l^2})^3}\,dl = \frac{\mu_0\cdot I\, b}{4\pi\, b^2}\left[\frac{L}{\sqrt{b^2+L^2}}\right]_0^a =$$

$d\vec{l}\times r = d\vec{l}\cdot \operatorname{sen}\alpha\cdot|\vec{r}|$

$d\vec{l}\times r = d\vec{l}\cdot\frac{b}{\sqrt{b^2+l^2}}$ *

$$= \boxed{\frac{\mu_0 I\, a}{4\pi b\cdot\sqrt{b^2+a^2}}}$$

$$\boxed{|B_T| = B_1 + 2B_2 = \frac{\mu_0 I}{2\pi\sqrt{b^2+a^2}}\left(\frac{a}{b}+\frac{b}{a}\right)}$$

Entrante en el papel

2

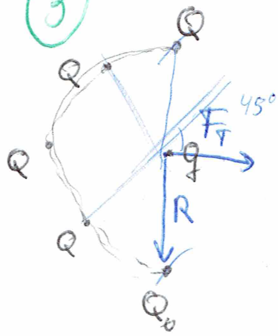
$$|B| = \int\frac{\mu_0}{4\pi}\cdot\frac{I\cdot d\vec{l}}{R^2} = \frac{\mu_0 I}{4\pi R^2}\cdot L = \frac{\mu_0 I}{4\cancel{\pi} R^{\cancel{2}}}\cdot\cancel{\pi}\cdot\cancel{R} = \boxed{\frac{\mu_0 I}{4R}}$$

Entrante en el papel.

* $\operatorname{sen}\alpha = \frac{b}{|\vec{r}|}$

$\operatorname{sen}\phi = \frac{a}{|\vec{r}|}$

③

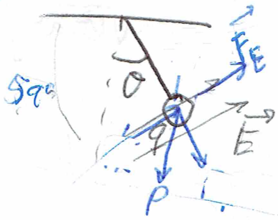


$$|F_Q| = \frac{K \cdot Q \cdot q}{R^2}$$

$$F_T = \frac{KQq}{R^2}\left(\vec{i} + \frac{\sqrt{2}}{2}\vec{i} + \cancel{\frac{\sqrt{2}}{2}\vec{j}} + \frac{\sqrt{2}}{2}\vec{i} - \cancel{\frac{\sqrt{2}}{2}\vec{j}} + \cancel{\vec{j}} - \cancel{\vec{j}}\right)$$

$$\boxed{F_T = \frac{K \cdot Q \cdot q}{R^2}(1+\sqrt{2})\,\vec{i}} \quad N$$

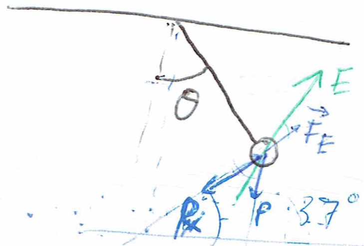
④



$\theta = 37°$

$\vec{E} = (3\vec{i} + 5\vec{j}) \cdot 10^5\ N/C$

$m = 1g$



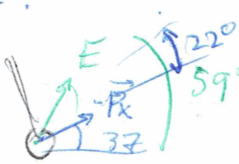
$$\vec{F}_E = q \cdot (3\vec{i} + 5\vec{j}) \cdot 10^5$$

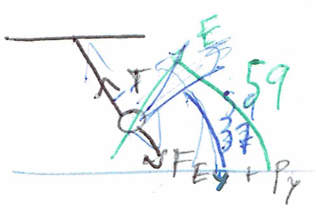
$$|P_x| = |P| \cdot \text{sen}\,\theta = 9'8 \cdot 10^{-3} \cdot \text{sen}(37) = 5'8978 \cdot 10^{-3}$$

$$|F_E| = 5'831 \cdot 10^5 \cdot q$$

$$\vec{P}_x = 5'8978 \cdot 10^{-3}\left(-\cos(37)\vec{i} + \text{sen}(37)\vec{j}\right)$$

$$\vec{F}_E = 5'831 \cdot 10^5 \cdot q\left(\cos(59)\vec{i} + \text{sen}(59)\vec{j}\right)$$





$$|F_E| \cdot \cos(22) = |P_x| \Rightarrow 5'831 \cdot 10^5 \cdot q \cdot 0'927 = 5'8978 \cdot 10^{-3}$$

$$q = \frac{5'8978 \cdot 10^{-3}}{10^5 \cdot 5'831 \cdot 0'927}$$

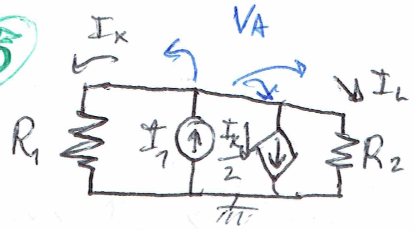
$$\boxed{q = 1'09 \cdot 10^{-8}\ C}$$

$$|P_y| = 9'8 \cdot 10^{-3} \cdot \cos(37) = 7'83 \cdot 10^{-3}\ N$$

$$F_{Ey} = -|F_E| \cdot \text{sen}(22) = -2'381 \cdot 10^{-3}\ N = 5'831 \cdot 10^5 \cdot q \cdot \text{sen}(22)$$

$$\boxed{T = 5'45 \cdot 10^{-3}\ N}$$

5



$I_1 = 6\ mA$

$R_1 = 2k\Omega$

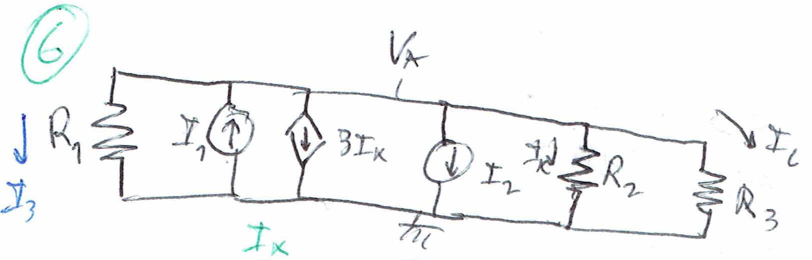
$R_2 = 4k\Omega$

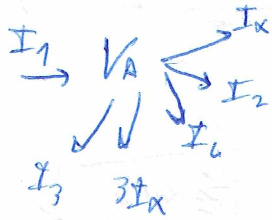
$$\boxed{I_L = \frac{V_A}{4} = \frac{6}{4} = 1'5\ mA}$$

$$I_1 = I_x + \frac{I_x}{2} + I_L$$

$$6 = \frac{2V_A}{2 \cdot 2} + \frac{V_A}{4} + \frac{V_A}{4} \Rightarrow 6 = \frac{4V_A}{4} \Rightarrow V_A = 6V$$

6





$I_1 = 6mA$

$I_2 = 3mA$

$R_1 = 6k\Omega$

$R_2 = 2k\Omega$

$R_3 = 3k\Omega$

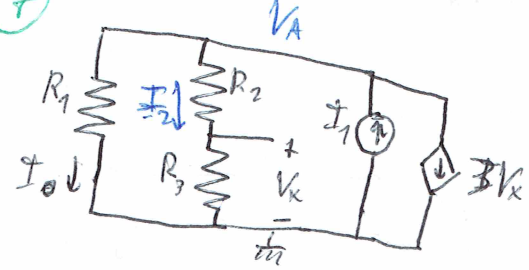
$$I_1 = \overset{I_x}{\frac{V_A}{R_2}} + \overset{I_L}{\frac{V_A}{R_3}} + \overset{I_3}{\frac{V_A}{R_1}} + I_2 + \overset{3 \cdot I_x}{3 \cdot \frac{V_A}{R_2}}$$

$$6 = \frac{V_A}{2} + \frac{V_A}{3} + \frac{V_A}{6} + 3 + \frac{3V_A}{2} \Rightarrow 3 = \frac{3V_A + 2V_A + V_A + 9V_A}{6} = \frac{15}{6}V_A$$

$$V_A = \frac{18}{15} = 1'2\ V$$

$$\boxed{I_L = \frac{V_A}{R_3} = \frac{1'2}{3} = 0'4\ mA}$$

7



$I_1 = 5A$

$R_1 = 6\Omega$

$R_2 = 8\Omega$

$R_3 = 4\Omega$

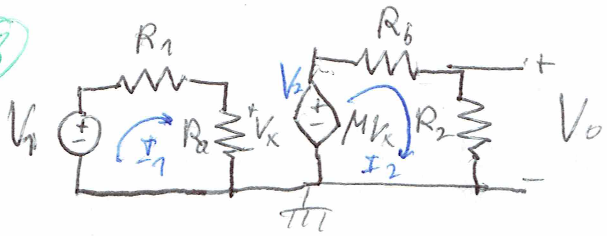
$$I_1 = I_2 + I_0 + 3V_x$$

$$5 = \frac{V_A}{R_2 + R_3} + \frac{V_A}{R_1} + 3(I_2 \cdot R_3)$$

$$5 = \frac{V_A}{12} + \frac{V_A}{6} + 3\left(\frac{V_A}{12} \cdot 4\right) \Rightarrow 5 = \frac{V_A + 2V_A + 12V_A}{12} \Rightarrow V_A = 4$$

$$I_0 = \frac{V_A}{R_1} = \frac{4}{6} = \boxed{\frac{2}{3}\ A}$$

8



$V_o = I_2 \cdot R_2$

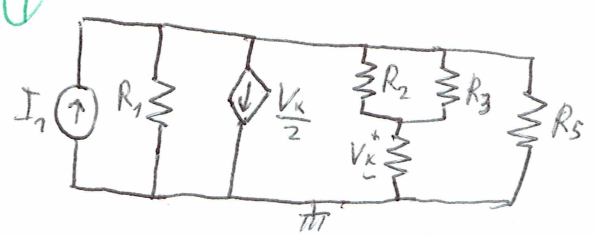
$I_2 = \mu \cdot V_x = \mu \cdot I_1 \cdot R_a$

$R_a \uparrow \Rightarrow I_2 \uparrow \Rightarrow V_o \uparrow$

$\boxed{R_a \to \infty}$

$V_2 = I_2 \cdot R_b + \underbrace{R_2 \cdot I_2}_{V_o} \Rightarrow V_o = V_2 - I_2 \cdot R_b \Rightarrow R_b \downarrow \Rightarrow V_o \uparrow \Rightarrow \boxed{R_b \to 0}$

9

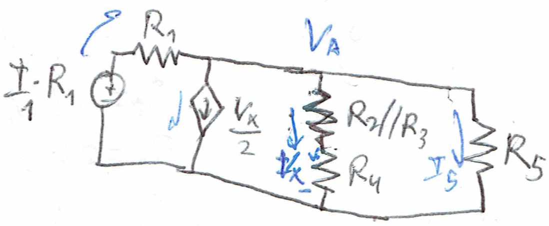


$I_1 = 11\ mA$ $\quad R_4 = 3k\Omega$

$R_1 = 2k\Omega$ $\quad R_5 = 10k\Omega$

$R_2 = 4k\Omega$

$R_3 = 4k\Omega$



$R_2 // R_3 = 2\ k\Omega$ $\qquad I_1 \cdot R_1 = 22\ V$

$\frac{1}{4} + \frac{1}{4} = \frac{2}{4}$

$\frac{22 - V_A}{R_1} = \frac{V_x}{2} + \frac{V_A}{2+3} + \frac{V_A}{10}$ $\qquad I_x = \frac{V_A}{5}$ $\qquad V_x = R_4 \cdot I_x = 3 \cdot \frac{V_A}{5}$

$\frac{22 - V_A}{2} = \frac{3 V_A}{10} + \frac{V_A}{5} + \frac{V_A}{10} \Rightarrow 110 - 5V_A = 3V_A + 2V_A + V_A$

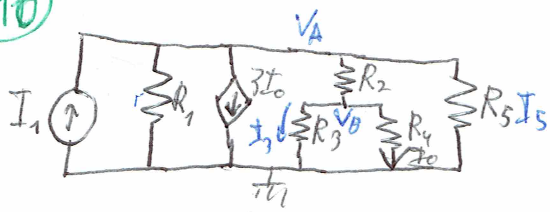
$110 = 11 V_A$

$V_A = 10V$

$I_5 = \frac{V_A}{10} = 1\ V$

$P_5 = I_5^2 \cdot R_5 = 1 \cdot \boxed{10\ mW}$

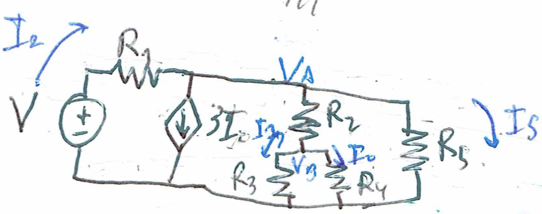
10



$I_1 = 6\ mA$ $\quad R_3 = 6k\Omega$

$R_1 = 6k\Omega$ $\quad R_4 = 3k\Omega$

$R_2 = 4k\Omega$ $\quad R_5 = 12k\Omega$



$V = I_1 \cdot R_1 = 36V$

$I_2 = 3I_0 + I_3 + I_0 + I_5$

$\frac{V_A - V_B}{4} = (I_0 + I_3)$

$\frac{36 - V_A}{6} = 3I_0 + \frac{V_B}{6} + \frac{V_B}{3} + \frac{V_A}{12} \Rightarrow 72 - 6V_B = 12V_B + 2V_B + 4V_B$

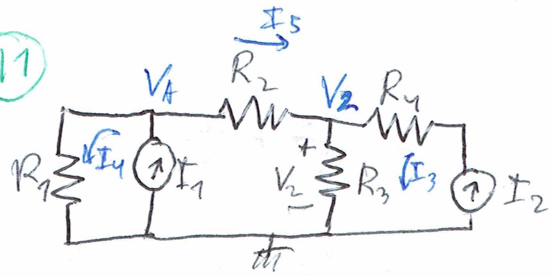
$V_A = V_B + \frac{4}{3}V_B + \frac{4}{6}V_B = 3V_B$

$72 = 27V_B \Rightarrow V_B = \frac{8}{3}\ V$

$V_A = 3V_B = 8V$

$I_5 = \frac{V_A}{12} = \frac{2}{3}$ $\qquad P_{R_5} = \left(\frac{2}{3}\right)^2 \cdot 12 = \boxed{5'33\ mW}$

11



$I_1 = 4mA$ $\quad R_2 = 4k\Omega$

$I_2 = 6\ mA$ $\quad R_3 = 6k\Omega$

$R_1 = 2k\Omega$ $\quad R_4 = 2k\Omega$

$\left.\begin{array}{l} I_1 = I_4 + I_5 \\ I_2 + I_5 = I_3 \end{array}\right\}$ $\left.\begin{array}{l} 4 = \frac{V_A}{2} + \frac{V_A - V_2}{4} \\ 6 + \frac{V_A - V_2}{4} = \frac{V_2}{6} \end{array}\right\}$ $\left.\begin{array}{l} 16 = 2V_A + V_A - V_2 \\ 72 + 3V_A - 3V_2 = 2V_2 \end{array}\right\}$ $\left.\begin{array}{l} 16 = 3V_A - V_2 \\ 72 = 5V_2 - 3V_A \end{array}\right\}$

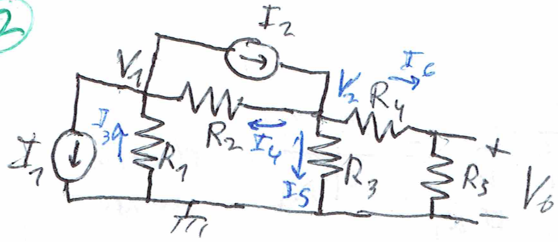
$V_A = \frac{16 + V_2}{3}$

$V_A = \frac{5V_2 - 72}{3}$

$\frac{16 + V_2}{\cancel{3}} = \frac{5V_2 - 72}{\cancel{3}}$

$88 = 4V_2 \Rightarrow \boxed{V_2 = 22\ V}$

12



$I_1 = 4mA$ $\quad R_3 = 12k\Omega$

$I_2 = 2mA$ $\quad R_4 = 2k\Omega$

$R_1 = 3k\Omega$ $\quad R_5 = 2k\Omega$

$R_2 = 6k\Omega$

$\left.\begin{array}{l} I_3 + I_4 = I_1 + I_2 \\ I_2 = I_4 + I_5 + I_6 \end{array}\right\}$ $\left.\begin{array}{l} -\frac{V_1}{3} + \frac{V_2 - V_1}{6} = 4 + 2 \\ 2 = \frac{V_2 - V_1}{6} + \frac{V_2}{12} + \frac{V_2}{2+2} \end{array}\right\}$

