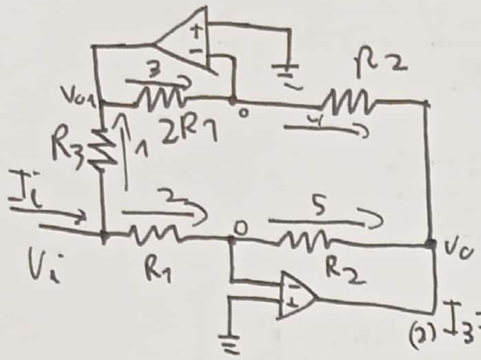
Enero 2022

PSF

1| Impedancia de entrada. Condición ∞. Diseñar para $AV = -10 V/V$



(1) $I_i = I_2 + I_1$

$$I_i = \frac{V_i - 0}{R_1} + \frac{V_i - V_{o1}}{R_3}$$

(2) $I_3 = I_4$ $\quad \frac{V_{o1} - 0}{2R_1} = \frac{0 - V_o}{R_2} \rightarrow V_{o1} = -\frac{2R_1}{R_2} V_o = +\frac{2\cancel{R_1}\cancel{R_2}}{\cancel{R_2}\cancel{R_1}} V_1 = 2V_i$

(3) $I_2 = I_5$ $\quad \frac{V_i - 0}{R_1} = \frac{0 - V_o}{R_2} \rightarrow V_i = -\frac{R_1}{R_2} V_o \rightarrow V_o = -\frac{R_2}{R_1} V_i$

- Sustituimos 2 en 1

$$\cancel{I_i = \frac{V_i}{R_1} + \frac{V_i}{R_3} - \frac{V_i}{R_3} - \frac{V_i}{R_1}}$$

$$I_i = V_i\left(\frac{1}{R_1} + \frac{1}{R_3}\right) - \frac{2V_i}{R_3} = V_i\left(\frac{R_3 - R_1}{R_3 R_1}\right) \rightarrow R_i = \frac{V_i}{I_i} = \frac{R_3 R_1}{R_3 - R_1}$$

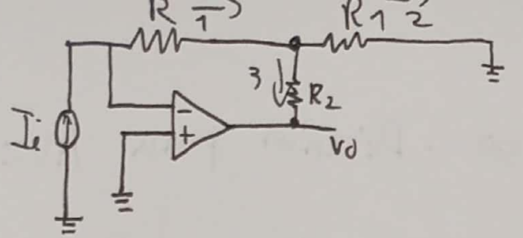
- La condición para $R_i \rightarrow \infty$ $\quad R_3 - R_1 = 0 \rightarrow \boxed{R_3 = R_1}$

- La ecuación $V_o = A_V V_{in}$ la obtuvimos en (3)

$$V_o = -\frac{R_2}{R_1} V_1 \rightarrow A_V = +\frac{R_2}{R_1} = +10 \rightarrow R_2 = 10 R_1$$

Pongamos $R_1 = 1 k\Omega$ por lo que $R_2 = 10 k\Omega$

2



a) exp. tens. salida y transimpedancia

$I_1 = I_2 + I_3$ $\qquad I_i = I_1 = \frac{0-V}{R} \to V = -I_i R$

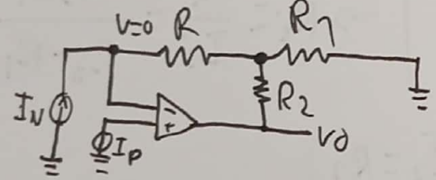
$$I_i = \frac{V-0}{R_1} + \frac{V-V_0}{R_2} = -\frac{I_i R}{R_1} + \frac{-I_i R - V_0}{R_2}$$

$$I_i\left(1+\frac{R}{R_1}+\frac{R}{R_2}\right) = -\frac{V_0}{R_2} \to \boxed{V_0 = -I_i\left(R_2+\frac{RR_2}{R_1}+R\right)}$$

$$\boxed{R_m = \frac{V_0}{I_i} = -\left(R_2 + \frac{RR_2}{R_1}+R\right)}$$

b) Corrientes de pol.