$I_6 = \frac{V_2}{R_4 + R_5}$

$I_6 = 0$

$-2V_1 + V_2 - V_1 = 36$

$V_2 - 3V_1 = 36$

$V_2 = 36 + 3V_1$

$24 = 2V_2 - 2V_1 + V_2 + 3V_2$

$24 = 6V_2 - 2V_1$

$6V_2 = 24 + 2V_1 \Rightarrow V_2 = 4 + \frac{1}{3}V_1$

$V_0 = I_6 \cdot R_5 = \boxed{0\ V}$

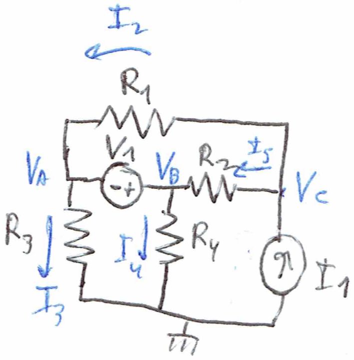
$36 + 3V_1 = 4 + \frac{1}{3}V_1$

$32 = -\frac{8}{3}V_1$

$V_2 = 4 - 4 = 0\ V$

$\boxed{V_1 = -12\ V}$

13



$V_1 = 12\,V$ $\quad R_1 = R_2 = R_3 = R_4 = 6\,k\Omega$

$I_1 = 2\,mA$

$I_1 = I_2 = I_3 + I_4$

$V_B = V_A + 12$

$I_1 = I_5 + I_2$ $\quad V_C = V_B$ $\quad I_5 = 0$

$2 = \frac{V_A}{R_3} + \frac{V_C}{R_4}$

$2 = \frac{V_C - V_B}{6} + \frac{V_C - V_A}{6}$

$I_2 = I_1$

$2 = \frac{V_A}{6} + \frac{V_C}{6}$

$12 = V_C - V_B + V_C - V_A$

$12 = V_A + V_C$

$12 = V_C - (V_A + 12) + V_C - V_A$

$V_C = 12 - V_A$

$24 = V_C - V_A + V_C - V_A$

$12 + V_A = 12 - V_A$

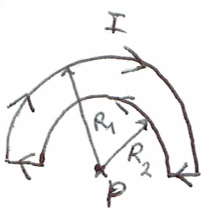
$24 + 2V_A = 2V_C$

$V_A = 0$

$12 + V_A = V_C$

$\boxed{V_C = 12\,V}$

14



1er cable (tramo):

$B_1 = \frac{\mu_0}{4\pi}\frac{I}{R_1^2}\int dl = \frac{\mu_0 I}{4\pi R_1^2} \underset{\pi R_1}{\underset{\shortparallel}{L}} = \frac{\mu_0 I}{4 R_1}$ Hacia dentro

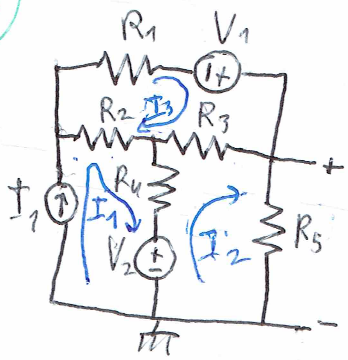
2do tramo:

$B_2 = \frac{\mu_0}{4\pi}\frac{I}{R_2^2}\int dl = \frac{\mu_0 I}{4\pi \cdot R_2^2} \underset{\pi \cdot R_2}{L} = \frac{\mu_0 I}{4 R_2}$ Hacia fuera

$R_2 < R_1 \Rightarrow B_2 > B_1$

$B_T = B_2 - B_1 = \boxed{\frac{\mu_0 I}{4}\left(\frac{1}{R_2} - \frac{1}{R_1}\right)}$ Hacia fuera

15



$V_1 = 6V$

$V_2 = 12V$

$I_1 = 2mA$

$R_1 = R_2 = R_4 = R_5 = 1k\Omega$

$R_3 = 2k\Omega$

$V_o = I_2 \cdot R_5 = I_2$

$$\left.\begin{aligned} V_{x1} &= (I_1 - I_3)R_2 + (I_1 - I_2)R_4 + V_2 \\ V_2 &= (I_2 - I_1)R_4 + (I_2 - I_3)R_3 + I_2 \cdot R_5 \\ V_1 &= (I_3 - I_2)R_3 + (I_3 - I_1)R_2 + I_3 \cdot R_1 \end{aligned}\right\} \begin{aligned} V_{x1} &= 2 - I_3 + 2 - I_2 + 12 \\ 12 &= I_2 - 2 + 2I_2 - 2I_3 + I_2 \\ 6 &= 2I_3 - 2I_2 + I_3 - 2 + I_3 \end{aligned}$$

$$\left.\begin{aligned} 14 &= 4I_2 - 2I_3 \Rightarrow 7 = 2I_2 - I_3 \\ 8 &= 4I_3 - 2I_2 \Rightarrow 4 = 2I_3 - I_2 \end{aligned}\right\} \begin{aligned} &\Rightarrow I_3 = 2I_2 - 7 \\ &\Rightarrow I_3 = 2 + \frac{I_2}{2} \end{aligned}$$

$2I_2 - 7 = 2 + \frac{I_2}{2}$

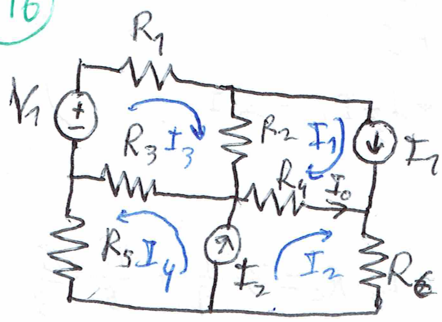
$4I_2 - 14 = 4 + I_2$

$3I_2 = 18$

$I_2 = 6\ mA$

$\boxed{V_o = 6V}$

16



$V_1 = 12V$

$I_1 = 2mA$

$I_2 = 4mA$ Diferente a mi I_2

$R_1 = R_2 = R_3 = R_4 = R_5 = R_6 = 1k\Omega$

$$\left.\begin{aligned} V_1 &= I_3 \cdot R_1 + (I_3 - I_1)R_2 + (I_3 + I_4)R_3 \\ V_{x1} &= (I_1 - I_2)R_4 + (I_1 - I_3)R_2 \\ V_{x2} &= (I_2 - I_1)R_4 + I_2 \cdot R_6 \\ V_{x2} &= (I_3 + I_4)R_3 + I_4 \cdot R_5 \end{aligned}\right\}$$

$I_o = I_2 - I_1 = I_2 - 2$

$I_2 + I_4 = 4$

$I_4 = 4 - I_2$

$$\left.\begin{aligned} 12 &= I_3 + I_3 - 2 + I_3 + 4 - I_2 \\ V_{x1} &= 2 - I_2 + 2 - I_3 \\ V_{x2} &= I_2 - 2 + I_2 \\ V_{x2} &= I_3 + 4 - I_2 + 4 - I_2 \end{aligned}\right\} \begin{aligned} 10 &= 3I_3 - I_2 \Rightarrow I_3 = \frac{10 + I_2}{3} \\ 4 &= V_{x1} + I_2 + I_3 \\ 2 &= 2I_2 - V_{x2} \\ + \quad 8 &= V_{x2} - I_3 + 2I_2 \\ \hline 10 &= 4I_2 - I_3 \Rightarrow 10 = 4I_2 - \frac{10}{3} - \frac{I_2}{3} \end{aligned}$$

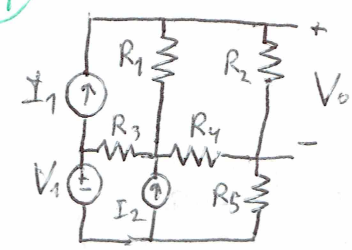
$30 = 12 I_2 - 10 - I_2$

$40 = 11 I_2$

$I_2 = 3'64 \text{ mA}$

$I_0 = I_2 - I_1 = 3'64 - 2 = \boxed{1'64 \text{ mA}}$

17



$V_1 = 6V$

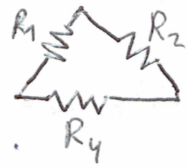
$I_1 = 3mA$

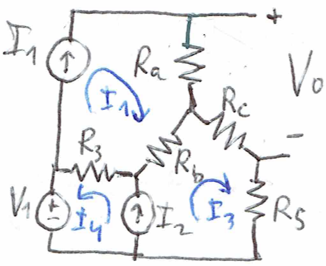
$I_2 = 1mA$

$R_1 = R_5 = 2k\Omega$

$R_2 = R_3 = 4k\Omega$

$R_4 = 12 k\Omega$

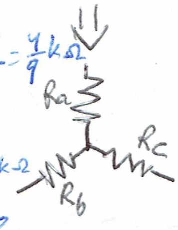




$R_a = \frac{R_2 \cdot R_1}{R_1 + R_2 + R_4} = \frac{8}{18} = \frac{4}{9} k\Omega$

$R_b = \frac{R_1 \cdot R_4}{18} = \frac{24}{18} = \frac{4}{3} k\Omega$

$R_c = \frac{R_2 \cdot R_4}{18} = \frac{48}{18} = \frac{8}{3} k\Omega$



$I_3 + I_4 = I_2$

$I_3 = 1 - I_4 \Rightarrow I_4 = 1 - I_3$

$$\left.\begin{array}{l} V_{x1} = I_1 R_a + (I_1 - I_3) R_b + (I_1 + I_4) R_3 \\ V_{x2} = (I_1 + I_4) R_3 + V_1 \\ V_{x2} = (I_3 - I_1) R_b + I_3 \cdot R_c + I_3 \cdot R_5 \end{array}\right\} \left.\begin{array}{l} V_{x1} = 3 \cdot \frac{4}{9} + 3 \cdot \frac{4}{3} - \frac{4}{3} I_3 + 4 \cdot 3 + 4 - 4 I_3 \\ V_{x2} = 12 + 4 - 4 I_3 + 6 \\ V_{x2} = \frac{4}{3} I_3 - 3 \cdot \frac{4}{3} + \frac{8}{3} I_3 + 2 I_3 \end{array}\right\}$$

$V_{x2} = 22 - 4 I_3 \Rightarrow -V_{x2} = -22 + 4 I_3$

$V_{x2} = 6 I_3 - 4$

+

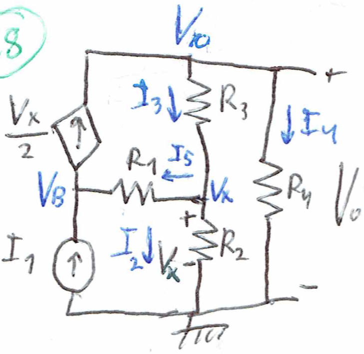
$0 = -26 + 10 I_3$

$I_3 = \frac{26}{10} = \frac{13}{5} \text{ mA}$

$V_0 = I_1 \cdot R_a + I_3 \cdot R_c = 3 \cdot \frac{4}{9} + \frac{13}{5} \cdot \frac{8}{3}$

$\boxed{V_0 = 8'27 V}$

18



$I_1 = 2mA$

$R_1 = 4k\Omega$

$R_2 = R_4 = 6k\Omega$

$R_3 = 2k\Omega$

$V_x = I_2 \cdot R_2$

$$\left.\begin{array}{l} I_1 + I_5 = \frac{V_x}{2} = \frac{I_2 \cdot R_2}{2} \\ I_3 = I_5 + I_2 \\ \frac{I_2 \cdot R_2}{2} = I_3 + I_4 \end{array}\right\}$$

$$\left.\begin{array}{l} 2 + \frac{V_x - V_B}{4} = \frac{V_x}{2} \\ \frac{V_0 - V_x}{2} = \frac{V_x - V_B}{4} + \frac{V_x}{6} \\ \frac{V_x}{2} = \frac{V_0 - V_x}{2} + \frac{V_0}{6} \end{array}\right\} \begin{array}{l} \Rightarrow 8 + V_x - V_B = 2 V_x \\ \Rightarrow 6 V_0 - 6 V_x = 3 V_x - 3 V_B + 2 V_x \\ \Rightarrow 3 V_x = 3 V_0 - 3 V_x + V_0 \end{array} \left\{\begin{array}{l} V_B = 8 - V_x \\ \Rightarrow 6 V_0 + 3 V_B = 11 V_x \\ 6 V_x = 4 V_0 \Rightarrow V_0 = \frac{3}{2} V_x \end{array}\right\}$$

$6\cdot\frac{3}{2}V_x + 3(8-V_x) = 11V_x$

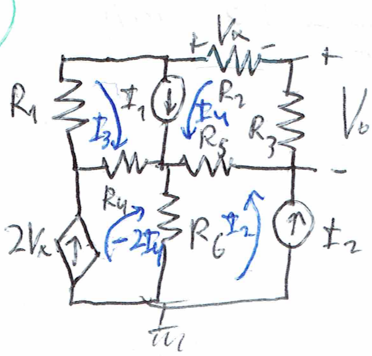
$9V_x + 24 - 3V_x = 11V_x$

$24 = (11-9+3)V_x$

$V_x = \frac{24}{5}$

$V_o = \frac{3}{2}V_x = \frac{3}{2}\cdot\frac{24}{5} = \boxed{\frac{36}{5}\ V}$

19



$I_1 = 1mA$

$I_2 = 0'5mA$

$R_1 = R_6 = 2k\Omega$

$R_2 = R_3 = R_4 = R_5 = 1k\Omega$

$V_x = -I_4\cdot R_2 = -I_4$

$I_3 + I_4 = 1 \Rightarrow I_3 = 1 - I_4$

$V_o = -I_4$

$V_{x1} = I_3 + 2I_4 + 2I_3$

$V_{x1} = I_4 - I_2 + I_4 + I_4$

$V_{xx} = -2I_4 - I_3 - 4I_4 + 2I_2$

$V_{x2} = I_2 - I_4 + 2I_2 - 4I_4$

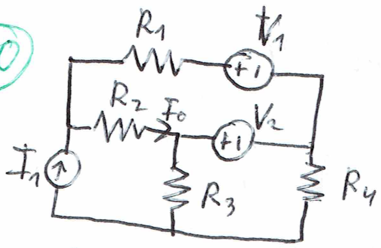
$V_{x1} = 3 - 3I_4 + 2I_4$

$-V_{x1} = 3I_4 - 0'5$

$0 = 3'5 - 4I_4 \Rightarrow I_4 = \frac{3'5}{4} = \frac{7}{8}$

$\boxed{V_o = -I_4 = -\frac{7}{8}}$

20

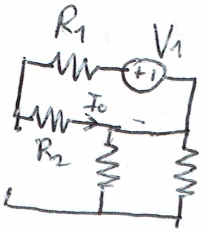


$V_1 = 12V$

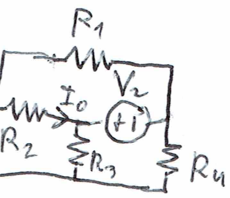
$V_2 = 6V$

$I_1 = 2mA$

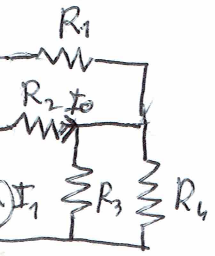
$R_1 = R_2 = R_3 = R_4 = 2k\Omega$

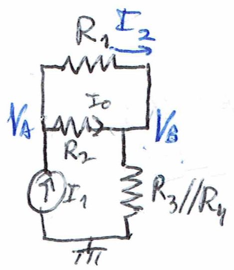


$V_1 = I_{o1}(R_1+R_2) \Rightarrow 12 = I_{o1}(4) \Rightarrow I_{o1} = 3\ mA$



$V_2 = (R_1+R_2)(-I_{o2}) \Rightarrow 6 = 4(-I_{o2}) \Rightarrow I_{o2} = -\frac{3}{2}\ mA$