Quitamos I_i a circt. abierto y añadimos I_N e I_P

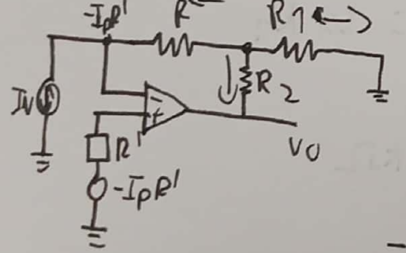


Como por + no puede entrar corriente I_P es como si estuviera entre 2 tierras por lo que no afecta.

I_N no afecta por estar también entre 2 tierras ¿?

Tengo dudas de esto, yo creo que habría que hacer el análisis con I_N

c) Para solucionarlo añadimos una resistencia a I_P



$V(+) = V(-) = -I_P R'$

$$I_N = \frac{+I_P R' + V}{R} \to V = \mp(I_P R' + I_N R)$$

$$\cancel{-I_N = \frac{V-0}{R_1} + \frac{V-V_0}{R_2}} \to \cancel{\frac{V_0}{R_2} = +I_N - \frac{V}{R_1} - \frac{V}{R_2}}$$

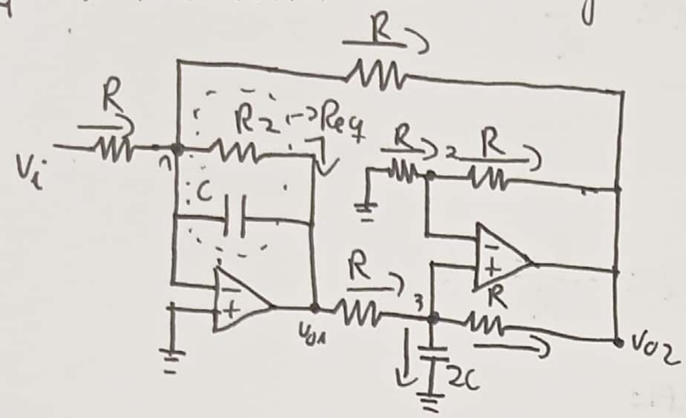
$$\frac{V-0}{R_1} + \frac{V-V_0}{R_2} \mp I_N = 0$$

$$V\left(\frac{1}{R_1}+\frac{1}{R_2}\right) + I_N = \frac{V_0}{R_2} \to \frac{V_0}{R_2} = I_N \mp I_N R\left(\frac{1}{R_1}+\frac{1}{R_2}\right) - I_P R'\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$$

$$V_0 = I_N\left(R_2 + \frac{RR_2}{R_1} + R\right) - I_P R'\left(\frac{R_2}{R_1}+1\right)$$

$$R_2 + \frac{RR_2}{R_1} + R = R'\left(\frac{R_2}{R_1}+1\right) \rightarrow \boxed{R' = \frac{R_1R_2 + RR_2 + RR_1}{R_2+R_1}}$$

3| a) Funciones de transf.



$$R_{eq} = \frac{1}{\frac{1}{R_2}+Cs} = \frac{R_2}{1+R_2Cs}$$

1: $\frac{V_i - 0}{R} = \frac{0-V_{o1}}{R_{eq}} + \frac{0-V_{o2}}{R} \rightarrow \frac{V_i}{R} = -\frac{V_{o1}}{R_{eq}} - \frac{V_{o2}}{R} = -\left(\frac{RCs}{R_{eq}} + \frac{1}{R}\right)V_{o2}$ *

2: $\frac{0-V}{\cancel{R}} = \frac{V-V_{o2}}{\cancel{R}} \rightarrow V = \frac{V_{o2}}{2}$

3: $\frac{V_{o1}-V}{R} = \frac{V-0}{1/2Cs} + \frac{V-V_{o2}}{R} \rightarrow \frac{V_{o1}}{R} = V\left(2Cs+\frac{2}{R}\right) - \frac{V_{o2}}{R} = V_{o2}\left(Cs+\frac{1}{R}\right) - \frac{V_{o2}}{R}$

$V_{o1} = RCs\,V_{o2}$

* $V_i = -\left(\frac{R^2Cs}{R_{eq}}+1\right)V_{o2} = -\left(\frac{R^2Cs(1+R_2Cs)}{R_2}+1\right)V_{o2} =$