$R_3//R_4 = 1k\Omega$

$I_1 = I_2 + I_{o2}$

$2 = \frac{V_A - V_B}{2} + \frac{V_A - V_B}{2}$

$2 = \frac{V_A - 2}{2} + \frac{V_A - 2}{2}$

$2 = V_A - 2 \Rightarrow V_A = 4$

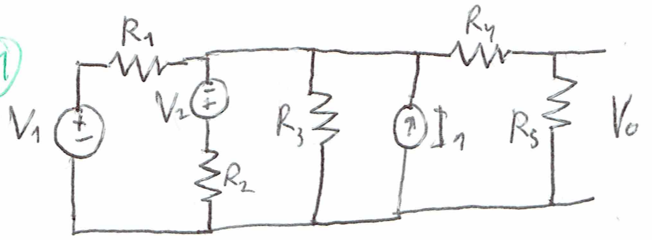
$V_B = I_1\cdot R_3//R_4 = I_1 = 2$

$I_{o2} = 1mA$

$I_o = I_{o1} + I_{o2} + I_{o3} = 3 - \frac{3}{2} + 1$

$\boxed{I_o = 2'5\ mA}$

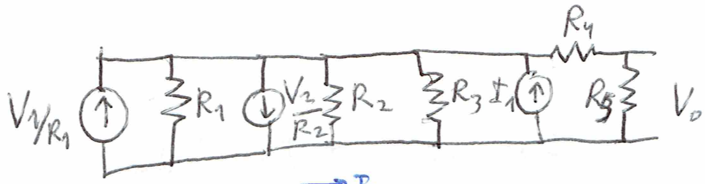
21



$I_1 = 2\,mA$ $\quad R_1 = 3\,k\Omega$

$V_1 = 6\,V$ $\quad R_2 = R_3 = 2\,k\Omega$

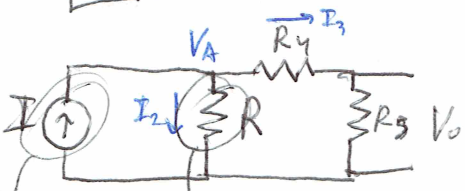
$V_2 = 5\,V$ $\quad R_4 = R_5 = 1\,k\Omega$



$$I = \frac{6}{3} + 2 - \frac{5}{2} = 1'5 \quad mA$$

$$\frac{1}{R} = \frac{1}{3} + \frac{1}{2} + \frac{1}{2} = \frac{4}{3}$$

$$R = \frac{3}{4}\,k\Omega$$



$\frac{V_1}{R_1} + I_1 - \frac{V_2}{R_2}$ $\quad R_1 // R_2 // R_3$

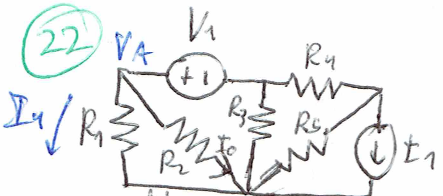
$$I = I_2 + I_3$$

$$V_0 = I_3 \cdot R_5 = I_3$$

$$1'5 = \frac{V_A}{3/4} + \frac{V_A}{2}$$

$$V_0 = I_3 = \frac{V_A}{2} = \frac{9}{22} = \boxed{0'41\,V} \qquad 1'5 = \frac{4}{3} V_A + \frac{V_A}{2} \Rightarrow 1'5 = \frac{11}{6} V_A \Rightarrow V_A = \frac{9}{11}$$

22



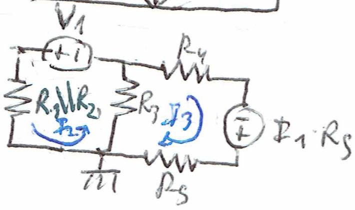
$V_1 = 12\,V$ $\quad R_1 = R_3 = 12\,k\Omega$

$I_1 = 2\,mA$ $\quad R_2 = 6\,k\Omega$

$R_4 = R_5 = 3\,k\Omega$

$$R_1 // R_2 = 4$$

$$\frac{1}{6} + \frac{1}{12} = \frac{3}{12} = \frac{1}{4}$$



$$V_1 = 4 \cdot I_2 + 12(I_2 + I_3)$$

$$I_1 R_5 = I_3 \cdot 3 + 12(I_2 + I_3) + 3 \cdot I_3$$

$$\left.\begin{aligned} 12 &= 4 I_2 + 12 I_2 + 12 I_3 \\ 6 &= 3 I_3 + 12 I_2 + 12 I_3 + 3 I_3 \end{aligned}\right\}$$

$$12 = 16 I_2 + 12 I_3 \Rightarrow 6 = 8 I_2 + 6 I_3 \Rightarrow 3 = 4 I_2 + 3 I_3$$

$$6 = 12 I_2 + 18 I_3 \Rightarrow 1 = 2 I_2 + 3 I_3$$

$$2 = 2 I_2 \Rightarrow I_2 = 1$$

$$I_4 + I_0 = 1$$

$$I_0 = \frac{V_A}{R_2} = \frac{4}{6} = \frac{2}{3} = \boxed{0'67\,mA}$$

$$\frac{V_A}{R_1} + \frac{V_A}{R_2} = 1 \Rightarrow \frac{V_A}{12} + \frac{V_A}{6} = 1 \Rightarrow V_A + 2 V_A = 12 \Rightarrow V_A = 4$$

23 $C = 25\mu F$ $V_{inicial} = -10V$ $t = 150\,s$

$I = 2'5\mu A$

$Q_{inicial} = V_{inicial} \cdot C = -10 \cdot 25 = -250\,\mu C$

$Q = I \cdot t \Rightarrow Q = 2'5 \cdot 150 = 375\,\mu C$

$Q_{final} = Q_{inicial} + Q = -250 + 375 = 125\,\mu C$

$V_{final} = \frac{Q_{final}}{C} = \frac{125}{25} = \boxed{5\,V}$

24 $E(t) = 12 \cdot sen^2 377t$ J

$i(t)$?

$E = \int V \cdot dq = \int \frac{Q}{C} dq = \frac{Q^2}{2C} = \frac{V^2 \cdot C^{\cancel{2}}}{2\cancel{C}} = \frac{C}{2} V^2$

$E = \frac{C}{2} V^2$ $V = \frac{Q}{C}$

$E = \frac{C}{2} \frac{Q^2}{C^2} = \frac{Q^2}{2C}$

$Q = |Q| \cdot sen\, 377t$

$\frac{|Q|^2}{2C} = 12 \Rightarrow |Q|^2 = 12 \cdot 50 = 6 \cdot 10^{-4}\,C$

$|Q| = 0'0245\,C$

$Q = 0'0245\, sen\, 377t$ C

$i(t) = \frac{dQ(t)}{dt} = 0'0245 \cdot 377 \cdot \cos 377t = \boxed{9'2365 \cdot \cos(377t) \quad (A)}$

25 $C = 10\mu F$

$i(t) = 10\cos(377t)$ (mA) $= 10^{-2} \cos(377t)$ (A)

a) V? $V(t) = \frac{Q(t)}{C} = \frac{26'53 \cdot 10^{\cancel{-6}} \cdot sen(377t)}{10 \cdot \cancel{10^{-6}}} = \boxed{2'65 \cdot sen(377t) \quad V}$

$i(t) = \frac{dQ(t)}{dt} = 10^{-2} \cos(377t)$

$Q(t) = \int 10^{-2} \cos(377t) dt = 10^{-2} \frac{sen(377t)}{377} = 26'53 \cdot 10^{-6} sen(377t)$

26 $L = 50\ mH$

$$i(t) = \begin{cases} 0 & t<0 \\ 2te^{-4t} & t \geq 0 \end{cases} \quad (A)$$

a) V?

$$V(t) = L \cdot \frac{di(t)}{dt} = 50 \cdot 10^{-3} \cdot (2-8t) \cdot e^{-4t} = (0'1 - 0'4t) \cdot e^{-4t}\ V$$

$$\frac{d(2te^{-4t})}{dt} = 2e^{-4t} + 2t \cdot (-4) \cdot e^{-4t} = e^{-4t}(2-8t)$$

$$V(t) = \begin{cases} 0 & t<0 \\ (0'1 - 0'4t) \cdot e^{-4t} & t \geq 0 \end{cases}$$

b) i_{max}

$$e^{-4t}(2-8t) = 0 \Rightarrow 2 = 8t \Rightarrow \boxed{t = \frac{1}{4}\ s}$$

0, 0'25	0'25 →
+	−
↗	↘

c) $V_{min.}$

$$V(t) = 0'1\, e^{-4t} - 0'4\, te^{-4t}$$

$$\frac{dV(t)}{dt} = 0'1 \cdot (-4) \cdot e^{-4t} - 0'4\left(e^{-4t} + t \cdot (-4) \cdot e^{-4t}\right) = -0'4 \cdot e^{-4t} - 0'4\, e^{-4t} + 1'6t \cdot e^{-4t} =$$

$$= (1'6t - 0'8) \cdot e^{-4t}$$

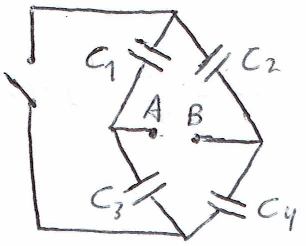
$$(1'6t - 0'8)\, e^{-4t} = 0$$

0, 0'5	0'5 →
−	+
↘	↗

$$1'6t = 0'8$$

$$\boxed{t = 0'5\ s}$$

27



$C_1 = 3 \mu F$

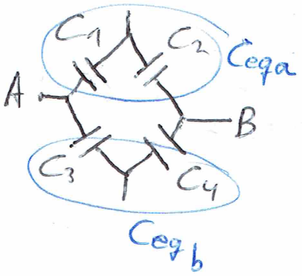
$C_2 = 6 \mu F$

$C_3 = 6 \mu F$

$C_4 = 12 \mu F$

Ceq. AB

a) Abierto.



$C_{eq_a}\ C_1, C_2 = 2$

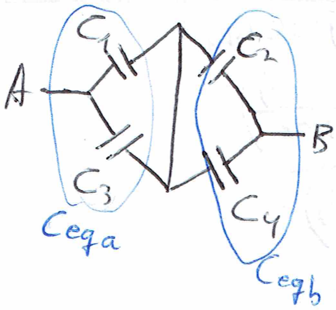
$$\frac{1}{3} + \frac{1}{6} = \frac{3}{6}$$

$C_T = C_{eq_a} // C_{eq_b} = 2 + 4 = \boxed{6 \mu F}$

$C_{eq_b}\ C_3, C_4 = 4$

$$\frac{1}{6} + \frac{1}{12} = \frac{3}{12}$$

b) Cerrado.



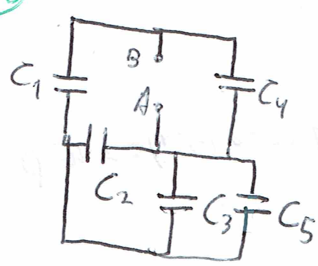
$C_{eq\,a} = C_1 + C_3 = 9 \mu F$

$C_{eq\,b} = C_2 + C_4 = 18 \mu F$

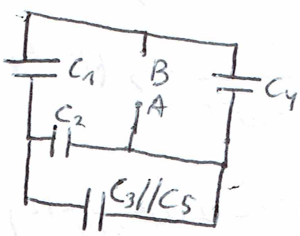
$$\frac{1}{9} + \frac{1}{18} = \frac{3}{18}$$

$C_T = \boxed{C_{eq} = 6 \mu F}$

28



$\Rightarrow$



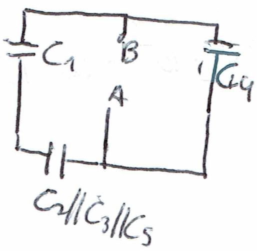
$C_1 = 4 \mu F$

$C_2 = 1 \mu F$

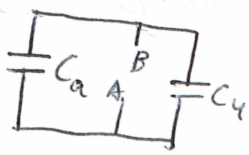
$C_3 = 8 \mu F$

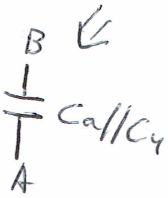
$C_4 = 6 \mu F$

$C_5 = 3 \mu F$



$\Rightarrow$





$C_3 // C_5 = 8 + 3 = 11 \mu F$

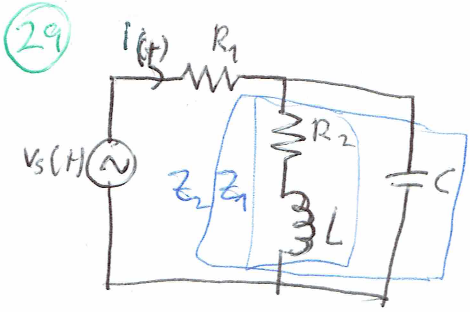
$C_2 // C_3 // C_5 = 1 + 11 = 12 \mu F$

$C_a = 3 \mu F$

$$\frac{1}{12} + \frac{1}{4} = \frac{4}{12}$$

$\boxed{C_T = C_a // C_4 = 3 + 6 = 9 \mu F}$

29



$R_1 = 1\Omega$

$R_2 = 2\,\Omega$

$L = 10\,mH = 10^{-2}\,H$

$C = 10\,\mu F = 10^{-5}\,F$

$V_s(t) = 120\cos(377t + \frac{\pi}{2})\,V$; $V_s = 120 \cdot e^{j\pi/2}$

$Z_L = j\omega L$

$Z_C = \frac{1}{j\omega C}$

$\omega = \frac{2\pi}{T} = 2\pi \cdot f$

$Z_1 = Z_{R_2} + Z_L = R_2 + j\omega L$

$Z_2 = Z_1 // Z_C$

$Z_{eq} = Z_{R_1} + Z_2$

$Z_{eq} = R_1 + \frac{R_2 + j\omega L}{1 - \omega^2 CL + j\omega C R_2}$

$\frac{1}{Z_2} = \frac{1}{R_2 + j\omega L} + \frac{1}{\frac{1}{j\omega C}} = \frac{1}{R_2 + j\omega L} + j\omega C$

$\frac{1}{Z_2} = \frac{j\omega C(R_2 + j\omega L) + 1}{R_2 + j\omega L}$

$Z_2 = \frac{R_2 + j\omega L}{1 - \omega^2 CL + j\omega C R_2}$

$$Z_{eq} = \frac{R_2 + j\omega L + R_1(1 - \omega^2 CL + j\omega C R_2)}{1 - \omega^2 CL + j\omega C R_2} = \frac{2 + j\omega \cdot 10^{-2} + 1 - \omega^2 \cdot 10^{-5} \cdot 10^{-2} + j\omega\, 10^{-5} \cdot 2}{1 - \omega^2 10^{-7} + j\omega\, 2 \cdot 10^{-5}}$$

$$Z_{eq} = \frac{3 + j\omega(10^{-2} + 2 \cdot 10^{-5}) - \omega^2 10^{-7}}{1 - \omega^2 10^{-7} + j\omega\, 2 \cdot 10^{-5}} = \frac{|\;|\, e^{j\,\mathrm{arctg}\left(\frac{\omega(10^{-2} + 2 \cdot 10^{-5})}{3 - \omega^2 \cdot 10^{-7}}\right)}}{|\;|\, e^{j\,\mathrm{arctg}\left(\frac{2 \cdot 10^{-5} \omega}{1 - \omega^2 \cdot 10^{-7}}\right)}}$$

$$\mathrm{arctg}\left(\frac{\omega(10^{-2} + 2 \cdot 10^{-5})}{3 - \omega^2 10^{-7}}\right) - \mathrm{arctg}\left(\frac{2 \cdot 10^{-5} \cdot \omega}{1 - \omega^2 \cdot 10^{-7}}\right) = 0$$

$$\frac{\cancel{\omega}(10^{-2} + 2 \cdot 10^{-5})}{3 - \omega^2 \cdot 10^{-7}} = \frac{2 \cdot 10^{-5} \cdot \cancel{\omega}}{1 - \omega^2 \cdot 10^{-7}} \Rightarrow (10^{-2} + 2 \cdot 10^{-5})(1 - \omega^2 \cdot 10^{-7}) = 2 \cdot 10^{-5}(3 - \omega^2 \cdot 10^{-7})$$

$10^{-2} + 2 \cdot 10^{-5} - \omega^2 10^{-9} - 2\omega^2 \cdot 10^{-12} = 6 \cdot 10^{-5} - 2\omega^2 \cdot 10^{-12}$

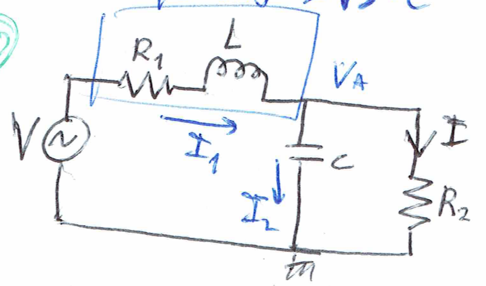
$1 + 2 \cdot 10^{-3} - \omega^2 \cdot 10^{-7} - \cancel{2\omega^2 \cdot 10^{-10}} = 6 \cdot 10^{-3} - \cancel{2\omega^2 \cdot 10^{-10}} \Rightarrow 1 + 2 \cdot 10^{-3} - 6 \cdot 10^{-3} = \omega^2 10^{-7}$

$\omega = \sqrt{\frac{1 - 4 \cdot 10^{-3}}{10^{-7}}} = 3155'95$

$$\boxed{f = \frac{\omega}{2\pi} = 502'3\ Hz}$$

$Z_1 = 2+j = \sqrt{5} \cdot e^{j0'464}\,\Omega$

(30)



$V = 20 \cdot e^{j\pi/3}\ V = 20\left(\frac{1}{2} + j\frac{\sqrt{3}}{2}\right)$ $\qquad 60^\circ = \frac{\pi}{3}$ rad

$R_1 = 2\,\Omega$

$R_2 = 1\,\Omega$

$Z_L = 1j\,\Omega$

$Z_C = -2j\,\Omega$

$I_1 = I_2 + I$

$$\frac{V - V_A}{Z_1} = \frac{V_A}{Z_C} + \frac{V_A}{Z_{R_2}}$$

$$\frac{10 + 10\sqrt{3}j - V_A}{2+j} = \frac{V_A}{-2j} + V_A \qquad (2+j)(-2j) = -4j + 2$$

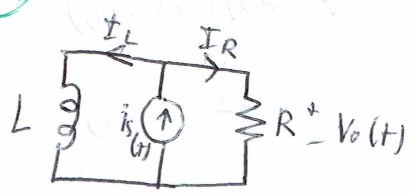
$$-2j\left[(10 + 10\sqrt{3}j) - V_A\right] = (2+j)V_A + (2-4j)V_A$$

$$2jV_A - 20j + 20\sqrt{3} = (4-3j)V_A \Rightarrow 20\sqrt{3} - 20j = (4-5j)V_A$$

$$V_A = \frac{20\sqrt{3} - 20j}{4-5j} = \frac{40 \cdot e^{-j\pi/6}}{6'403 e^{-j0'896}} = 6'247\, e^{j0'3724}$$

$$\boxed{I = V_A = 6'247 \cdot e^{j0'3724}\ A}$$

(31)



$i_s(t) = 100 \cdot \cos(5000t + 0'142)\ mA = 0'1 \cdot \cos(5000t + 0'142)\ A$

$L = 8\ mH$

$R = 30\,\Omega \qquad Z_L = j\omega L$

$I = 0'1 \cdot e^{j0'142}$

$$\frac{1}{Z_{eq}} = \frac{1}{Z_L} + \frac{1}{Z_R} = \frac{1}{j\omega L} + \frac{1}{R} = \frac{R + j\omega L}{j\omega L R}$$

$$Z_{eq} = \frac{j\omega L R}{j\omega L + R} = \frac{j5000 \cdot 8 \cdot 10^{-3} \cdot 30}{j5000 \cdot 8 \cdot 10^{-3} + 30} = \frac{1200\, e^{j\pi/2}}{50 \cdot e^{j0'9273}} = 24 \cdot e^{j0'6435}$$

$$V_o = I \cdot Z_{eq} = 0'1 \cdot e^{j0'142} \cdot 24 \cdot e^{j0'6435} = 2'4 \cdot e^{j0'786}$$

$$\boxed{V_o(t) = 2'4 \cdot \cos(5000t + 0'786)\ V}$$

$I_R = \frac{V_0}{Z_R} = \frac{2'4 \cdot e^{j0'786}}{30} = 0'08 \cdot e^{j0'786}$

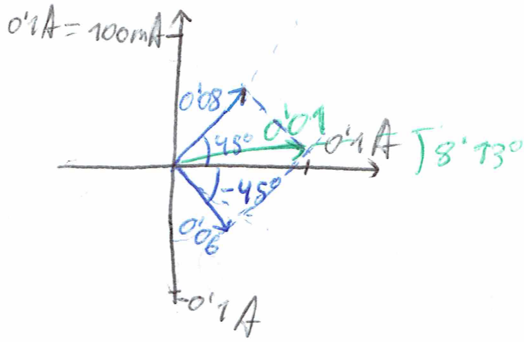
$I_L = \frac{V_0}{Z_L} = \frac{2'4 \cdot e^{j0'786}}{5000 \cdot 8 \cdot 10^{-3} \cdot e^{j\pi/2}} = 0'06\, e^{-j\pi/2}$

$\sqrt{0'08^2 + 0'06^2} = 0'01$

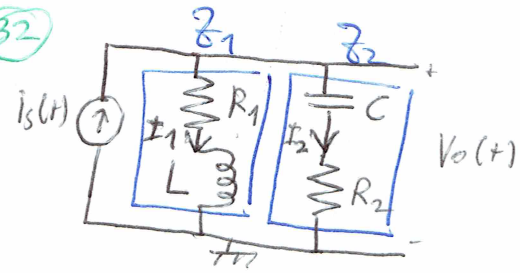
$I: \; 0'1, \; 8'14^\circ$

$I_R: \; 0'08, \; 45^\circ$

$I_L: \; 0'06, \; -45^\circ$



32



$i_s(t) = 0'3 \cos(10^4 t - \frac{3}{4}\pi)\, A$

$R_1 = 20\,\Omega$

$R_2 = 10\,\Omega$

$L = 6\,mH$

$C = 3'33\,\mu F$

$I_s = 0'3 \cdot e^{-j\frac{3}{4}\pi} = 0'3(0'732 - j0'682)$

$Z_1 = R_1 + j\omega L \Rightarrow 20 + j \cdot 10^4 \cdot 6 \cdot 10^{-3} = 63'25 \cdot e^{j1'25}$

$Z_2 = R_2 + \frac{1}{j\omega C} \Rightarrow 10 + \frac{1}{j \cdot 10^4 \cdot 3'33 \cdot 10^{-6}} = \frac{1 + 10(j \cdot 3'33 \cdot 10^{-2})}{j3'33 \cdot 10^{-2}} = \frac{1'054 \cdot e^{j0'321}}{3'33 \cdot 10^{-2} \cdot e^{j\pi/2}} = 31'65 \cdot e^{-j1'25}$

$I_s = I_1 + I_2$

$0'2196 - 0'2046j = \frac{V_0}{Z_1} + \frac{V_0}{Z_2} = \frac{V_0}{20+60j} + \frac{V_0 \cdot j3'33 \cdot 10^{-2}}{1 + 3'33 \cdot 10^{-1} j}$

$(20+60j)(1+0'333j) = 0'02 + 66'66j$

$(0'02 + 66'66j)(0'2196 - 0'2046j) = V_0(1 + 0'333j) + V_0 \cdot j3'33 \cdot 10^{-2}(20+60j)$

$13'643 - 14'634j = V_0[1 + 0'333j + 0'666j - 1'998]$

$V_0 = \frac{13'643 - 14'634j}{-0'998 + 0'999j} = \frac{20 \cdot e^{-j0'82}}{1'412 \cdot e^{j2'356}} = 14'164 \cdot e^{-j3'176} \simeq 14'164\, e^{-j\pi} = 14'164 \cdot e^{j\pi}$

$\boxed{V_0(t) = 14'164 \cdot \cos(10^4 t + \pi)\, V}$

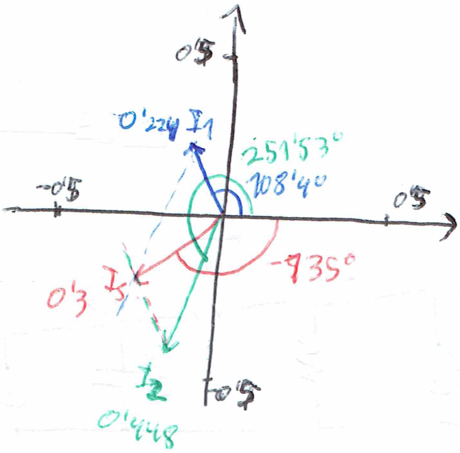
$$I_1 = \frac{V_0}{Z_1} = \frac{14'164 \cdot e^{j\pi}}{63'25 \cdot e^{j1'25}} = 0'224 \cdot e^{j1'892}$$

$$I_2 = \frac{V_0}{Z_2} = \frac{14'164 \cdot e^{j\pi}}{31'65 \cdot e^{-j1'25}} = 0'448 \cdot e^{j4'39}$$

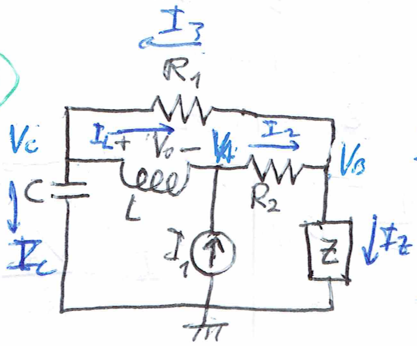
I_s: $0'3, -135^\circ$

I_1: $0'224, 108'4^\circ$

I_2: $0'448, 251'53^\circ$



33



$I_1 = 6 \cdot e^{j0}$ A

$R_1 = 1\,\Omega$

$R_2 = 1\,\Omega$

$Z_L = 1j\,\Omega$

$Z_C = -1j\,\Omega$

$$V_0 = 2e^{j\pi/4} = \sqrt{2} + \sqrt{2}j$$

$$I_L = \frac{V_0}{Z_L} = \frac{2e^{j\pi/4}}{e^{j\pi/2}} = 2e^{-j\pi/4} = 2\left(\frac{\sqrt{2}}{2} + j\frac{\sqrt{2}}{2}\right)$$

$$I_1 + I_L = \boxed{I_2 = 6 + \sqrt{2} - j\sqrt{2} = 7'414 - \sqrt{2}j}$$

$$\left.\begin{aligned} I_1 &= I_c + I_z \\ I_2 &= I_3 + I_z \\ I_3 &= I_L + I_c \end{aligned}\right\} \left.\begin{aligned} 6 &= I_c + I_z \\ 7'414 - \sqrt{2}j &= I_3 + I_z \\ I_3 &= I_c + \sqrt{2} - \sqrt{2}j \end{aligned}\right\} \Rightarrow I_3 = 7'414 - \sqrt{2}j - I_z$$

$I_c = -I_z + 6$,

Necesito otra ecuación

$$I_c + \sqrt{2} - \cancel{\sqrt{2}j} = 7'414 - \cancel{\sqrt{2}j} - I_z$$

$$I_c = 6 - I_z \Rightarrow I_c = 6 - 16'24 + \sqrt{2}j = -10'24 + \sqrt{2}j$$

*

$$I_c = \frac{V_c}{Z_c}$$

$$V_c - V_0 = V_A \Rightarrow V_c - V_0 = V_B + 7'414 + \sqrt{2}j$$

$$V_A - I_2 \cdot R_2 = V_B \Rightarrow V_A = V_B + I_2 R_2$$

$$V_B - V_c = I_3$$

$$V_B + I_2 = V_c - V_0 \Rightarrow V_B - V_c = -I_2 - V_0$$

$$\boxed{I_3 = -I_2 - V_0}$$

$$V_B - I_3 \cdot R_1 = V_c$$

$$I_3 = -7'414 + \cancel{\sqrt{2}j} - \sqrt{2} - \cancel{\sqrt{2}j} = -8'83$$

$$I_2 = I_3 + I_z \Rightarrow 7'414 - \sqrt{2}j = -8'83 + I_z \Rightarrow \boxed{I_z = 16'24 - \sqrt{2}j}$$

$\frac{V_B}{Z} = I_Z$

$\frac{V_c}{-j} = I_c = -10'24 + \sqrt{2}j$

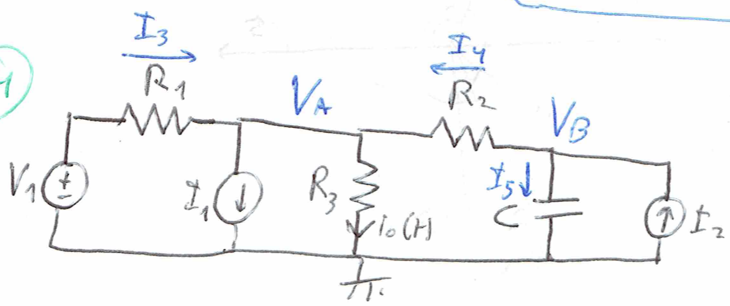
$V_c = 10'24j + \sqrt{2}$

$V_B = I_3 + V_c = 10'24j + \sqrt{2} - 8'83$

$V_B = -7'416 + 10'24j$

$$\boxed{Z = \frac{12'64 \cdot e^{j2'2}}{16'3 \cdot e^{-j0'09}} = 0'775 \cdot e^{j2'29}\ \Omega}$$

34



$V_1 = 12\ V$ $\quad R_1 = R_3 = 2\ \Omega$

$I_1 = 2\ A$ $\quad R_2 = 1\ \Omega$

$I_2 = 4A$ $\quad Z_c = -1j\ \Omega$

$$\left.\begin{array}{l} I_3 + I_4 = I_1 + I_0 \\ I_2 = I_4 + I_5 \end{array}\right\} \left.\begin{array}{l} I_3 + I_4 = 2 + I_0 \\ 4 = I_4 + I_5 \end{array}\right\}$$

$I_0 = \frac{V_A}{R_3}$

$\frac{12 - V_A}{2} + \frac{V_B - V_A}{1} = 2 + \frac{V_A}{2} \Rightarrow 12 - V_A + 2V_B - 2V_A = V_A + 4 \Rightarrow V_B = \frac{4 \cdot V_A - 8}{2}$

$4 = \frac{V_B - V_A}{1} + \frac{V_B \cdot j}{-j \cdot j}$

$4 = V_B - V_A + jV_B \Rightarrow V_B(1+j) = 4 + V_A$

$\frac{4V_A - 8}{2} = \frac{4 + V_A}{1+j}$

$(4V_A - 8)(1+j) = 8 + 2V_A$

$2V_A + 4V_A j - 8 - 8j = 8$

$V_A(2 + 4j) = 16 + 8j$

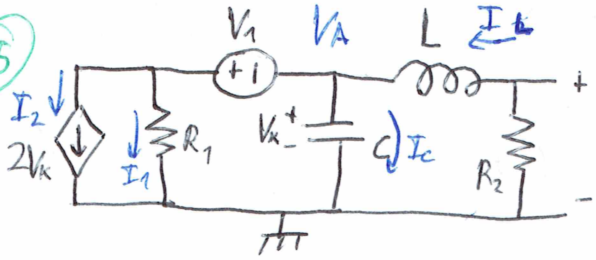
$V_A = \frac{16 + 8j}{2 + 4j} = \frac{17'89 \cdot e^{j0'464}}{\sqrt{20} \cdot e^{j1'11}}$

$V_A = 4 \cdot e^{-j0'646}$

$I_0 = \frac{4 \cdot e^{-j0'646}}{2} = \boxed{2 \cdot e^{-j0'646}}\ A$

$$\boxed{i_0(t) = 2\cos(\omega t - 0'644)\ A}$$

35



$V_1 = 6\ V$ $\quad Z_C = -j\ \Omega$

$R_1 = 2\ \Omega$ $\quad Z_L = 2j\ \Omega$

$R_2 = 1\ \Omega$

$I_L = I_2 + I_1 + I_C$ $\qquad V_x = V_A$

$$\frac{-V_A}{1+2j} = \frac{V_A+6}{2} + \frac{V_A\,j}{\cancel{-j}\,j} + 2V_A$$

$V_0 = -I_L \cdot R_2$

$$\frac{-V_A}{\frac{1}{2}+j} = V_A + 6 + 2V_Aj + 4V_A = 5V_A + 2V_Aj + 6$$

$$-V_A = \left(\tfrac{1}{2}+j\right)(5V_A + 2V_Aj + 6) = \tfrac{5}{2}V_A + V_Aj + 3 + 5jV_A - 2V_A + 6j$$