$= -\left(\frac{R^2Cs + R^2R_2C^2s^2 + R_2}{R_2}\right)V_{o2} = -\left(\frac{s^2 + \frac{R^2Cs}{R^2R_2C^2} + \frac{R_2}{R^2R_2C^2}}{\frac{R_2}{R^2R_2C^2}}\right)V_{o2} =$

$= -\left(\frac{s^2+\frac{s}{R_2C}+\frac{1}{R^2C^2}}{\frac{1}{R^2C^2}}\right)V_{o2} \rightarrow \frac{V_{o2}}{V_i} = \frac{-\frac{1}{R^2C^2}}{s^2+\frac{1}{R_2C}s+\frac{1}{R^2C^2}} = G_2$ Pasa bajo

Sust. V_{o2} por $\frac{V_{o1}}{RCs}$

$\frac{V_{o1}}{V_i} = \frac{-\frac{1}{RC}s}{s^2+\frac{1}{R_2C}s+\frac{1}{R^2C^2}} = G_1$ Pasa banda obtenemos sus parametros

$$G_2 = \frac{H_0 w_0^2}{s^2 + \frac{w}{Q}s + w_0^2}$$

$$-\cancel{H_0} w_0 = \sqrt{\frac{1}{R^2C^2}} = \frac{1}{RC}$$

$$-H_0 w_0^2 = -\frac{1}{R^2C^2} \rightarrow \boxed{H_0 = -1}$$

$$\frac{w_0}{Q} = \frac{1}{CR_2} \rightarrow \boxed{Q = \frac{R_2}{R}}$$

$$G_1 = \frac{\frac{H_0 w_0}{Q} s}{s^2 + \frac{w_0}{Q}s + w_0^2}$$

$$-w_0 = \frac{1}{RC}$$

$$-Q = \frac{R_2}{R}$$

$$-\frac{H_0 w_0}{Q} = \frac{-1}{RC} \rightarrow \boxed{H_0 = -Q = -\frac{R_2}{R}} = H_0$$

b) $C = 1nF$, $R = 15'8\,k\Omega$, $R_2 = 80'6\,k\Omega$

$w_0 = 63291'13\,Hz \rightarrow f_0 = 10073'04\,Hz$

$Q = 5'101$ $\quad H_{0_1} = -Q = -5,101$

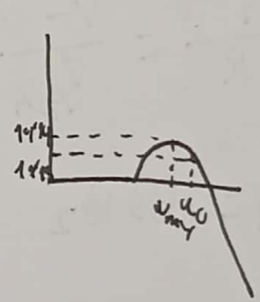
$H_{0_2} = -1$

G2

$$w_{max} = w_0\sqrt{1 - \frac{1}{2Q^2}} = 62680'14\,Hz$$

$$20\log_{10}|G(jw_{max})| = 20\log_{10}\left|\frac{H_0 Q}{\sqrt{1-\frac{1}{4Q^2}}}\right| = 14'19\,dB$$

$$20\log_{10}|G(jw_0)| = 20\log_{10}|H_0 Q| = 14'15\,dB$$



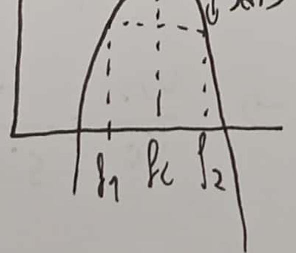
G1 $BW = f_2 - f_1 = \frac{f_0}{Q}$

$f_1 \cdot f_2 = f_0^2$

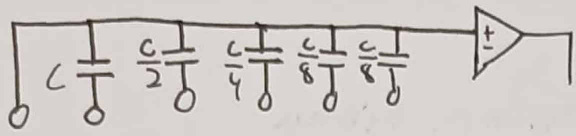
$$f_1^2 + \frac{f_0}{Q}f_1 - f_0^2 = 0$$

$f_1 = 9134'81\,Hz$

$$f_2 = \frac{f_0^2}{f_1} = 11107'74\,Hz$$

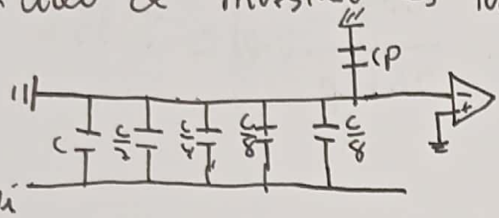


4| ADC redist. de carga $n=4$, $V_{ref}=3V$, $C=8pF$, $C_p=4pF$, $v_i=1'8V$ PSF 3



3 ciclos | muestreo
retención
redistribución

- Ciclo de muestreo → todos los cond. a tierra por arriba y a V_i por abajo

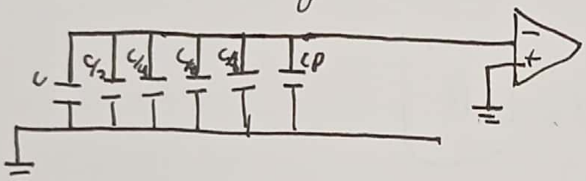


$Q_1 = V_i C_{eq}$ con $C_{eq} = \sum C = 2C$

C_p no importa aquí

- Ciclo de retención

Abrimos sw0 y los cond a tierra



C_p contribuye

La carga debe conservarse

$Q_1 = Q_p \rightarrow 2CV_i = -V_p(2C+C_p)$

$$V_p = -\frac{2C}{2C+C_p} V_i = -1'44V$$

- Ciclo de redistribución de carga

- Conectamos C a V_{ref} y el resto a tierra

$(V_{ref} - V_1)C = C_{eq} V_1 \rightarrow V_1 = \frac{C}{2C+C_p} V_{ref} = 1'2$

$V_1 + V_p = 1'2 - 1'44 = -0{,}24 < 0 \quad b_3 = 1$

- Conectamos C y $\frac{C}{2}$ a V_{ref} y el resto a tierra

$(V_{ref} - V_2)(C + \frac{C}{2}) = (\frac{C}{4} + \frac{2C}{8} + C_p) V_2 \rightarrow V_2 = \frac{C+\frac{C}{2}}{2C+C_p} V_{ref} = 1'8$

$V_2 + V_p = 1'8 - 1{,}44 = 0{,}36 > 0 \quad b_2 = 0$

- Conectamos C y $\frac{C}{4}$ a V_{ref} y el resto a tierra

$(V_{ref} - V_3)(C + \frac{C}{4}) = (\frac{C}{2} + \frac{2C}{8} + C_p) V_3 \rightarrow V_3 = \frac{C+\frac{C}{4}}{2C+C_p} V_{ref} = 1'5V$

$V_3 + V_p = 1'5 - 1'44 = 0'06 > 0 \quad b_1 = 0$

Por ultimo

Conectamos C_4 $\frac{C}{8}$ a V_{ref} y el resto a tierra

$$(V_{ref} - V_4)\left(C + \frac{C}{8}\right) = \left(\frac{C}{2} + \frac{C}{4} + \frac{C}{8} + C_p\right) V_4 \rightarrow V_4 = \frac{C + \frac{C}{8}}{2C + C_p} V_{ref} = 1'35V$$

$V_4 + V_p = -0'04 < 0 \quad b_0 = 1$

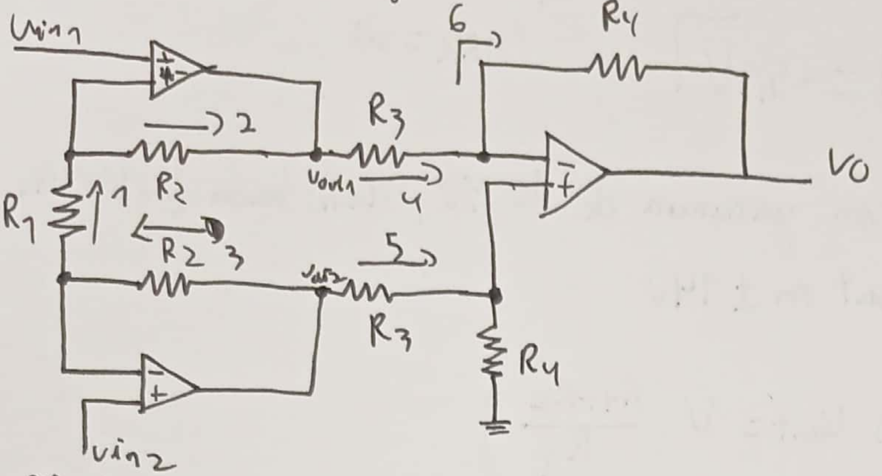
Codigo de salida $b_3 b_2 b_1 b_0 = 1001$

$$V_0 = V_{ref}\left(\frac{1}{2} + \frac{1}{16}\right) = 1'6875V$$

Error $E = \frac{V_0 - V_i}{V_{LSB}} = \frac{1'6875 - 1'8}{3/2^4} = -0'6 \text{ LSB}$