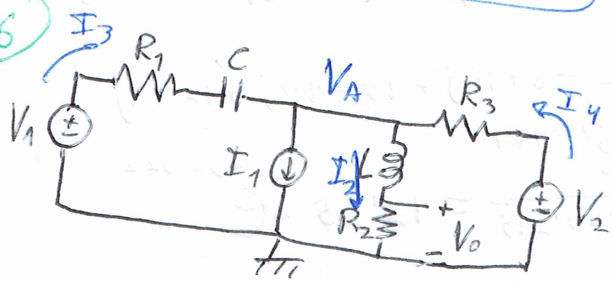
$$-\tfrac{3}{2}V_A - 7V_Aj = 3 + 6j$$

$$V_A = \frac{3+6j}{-\frac{3}{2}-7j} = \frac{6+12j}{-3-14j} = \frac{13'42 \cdot e^{j1'11}}{14'32 \cdot e^{j1'36}} = 0'94 \cdot e^{-j0'25}$$

$$I_L = \frac{-V_A}{1+2j} = \frac{0'94 \cdot e^{-j0'25}}{\sqrt{5} \cdot e^{j1'11}} = 0'42 \cdot e^{j\,1'36}$$

$$\boxed{V_0 = -I_L = -0'42 \cdot e^{-j1'36}}$$

36



$V_1 = 12\ V$ $\quad Z_C = -j\ \Omega$

$V_2 = 4\ V$ $\quad Z_L = 2j\ \Omega$

$R_1 = R_2 = 2\ \Omega$ $\quad I_1 = 2\ A$

$R_3 = 1\ \Omega$

$I_3 + I_4 = I_1 + I_2$

$$\frac{12-V_A}{2-j} + \frac{4-V_A}{1} = 2 + \frac{V_A}{2+2j}$$

$(2-j)(2+2j) = 6+2j$

$$I_2 = \frac{V_A}{2+2j} = \frac{4'37\,e^{j0'3}}{2'83 \cdot e^{j0'}}$$

$I_2 = 1'54 \cdot e^{-j0'42}$

$$(12-V_A)(2+2j) + (2-V_A)(6+2j) = V_A\,(2-j)$$

$$24 - 2V_A + 24j - 2V_Aj + 12 + 4j - 6V_A - 2V_Aj = 2V_A - \cancel{V_A}j$$

$V_0 = I_2 \cdot R_2$

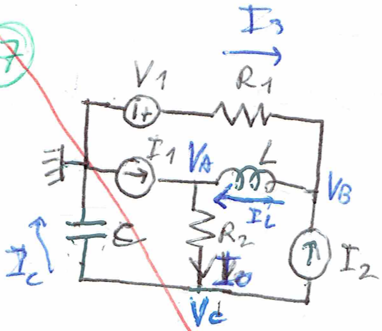
$$36 + 28j = 10V_A + 3V_Aj$$

$V_0 = 2 \cdot 1'54 \cdot e^{-j0'42}$

$$V_A = \frac{36+28j}{10+3j} = \frac{45'61 \cdot e^{j0'66}}{10'44 \cdot e^{j0'29}} = 4'37 \cdot e^{j0'37}$$

$$\boxed{V_0 = 3'08 \cdot e^{-j0'42}\ V}$$

37



$V_1 = 12\ V$ $\quad I_1 = 2\ A$

$R_1 = R_2 = 2\ \Omega$ $\quad I_2 = 4\ A$

$Z_L = 1j\ \Omega$

$Z_C = -2j\ \Omega$

$$\left.\begin{aligned} I_1 + I_L &= I_o \\ I_2 + I_3 &= I_L \\ I_o &= I_2 + I_c \end{aligned}\right\}$$

$$\left.\begin{aligned} &2 + \frac{V_B - V_A}{j} = \frac{V_A - V_c}{2} \Rightarrow 4j + 2V_B - 2V_A = jV_A - jV_c \\ &4 + \frac{12 - V_B}{2} = \frac{V_B - V_A}{j} \Rightarrow 8j + 12j - jV_B = 2V_B - 2V_A \\ &\frac{V_A - V_c}{2} = 4 + \frac{V_c \cdot j}{-2j\,j} \Rightarrow V_A - V_c = 8 + V_c j \end{aligned}\right\}$$

$$V_A - 8 = V_c + V_c j \Rightarrow V_c = \frac{V_A - 8}{1+j}$$

$$2V_B + jV_B = 2V_A + 20j \Rightarrow V_B = \frac{2V_A + 20j}{2+j}$$

$$4j + 2\left(\frac{2V_A + 20j}{2+j}\right) - 2V_A = jV_A - j\left(\frac{V_A - 8}{1+j}\right) \qquad (2+j)(1+j) = +1+3j$$

$$4j(1+3j) + (4V_A + 40j)(1+j) - 2V_A(1+3j) = jV_A(1+3j) - (V_A j - 8j)(2+j)$$

$$4j - 12 + (4+4j)V_A + 40j - 40 - V_A(2+6j) = V_A(-3+j) + V_A(+1-2j) - 8 + 16j$$

$$V_A(4 + 4j - 2 - 6j + 3 - j - 1 + 2j) = -8 + 16j + 40 - 40j + 12 - 4j$$

$$V_A = \frac{44 - 28j}{4 - j} = \frac{52'154 \cdot e^{-j0'567}}{4'123 \cdot e^{-j0'245}} = 12'65 \cdot e^{-j0'322}$$

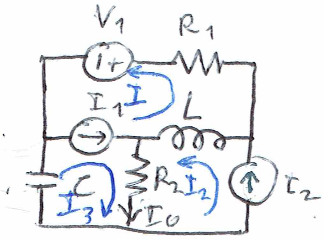
$$\| \quad 12'65(0'95 - j\,0'316)$$

$$V_c = \frac{V_A - 8}{1+j} = \frac{4'0175 - j3'9974}{1+j} = \frac{5'67 \cdot e^{-j0'783}}{\sqrt{2} \cdot e^{j\pi/4}} =$$

$$= 4'01 \cdot e^{-j1'568} \approx 4 \cdot e^{-j\pi} = 4 \cdot e^{j\pi} = 4(-1) = -4$$

$$I_o = \frac{V_A - V_c}{2} = \frac{12'02 - 4j - (-4)}{2} = \frac{8 - 4j}{2} = 4 - 2j\ A$$

37



$V_1 = 12\,V$ $\quad I_1 = 2\,A$

$R_1 = R_2 = 2\,\Omega$ $\quad I_2 = 4\,A$

$Z_L = 1j\,\Omega$

$Z_C = -2j\,\Omega$

$I_o = I_2 + I_3$

$I_1 = I + I_3 \Rightarrow I = 2 - I_3$

$$\left.\begin{aligned} V_{x1} &= (I - I_2) Z_L + I \cdot R_1 + V_1 \\ V_{x2} &= (I_2 - I) Z_L + (I_2 + I_3) R_2 \\ V_{x1} &= (I_2 + I_3) R_2 + I_3 \cdot Z_C \end{aligned}\right\} \quad \left.\begin{aligned} V_{x1} &= (I-4)j + 2I + 12 \\ V_{x2} &= (4 - I)j + (4 + I_3)\cdot 2 \\ V_{x1} &= (4 + I_3)\cdot 2 + I_3(-2j) \end{aligned}\right\}$$

$$V_{x1} = j(2 - I_3) - 4j + 4 - 2I_3 + 12$$

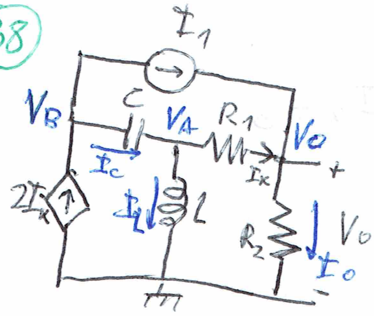
$$V_{x1} = 8 + 2I_3 - 2jI_3$$

$$0 = 2j - I_3 j - 4j + 16 - 2I_3 - 8 - 2I_3 + 2jI_3$$

$$0 = -2j + 8 + jI_3 - 4I_3 \Rightarrow I_3 = \frac{-8 + 2j}{-4 + j} = 2\ A$$

$$I_o = I_2 + I_3 = 4 + 2 = \boxed{6\ A}$$

38



$I_1 = 4\ A$

$Z_L = j\,\Omega$

$R_1 = R_2 = 1\,\Omega$

$$\left.\begin{aligned} I_1 + I_x &= I_o \\ 2I_x &= I_1 + I_c \\ I_c &= I_x + I_L \end{aligned}\right\} \quad \begin{aligned} &4 + V_A - V_o = V_o \Rightarrow V_A = 2V_o - 4 \\ &\left.\begin{aligned} 2V_A - 2V_o &= 4 + \frac{V_B - V_A}{Z_c} \\ \frac{V_B - V_A}{Z_c} &= V_A - V_o + \frac{V_A}{j} \end{aligned}\right\} \quad \begin{aligned} 2V_A - 2V_o &= 4 + I_c \\ I_c &= V_A - V_o + \frac{V_A}{j} \end{aligned} \end{aligned}$$

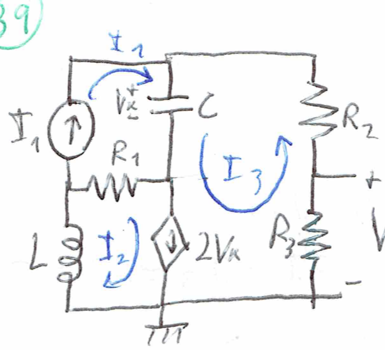
$$2V_A - 2V_o - 4 = V_A - V_o - jV_A$$

$$V_A(1 + j) = 4 + V_o$$

$$(2V_o - 4)(1 + j) = 4 + V_o \Rightarrow V_o(2 + 2j) - 4 - 4j = 4 + V_o \Rightarrow V_o = \frac{8 + 4j}{1 + 2j} = \frac{8'944 \cdot e^{j0'46}}{\sqrt{5}\, e^{j1'11}} =$$

$$= \boxed{V_o = 4 \cdot e^{-j0'65}\ V}$$

39



$I_1 = 4\ A$

$R_1 = R_2 = R_3 = 1\ \Omega$

$Z_L = 1j\ \Omega$

$Z_C = -1j\ \Omega$

$V_0 = -I_3$

$V_x = (I_1 + I_3) Z_C = -4j - I_3 j$

$I_2 + I_3 = 2V_x = -8j - 2I_3 j$

$I_2 + I_3 = -8j - 2I_3 j$

$I_3(1+2j) = -I_2 - 8j$

$I_3 = \dfrac{-I_2 - 8j}{1+2j}$

$V_{x1} = -4j - I_3 j + 4 - I_2$

$V_{x2} = I_2 \cdot j + I_2 - 4$

$V_{x2} = I_3 + I_3 - 4j - I_3 j$ ...

$I_2(1+j) - 4 = (2-j) I_3 - 4j$

$I_2 + jI_2 - 4 = (2-j) \cdot \dfrac{-I_2 - 8j}{1+2j} - 4j$

$(I_2 + jI_2 - 4 + 4j)(1+2j) = (2-j)(-I_2 - 8j)$

$I_2 + jI_2 - 4 + 4j + 2jI_2 - 2I_2 - 8j \cancel{-8} = -2I_2 - 16j + jI_2 \cancel{-8}$

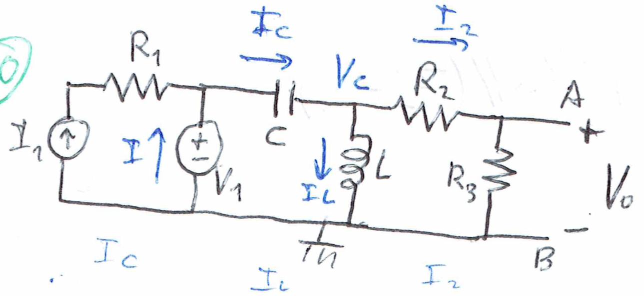
$I_2(1 \cancel{+j} + 2j - 2 + 2 \cancel{-j}) = -16j + 8j - 4j + 4$

$I_2 = \dfrac{(4-12j)(1-2j)}{(1+2j)(1-2j)} = \dfrac{-20-20j}{5} = -4-4j$

$I_3 = \dfrac{+4+4j-8j}{1+2j} = \dfrac{(4-4j)(1-2j)}{(1+2j)(1-2j)} = \dfrac{-4-12j}{5} = -0'8 - 2'4j$

$\boxed{V_0 = -I_3 = 0'8 + 2'4j}$

40



$V_1 = 12\ V$ $\quad Z_L = 2j\ \Omega$

$I_1 = 6\ A$ $\quad Z_c = -j\ \Omega$

$R_1 = R_2 = 2\ \Omega$

$R_3 = 1\ \Omega$

$$\frac{12 - V_c}{-j} = \frac{V_c}{2j} + \frac{V_c}{3}$$

$$12j - V_c j = \frac{-V_c j}{2} + \frac{V_c}{3}$$

$$72j - 6V_c j = -3V_c j + 2V_c$$

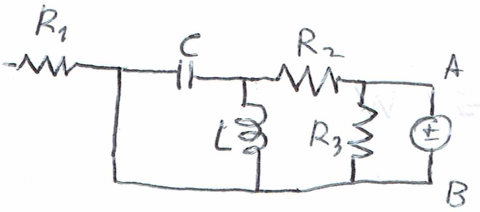
$$72j = V_c(2+3j)$$

$$V_c = \frac{72j}{2+3j}$$

$$V_0 = V_{th} = R_3 \cdot I_2 = I_2 = \frac{V_c}{3}$$

$$V_0 = \frac{1}{3} \cdot \frac{72j}{(2+3j)} = \frac{72 \cdot e^{j\pi/2}}{10'817 \cdot e^{j0'983}} =$$

$$= \boxed{6'66 \cdot e^{j0'588}\ V} = V_{th}$$



$$Z_{th} = \cancel{Z} R_3 // (\cancel{Z_{R_2}} R_2 + (Z_L // Z_c)) = 1 // \left(2 + \frac{2j}{j-2}\right)$$

$$\frac{1}{2} - \frac{1}{j} = \frac{j-2}{2j} \qquad \frac{(j-2)2}{(j-2)} + \frac{2j}{j-2} = \frac{2j-4+2j}{j-2} = \frac{4j-4}{j-2}$$

$$Z_L // Z_c = \frac{2j}{j-2}$$

$$\frac{1}{Z_{th}} = 1 + \frac{j-2}{4j-4} = \frac{4j-4+j-2}{4j-4} = \frac{5j-6}{4j-4}$$

$$Z_{th} = \frac{4j-4}{5j-6} = \frac{4\sqrt{2} \cdot e^{j2'356}}{\sqrt{61} \cdot e^{j2'447}} = \boxed{0'72 \cdot e^{-j0'091}\ \Omega}$$

41

$I_1 = 2e^{j\pi/6}$ A

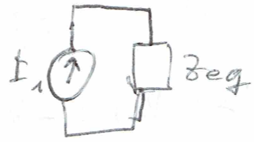
$R = 4\,\Omega$

$Z_L = 2j\,\Omega$

$Z_C = -4j\,\Omega$

$Z_{eq} = Z_R // (Z_L + Z_C)$

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



$$Z_{eq} = \frac{4(1-2j)}{(1+2j)(1-2j)} = \frac{4-8j}{5} = 0'8 - 1'6j = 1'79 \cdot e^{-j1'11}$$

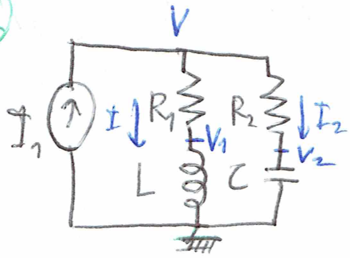
$$V = I_1 \cdot Z_{eq} = 2 \cdot e^{j\pi/6} \cdot 1'79 \cdot e^{-j1'11} = 3'58 \cdot e^{-j0'58}$$

$i(t) = 2 \cdot \cos(\omega t + \pi/6)$

$v(t) = 3'58 \cdot \cos(\omega t - 0'58)$

$$\bar{P} = \frac{I \cdot V}{2} \cdot \cos(\pi/6 + 0'58) = \frac{7'16}{2} \cdot 0'45 = \boxed{1'61\ W}$$

42



$I_1 = 6$ A

$R_1 = R_2 = 2\,\Omega$

$Z_L = 2j\,\Omega$

$Z_C = -1j\,\Omega$

$I_1 = I + I_2$

$$6 = \frac{V}{2+2j} + \frac{V}{2-j}$$

$(2+2j)(2-j) = 6 + 2j$

$36 + 12j = 2V - jV + 2V + 2jV$

$$V = \frac{36+12j}{4+j} = \frac{37'95 \cdot e^{j0'322}}{4'123\ e^{j0'245}} = 9'2 \cdot e^{j0'077}$$

$$I = \frac{V}{2+2j} = \frac{9'2 \cdot e^{j0'077}}{2'83 \cdot e^{j0'785}}$$

$I = 3'25 \cdot e^{-j0'708}$ A

$$I_2 = \frac{V}{2-j} = \frac{9'2 \cdot e^{j0'077}}{\sqrt{5} \cdot e^{-j0'464}}$$

$I_2 = 4'11 \cdot e^{j0'542}$ A

$V_1 = I \cdot Z_L = 2 \cdot e^{j\pi/2} \cdot 3'25 \cdot e^{-j0'708} = 6'5 \cdot e^{j0'863}$

$V_2 = I_2 \cdot Z_C = e^{-j\pi/2} \cdot 4'11\ e^{j0'542} = 4'11\ e^{-j1'029}$

$V - V_1 = I \cdot Z_{R_1} = 2 \cdot 3'25 \cdot e^{-j0'708} = 6'5 \cdot e^{-j0'708}$

$V - V_2 = I_2 \cdot Z_{R_2} = 2 \cdot 4'11 \cdot e^{j0'542} = 8'22 \cdot e^{j0'542}$

$$\overline{P}_{R_1} = \frac{6'5 \cdot 3'25}{2} \cdot \overbrace{\cos(-0'708+0'708)}^{1} = 10'56\,W$$ Consumida

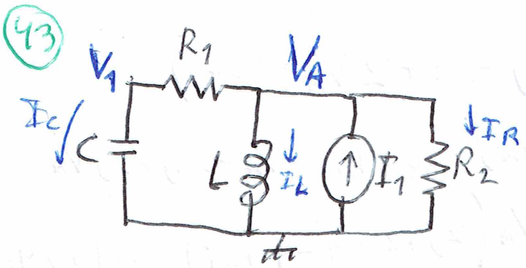
$$\overline{P}_{R_2} = \frac{8'22 \cdot 4'11}{2} \cdot \overbrace{\cos(0'542-0'542)}^{1} = 16'89\,W$$ Consumida

$$\overline{P}_{L} = \frac{6'5 \cdot 3'25}{2} \cdot \overbrace{\cos(-0'708-0'863)}^{0} = 0\,W$$

$$\overline{P}_{C} = \frac{8'22 \cdot 4'11}{2} \cdot \overbrace{\cos(0'542+1'029)}^{0} = 0\,W$$

$$P_{I_1} = \frac{6 \cdot 9'2}{2} \cdot \cos(0'077) = 27'52\,W$$ Suministrada

43



$R_1 = 4\,\Omega$

$R_2 = 2\,\Omega$

$Z_L = 1j\,\Omega$

$Z_c = -2j\,\Omega$

$I_1 = 4e^{j0}\,A$

$$I_1 = I_c + I_L + I_R$$

$$4 = \frac{V_A}{4-2j} + \frac{V_A}{j} + \frac{V_A}{2}$$

$$8 = \frac{V_A}{2-j} - 2V_A j + V_A$$

$$\frac{V_A}{2-j} = 8 + 2V_A j - V_A$$

$$V_A = (2-j)(8+2V_A j - V_A)$$

$$V_A = 16 + 4V_A j - 2V_A - 8j + 2V_A + V_A j$$

$$V_A(1-4j+2-2+j) = 16-8j$$

$$V_A(1-5j) = 16-8j$$

$$V_A = \frac{16-8j}{1-5j} = \frac{17'89 \cdot e^{-j0'464}}{5'1 \cdot e^{-j1'373}} = 3'51 \cdot e^{j0'91}$$

$$I_L = \frac{3'51 \cdot e^{j0'91}}{e^{j\pi/2}} = 3'51 \cdot e^{-j0'661}$$

$$I_R = \frac{3'51 \cdot e^{j0'91}}{2} = 1'76 \cdot e^{j0'91}$$

$$I_c = \frac{3'51 \cdot e^{j0'91}}{4'47 \cdot e^{-j0'464}} = 0'79 \cdot e^{j1'374}$$

$$V_1 = I_c \cdot Z_c = 2\,e^{-\pi/2 j} \cdot 0'79 \cdot e^{j1'374} = 1'58 \cdot e^{-j0'2}$$

$$V_A - V_1 = I_c \cdot R_1 = 4 \cdot 0'79 \cdot e^{j1'374} = 3'16 \cdot e^{j1'374}$$

$$\overline{P}_{R_2} = \frac{1'76 \cdot 3'51}{2} \cdot \cos\underbrace{(0'91-0'91)}_{1} = \boxed{3'09\,W}$$ (consumida)

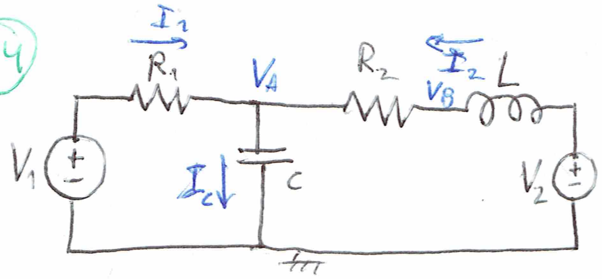
$$\overline{P}_{R_1} = \frac{0'79 \cdot 3'16}{2} \cdot \underbrace{\cos(1'374-1'374)}_{1} = \boxed{1'25\,W}$$ (consumida)

$\overline{P}_{I_1} = \frac{4 \cdot 3'51}{2} \cdot \cos(0'91) = \boxed{4'31 \cdot W}$ (suministrada)

$\overline{P}_C = \frac{0'79 \cdot 1'58}{2} \cdot \cos(1'374 + 0'2) = 0\ W$

$\overline{P}_L = \frac{3'51 \cdot 3'51}{2} \cdot \cos(0'91 + 0'661) = 0\ W$

44



$V_1 = 12\ V$ $\quad Z_L = 1j\ \Omega$

$V_2 = 6\ V$ $\quad Z_C = -2j\ \Omega$

$R_1 = 1\ \Omega$

$R_2 = 2\ \Omega$

$I_1 + I_2 = I_c$

$\frac{12 - V_A}{1} + \frac{6 - V_A}{2+j} = \frac{V_A}{-2j} = \frac{V_A j}{2}$

$24 - 2V_A + \frac{12 - 2V_A}{2+j} = V_A j$

$12 - 2V_A = (V_A j - 24 + 2V_A)(2+j)$

$12 - 2V_A = 2V_A j - 48 + 4V_A - V_A - 24j + 2jV_A$

$12 + 48 + 24j = V_A(2j + 2 + 4 - 1 + 2j) = V_A(5 + 4j)$

$V_A = \frac{64'62 \cdot e^{j0'381}}{6'4 \cdot e^{j0'675}} = 10'1 \cdot e^{-j0'294}$

$\quad = 9'67 - j2'93$

$I_1 = 12 - 9'67 + j2'93 = 3'74 \cdot e^{j0'899}$

$I_2 = \frac{6 - 9'67 + j2'93}{2'23 \cdot e^{j0'464}} = \frac{4'7 \cdot e^{j2'47}}{2'23 \cdot e^{j0'464}} = 2'11 \cdot e^{j2'01}$

$I_c = \frac{10'1 \cdot e^{-j0'294}}{2 \cdot e^{-j\pi/2}} = 5'05 \cdot e^{j1'277}$

$V_B = V_A + I_2 \cdot R_2 = V_A + 4'22 \cdot e^{j2}$

$V_B = 9'67 - j2'93 - 1'79 + 3'82j$

$V_B = 7'88 + 0'89j$

$V_B - V_A = 4'22 \cdot e^{j2'01}$

$\overline{P}_{R_1} = \frac{3'74 \cdot 3'74}{2} \cdot \underbrace{\cos(0'899 - 0'899)}_{1} = 7\ W$ consume

$\overline{P}_{R_2} = \frac{4'22 \cdot 2'11}{2} \cdot \underbrace{\cos(2'01 - 2'01)}_{1} = 4'45\ W$ consume

$V_2 - V_B = I_2 \cdot Z_L = 2'11 \cdot e^{j2'01} \cdot e^{j\pi/2} = 2'11 \cdot e^{j3'581}$

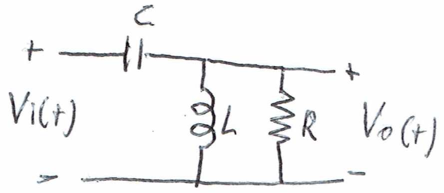
$\overline{P}_L = \frac{2'11 \cdot 2'11}{2} \cdot \cos(3'581 - 2'01) = 0\ W$

$\overline{P}_C = \frac{9'67 \cdot 5'05}{2} \cdot \cos(1'277 + 0'294) = 0\ W$

$\overline{P}_{V_1} = \frac{12 \cdot 3'74}{2} \cdot \cos(0'899) = 13'97\ W$ suministra

$\overline{P}_{V_2} = \frac{6 \cdot 2'11}{2} \cdot \cos(2'01) = 2'69\ W$ consume

45



$$\frac{V_i - V_o}{Z_C} = \frac{V_o}{Z_L} + \frac{V_o}{Z_R} \qquad Z_C = \frac{1}{j\omega C} \quad Z_L = j\omega L \quad Z_R = R$$

$$(V_i - V_o) j\omega C = \frac{V_o}{j\omega L} + \frac{V_o}{R} = V_o\left(\frac{1}{j\omega L} + \frac{1}{R}\right) \Rightarrow$$

$$\Rightarrow j\omega C V_i - j\omega C V_o = V_o\left(\frac{R + j\omega L}{j\omega L R}\right) \Rightarrow j\omega C V_i = V_o\left(\frac{R+j\omega L}{j\omega L R} + j\omega C\right) \Rightarrow$$

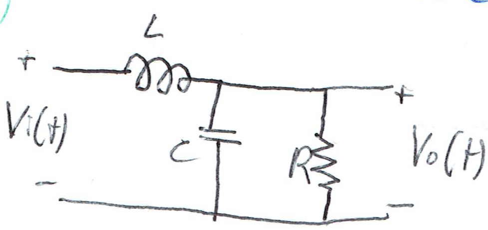
$$\Rightarrow V_o\left(\frac{R + j\omega L - \omega^2 C L R}{j\omega L R}\right) = j\omega C V_i \Rightarrow \frac{V_o}{V_i} = \frac{j\omega C j\omega L R}{R + j\omega L - \omega^2 C L R} = \boxed{\frac{-\omega^2 C L R}{R - \omega^2 C L R + j\omega L}}$$

$$\omega \to 0 \Rightarrow T(\omega) \to \frac{0}{R - 0} = 0$$

$$\omega \to \infty \Rightarrow T(\omega) \to \frac{-\omega^2 C L R}{-\omega^2 C L R} \to 1$$

Filtro de paso alta

46



$$\frac{V_i - V_o}{Z_L} = \frac{V_o}{Z_C} + \frac{V_o}{Z_R} \qquad Z_C = \frac{1}{j\omega C} \quad Z_L = j\omega L \quad Z_R = R$$

$$\frac{V_i - V_o}{j\omega L} = V_o \cdot j\omega C + \frac{V_o}{R} \Rightarrow$$

$$\Rightarrow \frac{V_i}{j\omega L} = V_o\left(\frac{1}{j\omega L} + j\omega C + \frac{1}{R}\right) \Rightarrow \frac{V_i}{j\omega L} = V_o\left(\frac{R + j\omega C \cdot j\omega L \cdot R + j\omega L}{j\omega L \cdot R}\right) \Rightarrow$$

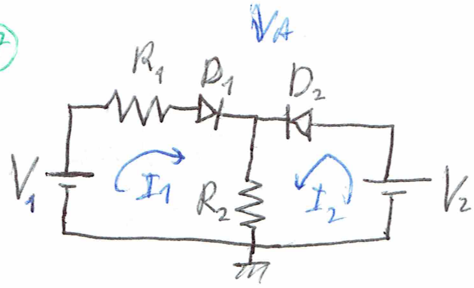
$$\Rightarrow \frac{V_i}{j\omega L} = V_o\left(\frac{R - \omega^2 C L R + j\omega L}{j\omega L R}\right) \Rightarrow \frac{V_o}{V_i} = \frac{\cancel{j\omega L} R}{(R - \omega^2 C L R + j\omega L)\cancel{j\omega L}} = \boxed{\frac{R}{R - \omega^2 C L R + j\omega L}}$$

$$\omega \to 0 \Rightarrow T(\omega) \to \frac{R}{R} = 1$$

$$\omega \to \infty \Rightarrow T(\omega) \to \frac{R}{-\omega^2 C L R + j\omega L} \to 0$$

Filtro de paso baja

47



$V_1 = 10V \quad R_1 = 4k\Omega$

$V_2 = 3V \quad R_2 = 6k\Omega$

$I_{R_1} = I_1$

$I_{R_2} = I_1 + I_2$

D_1, D_2 OFF $\Rightarrow V_{D1} = 10V, V_{D2} = 3V$ Absurdo

D_1 OFF, D_2 ON $\Rightarrow V_{D1} = 7V$ Absurdo $\Rightarrow D_1$ ON

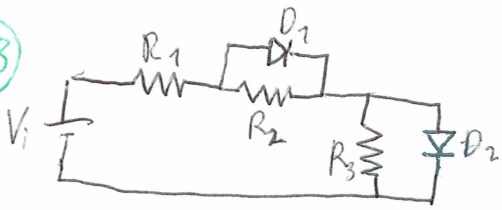
D_2 OFF $\Rightarrow$ $I_2 = 0, \quad I_1 = \dfrac{V_1}{R_1+R_2} = \dfrac{10}{10} = 1$ mA

$V_A = I_1 \cdot R_2 = 6V > 3V \Rightarrow$ Suposición correcta, D_2 OFF

$\boxed{I_{R1} = I_1 = 1mA}$

$I_{R_2} = I_1 + I_2 = 1 + 0 = \boxed{1 \text{ mA}}$

48



$R_1 = R_2 = R_3 = 1k\Omega$

$V_{\gamma_1} = V_{\gamma_2} = 0'6V$

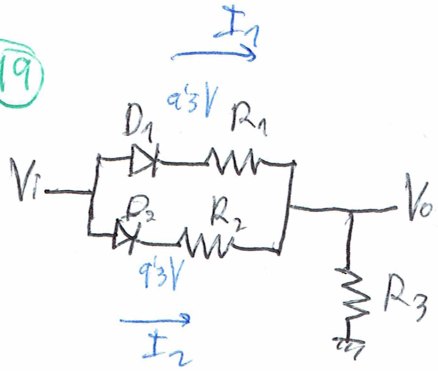
Ambos en corte: $I = \dfrac{V_i}{R_1+R_2+R_3} = \dfrac{V_i}{3}$

$$\left.\begin{aligned} V_{R_2} &= I \cdot R_2 = \frac{V_i}{3} \cdot 1 \\ V_{R_3} &= I \cdot R_3 = \frac{V_i}{3} \cdot 1 \end{aligned}\right\}$$

Ambos comenzarán a conducir a la vez y lo harán para:

$0'6 = \dfrac{V_i}{3} \Rightarrow \boxed{V_i = 1'8V}$

49



$R_1 = 2\,k\Omega$

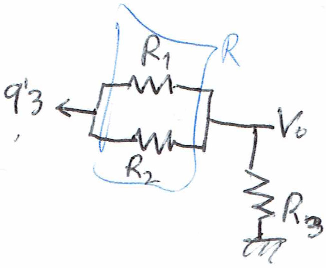
$R_2 = 100\,\Omega = 0'1\,k\Omega$

$R_3 = 2\,k\Omega$

$V_i = 10\,V$

$V_\gamma = 0'7\,V$

$10 > 0'7 \Rightarrow$ ambos conducen



$$I_1 = \frac{9'3 - V_o}{R_1} = \boxed{0'21\ mA}$$

$$I_2 = \frac{9'3 - V_o}{R_2} = \boxed{4'2\ mA}$$

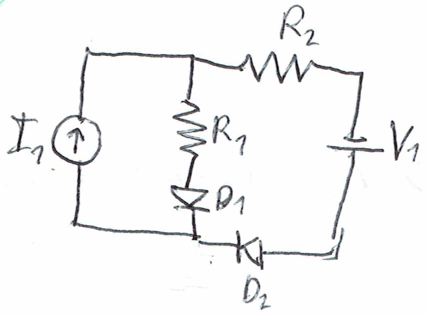
$R = R_1 // R_2$

$$\frac{1}{R} = \frac{1}{2} + \frac{1}{0'1} = 10'5 \Rightarrow R = \frac{1}{10'5} = 0'09524\ k\Omega$$

$$I = \frac{9'3}{0'095 + 2} = 4'44\ mA$$

$$\boxed{V_o = I \cdot R_3 = 8'88\ V}$$

50



$R_1 = 2\,k\Omega$

$R_2 = 1\,k\Omega$

$I_1 = 5\,mA$

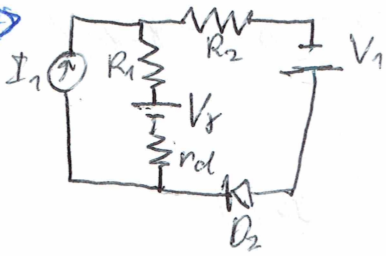
$V_1 = 10\,V$

$V_\gamma = 0'7\,V$

$r_d = 20\,\Omega = 0'02\,k\Omega$

Sup. D_1, D_2 OFF $\Rightarrow V_{D_2} = 10\,V$ Absurdo

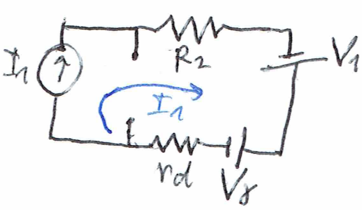
Sup. D_1 ON, D_2 OFF $\Rightarrow$



$V_{I_1} = I_1 (R_1 + r_d) + V_\gamma$

$V_{D_2} = 10\,V$ Absurdo $\Rightarrow D_2$ ON

Sup. D_1 OFF, D_2 ON



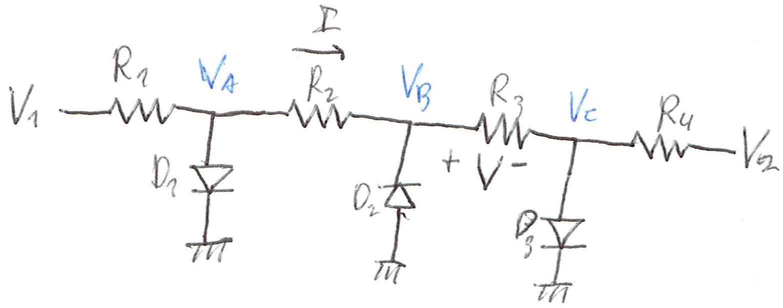
$V_1 - V_\gamma + V_{I_1} = I_1 (R_2 + r_d) \Rightarrow V_{I_1} + 9'3 = 5'1$

$\boxed{V_{I_1} = -4'2\ V}$

$\boxed{V_{D_1} = -4'2\ V \Rightarrow \text{suposición correcta}}$

$\boxed{I_{D_1} = 0}$ $\boxed{I_{D_2} = 5\ mA}$

51



$R_1 = R_2 = R_3 = R_4 = 1\,k\Omega$

$V_1 = 15\,V$

$V_2 = -15\,V$

Sup D_1, D_2, D_3 OFF $\Rightarrow V_{D1} = 7'5\,V$, Absurdo $\Rightarrow D_1$ ON

Sup D_1 ON, D_2, D_3 OFF $\Rightarrow V_{D2} = 5\,V$, Absurdo $\Rightarrow D_2$ ON

Sup D_1, D_2 ON, D_3 OFF $\Rightarrow \left.\begin{array}{l} V_A = 0 \\ V_B = 0 \end{array}\right\} \Rightarrow \boxed{I_{R_2} = 0}$

$V_c = -7'5\,V \Rightarrow \boxed{V_{R_3} = 7'5\,V}$

52

Sup D_1, D_2, D_3 OFF $\Rightarrow V_{D1} = 7'5\,V$, Absurdo $\Rightarrow D_1$ ON

Sup D_1 ON, D_2, D_3 OFF

$V_A = 0'7\,V$

$I = \dfrac{+15 + 0'7}{3} = 5'23\,mA$

$V_B = 0'7 - 5'23 = -4'53\,V \Rightarrow V_{D2} = 4'53\,V$, Absurdo $\Rightarrow D_2$ ON

Sup D_1, D_2 ON, D_3 OFF

$V_A = 0'7$

$V_B = -0'7$

$I_1 = \dfrac{-0'7 + 15}{2} = 7'15\,mA$

$V_c = -0'7 - 7'15 = -7'85\,V$

$V_{D3} = -7'85\,V$

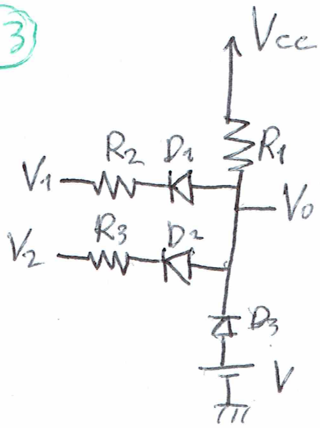
D_3 OFF

Suposición correcta.

$I = V_A - V_B = 0'7 - (-0'7) = \boxed{1'4\,mA}$

$V = V_B - V_c = -0'7 - (-7'85) = \boxed{7'15\,V}$

53



$R_1 = 10\,k\Omega$

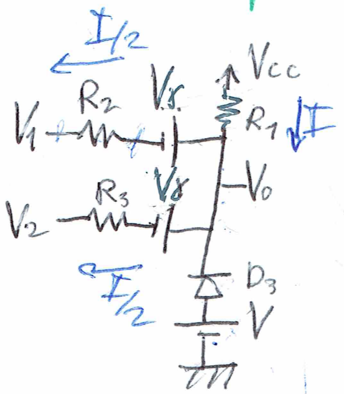
$R_2 = R_2 = 0'47\,k\Omega$

$V = 3'7\,V$

$V_\gamma = 0'7\,V$

a) $V_1 = V_2 = 25V$

$V_{cc} = 32V$



$$I = \frac{I}{2} + \frac{I}{2}$$

$$\frac{V_{cc}-V_o}{R_1} = 2\cdot\frac{V_o - V_\gamma - V_1}{R_2}$$

$$\frac{32-V_o}{10} = 2\cdot\frac{V_o - 0'7 - 25}{0'47}$$

$$3'2 - 0'1\,V_o = 4'255\,V_o - 109'36$$

$$112'56 = 4'355\,V_o$$

$$\boxed{V_o = 25'846\,V}$$

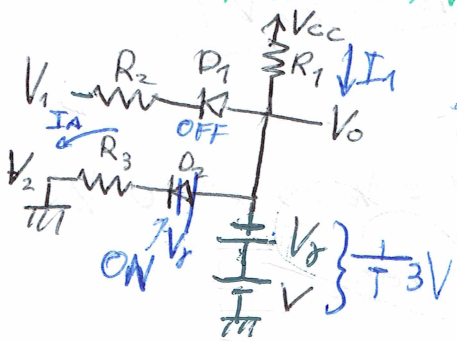
b) D_1 ON

D_2 ON

D_3 OFF

54

a) $V_1 = 25V,\ V_2 = 0V,\ V_o = 3V$



$$I_A = \frac{3-V_\gamma}{R_3} = 4'894\,V$$

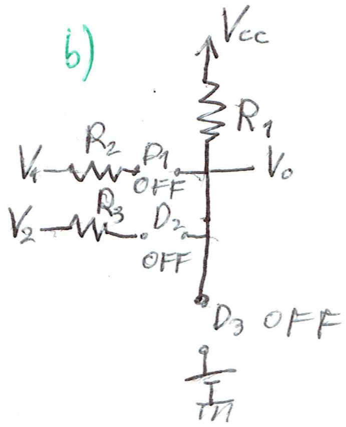
$$I_1 = \frac{V_{cc}-V_o}{R_1} = \frac{V_{cc}-3}{10}$$

$$I_A = I_1$$

$$\frac{V_{cc}-3}{10} = 4'894$$

$$V_{cc} = 51'94\,V$$

b)

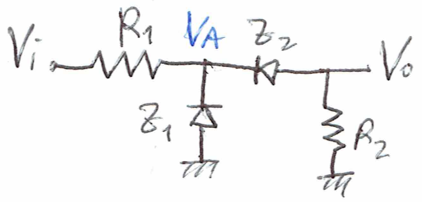


$V_o = 10V$
$V_1 = V_2 = 25V$

$$\boxed{V_{cc} = V_o = 10V}$$

$$\boxed{10V \leq V_{cc} \leq 51'94V}$$

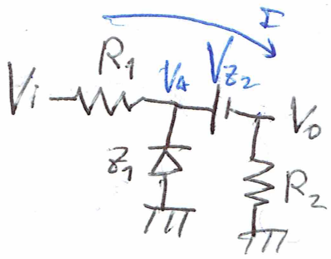
55



$R_1 = 500\Omega$ $\quad V_{Z1} = 12V$
$R_2 = 1k\Omega$ $\quad V_{Z2} = 5V$
$V_i = 10V$

Sup. Z_1, Z_2 OFF $\Rightarrow$ $\left.\begin{matrix} V_A = V_i \\ V_o = 0 \end{matrix}\right\}$ Z_2 roto.

$$I = \frac{10 - 3'33 - 5}{0'5} = 3'33\ mA$$



$$\frac{V_i - V_o - V_{Z2}}{R_1} = \frac{V_o}{R_2}$$

$$\boxed{I_{Z1} = 0\ mA}$$
$$\boxed{I_{Z2} = 3'33\ mA}$$

$$\frac{10 - 5 - V_o}{0'5} = \frac{V_o}{1} \Rightarrow 10 - 2V_o = V_o$$

$$\boxed{V_o = 3'33\ V}$$

56 Z_2 roto, Sup. Z_1 OFF

$$\frac{V_i - V_o - V_{Z2}}{R_1} = \frac{V_o}{R_2} \Rightarrow \frac{15 - V_o}{0'5} = V_o \Rightarrow 30 - 2V_o = V_o \Rightarrow V_o = 10\ V$$

$V_A = V_o + V_{Z2} = 15\ V > 12 = V_{Z1}$ Absurdo. Z_1 roto.

$$V_o = V_{Z1} - V_{Z2} = 12 - 5 = \boxed{7\ V}$$

$$I = \frac{V_i - V_{Z1}}{R_1} = \frac{20 - 12}{0'5} = 16\ mA$$

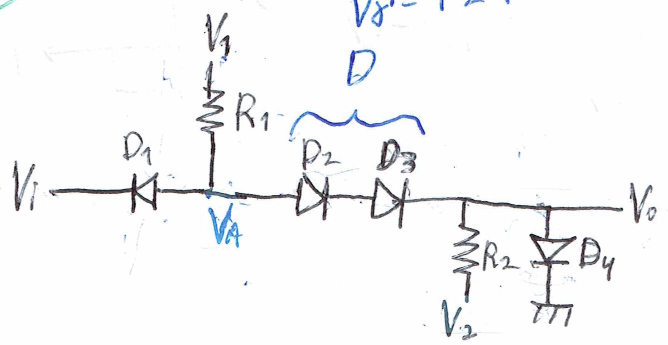
$$I = I_{Z1} + I_{Z2}$$

$$I_{Z2} = \frac{V_o}{R_2} = \boxed{7\ mA}$$

$$I_{Z1} = I - I_{Z2} = \boxed{9\ mA}$$

57

$V_{\gamma}' = 1'2\ V$



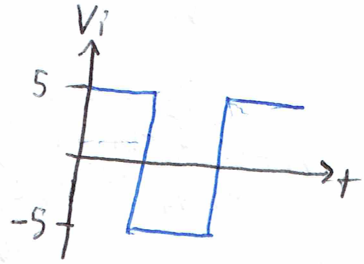
$R_1 = 2\,k\Omega$

$R_2 = 3\,k\Omega$

$V_{\gamma} = 0'6\ V$

$V_1 = 9\ V$

$V_2 = -1\ V$



$V_i = 5\ V$:

Sup. D ON, D_1 OFF, D_4 OFF

$$\frac{V_1 - V_o - 1'2}{R_1} = \frac{V_o - V_2}{R_2} \Rightarrow \frac{9 - 1'2 - V_o}{2} = \frac{V_o + 1}{3}$$

$$3(7'8 - V_o) = 2V_o + 2$$

$$21'4 = 5V_o \Rightarrow V_o = 4'28\ V$$

Absurdo

D_4 ON.

D ON, D_1 OFF, D_4 ON

$\boxed{V_o = V_{\gamma} = 0'6\ V}$

$V_o + 1'2 = 1'8 < V_i$ Suposición correcta.

$V_i = -5\ V$:

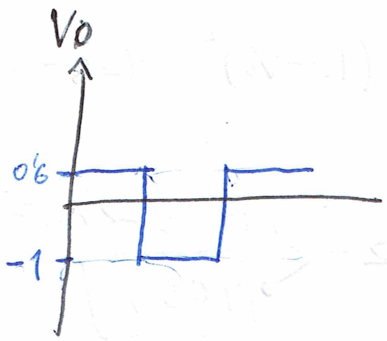
D_1 conduce, D_2, D_3, D_4 OFF

$$I_1 = \frac{V_1 - (-5 + V_{\gamma})}{2} = 6'7\ mA$$

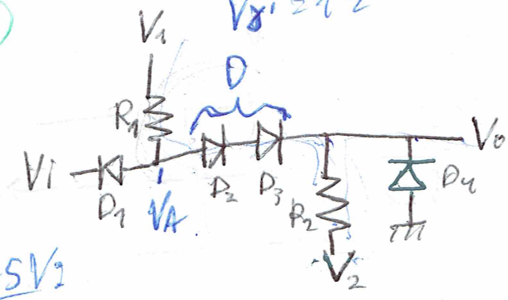
$V_A = -5 + V_{\gamma} = -4'4\ V$

$\boxed{V_o = -1\ V}$

$V_o > V_A \Rightarrow$ Suposición correcta



58

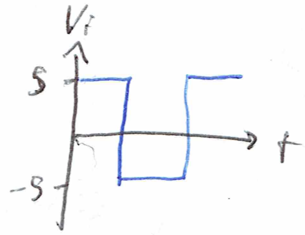


$V_{\gamma'} = 1'2$

$R_1 = 2k\Omega$ $\quad V_1 = 9V$

$R_2 = 3k\Omega$ $\quad V_2 = -1V$

$V_\gamma = 0'6V$



$V_i = 5V$:

Sup. D_1 OFF, D ON, D_4 OFF

$$\frac{V_1 - V_o - 1'2}{R_1} = \frac{V_o - V_2}{R_2} \Rightarrow \frac{7'8 - V_o}{2} = \frac{V_o + 1}{3} \Rightarrow 21'4 = 5V_o \Rightarrow \boxed{V_o = 4'28V}$$

$$V_o + 1'2 = 5'48V < \underset{V_i + V_\gamma}{5'6} \quad D_1 \text{ OFF}$$

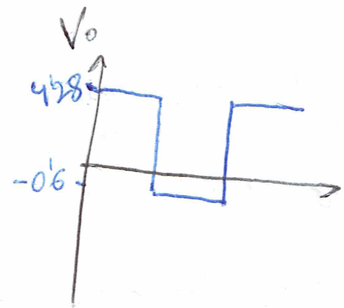
$$4'28 > 0'6 \Rightarrow D_4 \text{ OFF}$$

Suposición correcta.

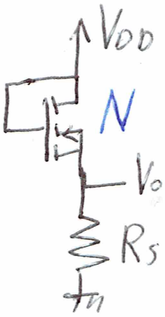
$V_i = -5V$: D_1 ON, D OFF, D_4 ON

$$\boxed{V_o = -0'6V = V_\gamma}$$

$$V_A = V_i + V_\gamma = -4'4V < V_o \Rightarrow D \text{ OFF}$$



59



$V_{DD} = 12V$

$V_T = 2V$

$K = 2mA/V^2$

$R_S = 10k\Omega$

NMOSFET SAT:

$$I = \frac{k}{2}(V_{GS} - V_T)^2 = (12 - V_o - 2)^2$$

$$I = \frac{V_o}{R_S}$$

$$\frac{V_o}{10} = (10 - V_o)^2 = 100 - 200V_o + V_o^2$$

$$V_o = 1000 - 200V_o + 10V_o^2$$

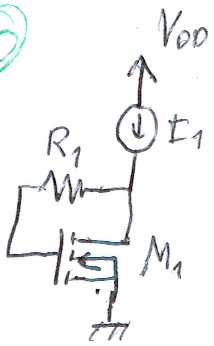
$$0 = 1000 - 201V_o + 10V_o^2$$

$$V_o = \frac{201 \pm \sqrt{201^2 - 4 \cdot 10000}}{20} = \frac{201 \pm 20'025}{20} = \begin{cases} 11'05 \Rightarrow V_{GS} = 0'95 < 2 = V_T \text{ Absurdo.} \\ \boxed{9'05V} \end{cases}$$

$$\boxed{I = \frac{9'05}{10} = 0'905\ mA}$$

$$\boxed{V_{DS} = V_{DD} - V_o = 2'95V}$$

60



$V_{DD} = 10V$

$R_1 = 100k\Omega$

$I_1 = 0'2\,mA$

$K = 0'1\,mA/V^2$

$V_D < 5V$

M_1 sat.

$0'2 = \frac{0'1}{2}(V_G - V_T)^2$

$4 = (V_G - V_T)^2$

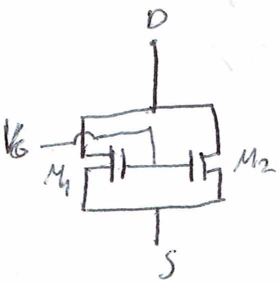
$V_D = V_G$

$2 = V_G - V_T$

$V_D = 2 + V_T \Rightarrow \boxed{V_T < 3V}$

61

Meq.



$K_1 = K_2 = 2\,mA/V^2$

$V_{T1} = 1V$

$V_{T2} = 2V$

$V_{GS1} = V_{GS2}$

Si $V_{T1} = V_{T2}$

$I_{eq} = I_1 + I_2$

$\frac{K}{2}(V_{GS} - V_T)^2 = \frac{K_1}{2}(V_{GS} - V_T)^2 + \frac{K_2}{2}(V_{GS} - V_T)^2$

$\frac{K}{2} = \frac{K_1}{2} + \frac{K_2}{2} \Rightarrow \underline{K = 4\,mA/V^2}$

a) $V_{GS} = 1V \Rightarrow$ Circula intensidad $\Rightarrow \boxed{V_T\,eq = 1V}$

b) $V_{GS} = 3V$

$I_D\,sat = I_D\,lin \Rightarrow \cancel{\frac{K}{2}}(V_{GS} - V_T)^2 = \cancel{\frac{K}{2}}[2(V_{GS} - V_T)V_{DS} - V_{DS}^2]$

$(3-1)^2 = 2 \cdot 2\,V_{DS} - V_{DS}^2$

$4 = 4V_{DS} - V_{DS}^2$

$\boxed{V_{DS,sat} = 2\,V}$

c) $I_D(V_{GS})$ M_1, M_2 sat.

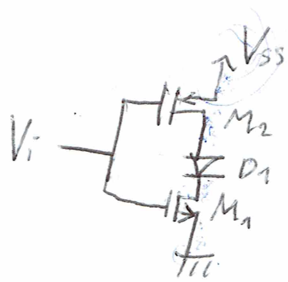
$$I = I_1 + I_2$$

$$I = \frac{K_1}{2}(V_{GS} - V_{T1})^2 + \frac{K_2}{2}(V_{GS} - V_{T2})^2$$

$$I = \frac{2}{2}(V_{GS} - 1)^2 + \frac{2}{2}(V_{GS} - 2)^2 = V_{GS}^2 - 2V_{GS} + 1 + V_{GS}^2 - 4V_{GS} + 4$$

$$\boxed{I = 2V_{GS}^2 - 6V_{GS} + 5 \quad mA}$$

62



$|V_{T2}| = 1'5V$

$V_{T1} = 1'5V$

$K_1 = K_2 = 2 mA/V^2$

$V_{SS} = 10V$

$V_\gamma = 2V$

D_1 ON Supongo M_1, M_2 lin.

$$V_{D_2} - V_{D_1} = 2V$$

M_2: $|V_{GS}| = V_{SS} - V_i \Rightarrow V_{SS} - V_i > 1'5\ V$ ON

$|V_{DS2}| = \cancel{V_{SS}} - V_{D2} < \cancel{V_{SS}} - V_i - |V_{T2}|$

$V_{D2} > V_i + 1'5$ Lin.

M_1:

$V_{GS} = V_i \Rightarrow V_i > 1'5V$ ON

$V_{D1} < V_i - 1'5$ Lin.

$$\left.\begin{array}{l} V_i < V_{D2} - 1'5 \\ V_i > V_{D1} + 1'5 \end{array}\right\} \quad V_{D_2} = 2 + V_{D1}$$

Contradicción

$V_i < 2 + V_{D1} - 1'5$

$V_i < V_{D1} + 0'5$

(63) M_1, M_2 sat. D_1 ON $V_{O2} - V_{O1} = 2V$

$|V_{DS2}| = \cancel{V_{SS}} - V_{O2} > \cancel{V_{SS}} - V_i - |V_{T2}| = |V_{GS}| - |V_{T2}|$

$\boxed{V_{O2} < V_i + 1'5}$

$V_{GS} - V_T = V_i - 1'5 < V_{O1}$ $V_{O1} + 2 = V_{O2}$

$V_i < V_{O1} + 1'5$

$V_{O1} + 2 < V_i + 1'5$

$V_{O1} + 0'5 < V_i$

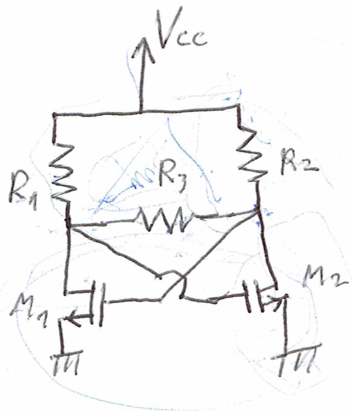
$I_{M1} = I_{M2}$

$\frac{\cancel{K_1}}{\cancel{2}} (V_i - 1'5)^{\cancel{2}} = \frac{\cancel{K_2}}{\cancel{2}} (V_{SS} - V_i - 1'5)^{\cancel{2}}$ $K_1 = K_2$

$V_i - \cancel{1'5} = 10 - \cancel{1'5} - V_i$

$\boxed{V_i = 5V}$

64



$R_1 = R_2 = 0'5\,k\Omega$

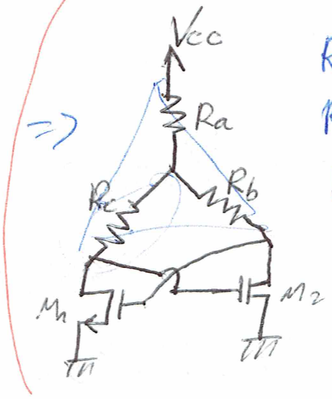
$R_3 = 1\,k\Omega$

$V_{T1} = V_{T2} = 1\,V$

$k_1 = k_2 = 2\,mA/V^2$

$V_{cc} = 5\,V$

$\Rightarrow$



$R_a = 0'125\,k\Omega$

$R_b = 0'25\,k\Omega$

$R_c = 0'25\,k\Omega$

$V_{GS2} = V_{DS1}$

$V_{DS2} = V_{GS1}$

M_1, M_2 sat.

$V_{GS2} - V_{T2} < V_{DS2} \Rightarrow V_{GS2} - 1 < V_{GS1}$

$V_{GS1} - V_{T1} < V_{DS1} \Rightarrow V_{GS1} - 1 < V_{GS2}$

$V_{GS1} = V_{GS2} = V_{DS1} = V_{DS2}$

$V_{GS1} + 1 > V_{GS2} > V_{GS1} - 1$

$V_{DS} = V_{GS} = V$

$$I = \frac{k}{2}(V_{GS} - V_T)^2$$

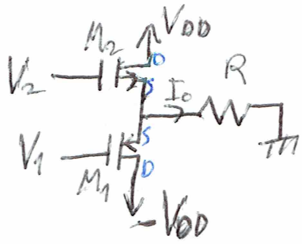
$$I = \frac{V_{cc} - V_{GS}}{0'5}$$

$$\frac{5 - V}{0'5} = (V-1)^2$$

$$10 - 2V = V^2 - 2V + 1$$

$$0 = V^2 - 9 \Rightarrow \boxed{V_{GS} = 3\,V}$$

65



$R = 1\,k\Omega$

$K_1 = k_2 = 2\,mA/V^2$

$|V_{T1}| = |V_{T2}| = 1\,V$

$|V_{GS1}| - |V_T| < |V_{DS1}|$

$\underbrace{V_{GS2}}_{V_2 - I_o} - V_T < V_{DS2}$

$I_o - V_1$

M_1, M_2 sat.

$I_2 = I_1 + I_o$

$$\frac{k}{2}(V_2 - I_o - 1)^2 = \frac{k}{2}(I_o - V_1 - 1)^2 + I_o$$

$$I_o = (V_2 - I_o - 1)^2 - (I_o - V_1 - 1)^2 = (V_2 - V_1 - 2)(V_2 + V_1 - 2I_o)$$

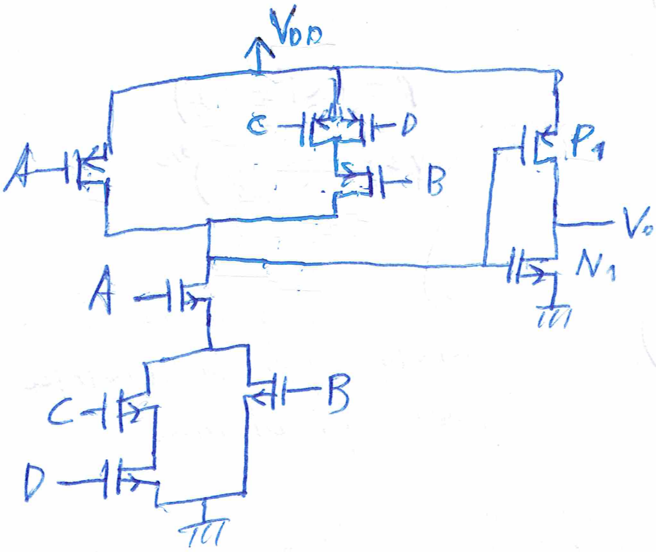
$$I_o = -2I_o(V_2 - V_1 - 2) + (V_2 + V_1)(V_2 - V_1 - 2)$$

$$I_o + 2I_o(V_2 - V_1 - 2) = (V_2 + V_1)(V_2 - V_1 - 2)$$

$$I_o(1 + 2(V_2 - V_1 - 2)) = (V_2 + V_1)(V_2 - V_1 - 2) \Rightarrow \boxed{I_o = \frac{(V_2 + V_1)(V_2 - V_1 - 2)}{1 + 2(V_2 - V_1 - 2)}\ mA}$$

66 $Y = A(B+CD)$ CMOS

A	B	C	D
1	0	1	1



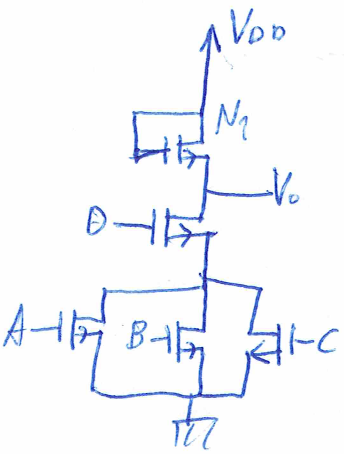
N_A : ON
P_A : OFF
N_B : OFF
P_B : ON
N_C : ON
P_C : OFF
N_D : ON
P_D : OFF

N_1 : OFF
P_1 : ON

$\boxed{Y : 1}$

67 $Y = \overline{(A+B+C)\cdot D}$ NMOS

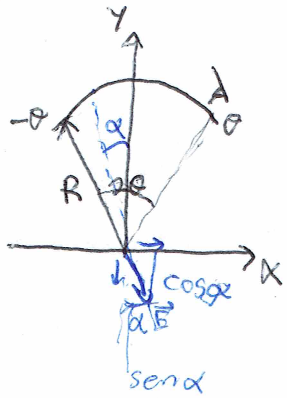
A	B	C	D
1	1	1	0



N_A : ON
N_B : ON
N_C : ON
N_D : OFF
N_1: SAT (ON)

$\boxed{Y : 1}$

68



$$E = \int_{-\theta}^{\theta} \frac{k \cdot dQ}{R^2} (\operatorname{sen}\alpha\, \vec{i} - \cos\alpha\, \vec{j})$$

$$dQ = \lambda \cdot d\vec{l} = \lambda \cdot R \cdot d\alpha$$

$$d\vec{l} = R \cdot d\alpha$$

$$E = \int_{-\theta}^{\theta} \frac{K \cdot \lambda \cdot R\, d\alpha}{R^2} (\operatorname{sen}\alpha\, \vec{i} - \cos\alpha\, \vec{j}) = \frac{1}{4\pi\varepsilon_0} \cdot \frac{\lambda}{R} \left[\int_{-\theta}^{\theta} \operatorname{sen}\alpha\, d\alpha\, \vec{i} - \int_{-\theta}^{\theta} \cos\alpha\, d\alpha\, \vec{j} \right]$$

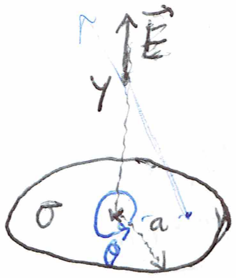
$$\left[-\cos\alpha\right]_{-\theta}^{\theta} \qquad \left[\operatorname{sen}\alpha\right]_{-\theta}^{\theta}$$

$$-\cos\theta + \cos(-\theta) = 0 \qquad \operatorname{sen}\theta - \operatorname{sen}(-\theta) = 2 \cdot \operatorname{sen}\theta$$

$$\vec{E} = \frac{\lambda}{{}_{2}\cancel{4}\pi\varepsilon_0 R} (-\cancel{2}\operatorname{sen}\theta)\, \vec{j}$$

$$\boxed{\vec{E} = -\frac{\lambda \operatorname{sen}\theta}{2\pi\varepsilon_0 R}\, \vec{j}}$$

(69)



$$\vec{E} = \int \frac{k \cdot \sigma \cdot ds}{r^3} \cdot \vec{r}$$

$ds = dx \cdot x \cdot d\theta$

$\vec{r} = (x\vec{i} + y\vec{j})$

$r^3 = (x^2+y^2)^{3/2}$

$$\vec{E} = \int_0^a \int_0^{2\pi} \frac{k \cdot \sigma \cdot dx \cdot x \cdot d\theta}{(x^2+y^2)^{3/2}} (\cancel{x\vec{i}} + y\vec{j})$$

cada componente $\vec{i}$ se anula por la simetría del problema.

$$\vec{E} = k \cdot \sigma \int_0^a \frac{x\, dx}{(x^2+y^2)^{3/2}} \cdot \int_0^{2\pi} d\theta \cdot y\vec{j} = \frac{1 \cdot \sigma \cdot y}{\cancel{4}_2 \pi \varepsilon_0} \cdot \frac{1}{\cancel{2}} \left[\frac{(x^2+y^2)^{-1/2}}{-\cancel{1/2}} \right]_0^a \cdot \cancel{2\pi} \cdot \vec{j} =$$

$$= \frac{\sigma y (-)}{\varepsilon_0 \cdot 2} \left[\frac{1}{\sqrt{a^2+y^2}} - \frac{1}{y} \right] = \boxed{\frac{\sigma}{2\varepsilon_0} \left[1 - \frac{y}{\sqrt{a^2+y^2}} \right] \vec{j}}$$

$$\boxed{\lim_{a \to \infty} E = \frac{\sigma}{2\varepsilon_0} \vec{j}}$$