Enero 2021

1] Ganancia en modo común, diferencial y factor de rechazo en cada una y el total



1ª etapa

$$\frac{V_{i2}-V_{i1}}{R_1} = \frac{V_{i1}-V_{o1}}{R_2} \rightarrow V_{out_1} = R_2\left[\frac{V_{i1}}{R_2} + \frac{V_{i1}}{R_1} - \frac{V_{i2}}{R_1}\right]$$

$$\frac{V_{out2}-V_{in2}}{R_2} = \frac{V_{i2}-V_{i1}}{R_1} \rightarrow V_{out2} = R_2\left[\frac{V_{i2}}{R_2} + \frac{V_{i2}}{R_1} - \frac{V_{i1}}{R_1}\right]$$

$$V_{out} = A_d V_d + A_{cm} V_{cm} \quad \left| \begin{array}{l} A_d = V_{i2}-V_{i1} \\ A_{CM} = \dfrac{(V_{i2}+V_{i1})}{2} \end{array}\right.$$

Diferencial $V_{out2} - V_{out1} = (V_{i2}-V_{i1})\left(1+2\frac{R_2}{R_1}\right) \rightarrow A_{d1} = 1+2\frac{R_2}{R_1} = 11 V/V$

Modo común $\frac{V_{o2}+V_{o1}}{2} = \frac{V_{i1}+V_{i2}}{2}\cdot 1 \rightarrow A_{CM1} = 1$

$$CMRR_1 = 20\log_{10}\frac{A_{d1}}{A_{CM1}} = 20{,}83\, dB$$

2ª etapa

$$\frac{V_{o1}-V}{R_3} = \frac{V-V_o}{R_4}$$

$$\frac{V_{o2}-V}{R_3} = \frac{V-0}{R_4} \rightarrow V = V_{o2}\frac{R_4}{R_3+R_4}$$

$V_{out} = (V_{o2}-V_{o1})\frac{R_4}{R_3}$ Parámetro diferencial

$A_{d2} = \frac{R_4}{R_3} = 2 V/V$

$A_{CM2} = 0$

$CMRR_2 = 20\log_{10}\left(\frac{2}{0}\right) = \infty$

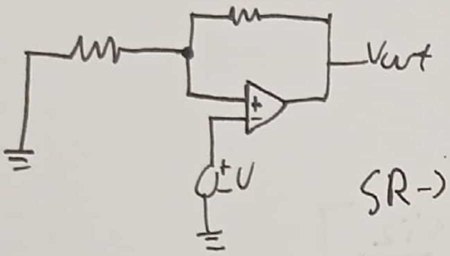
Para el total sustituimos V_{o2} y V_{o1}

$$V_{out} = \left[(V_{i2} - V_{i1})\left(1 + 2\frac{R_2}{R_1}\right)\right]\frac{R_4}{R_3} = \left|\begin{array}{l} A_d = \left(1+2\frac{R_2}{R_1}\right)\frac{R_4}{R_3} = 22 V/V \\ A_{CM} = 0 \\ CMRR = \infty \end{array}\right.$$

$$\boxed{V_{out} = 22\,(2{,}25 - 2{,}5) = -5{,}5V}$$

2/ AO a ±15 V (no inv.) con ganancia de 10 V/V, ancho banda $f_T = 1{,}5 MHz$

Vrespuesta $S = 0{,}8 \frac{V}{\mu s}$ y sat en ±14V



$\rightarrow V_{out} = V\left(\frac{R_1+R_2}{R_1}\right)$

SR → max. pendiente del cambio posible para la salida

$$SR = \left.\frac{dV_{out}}{dt}\right|_{max} = V_{max} \cdot \omega$$

Ancho de Banda → $BW = f_T B = \frac{f_T}{ganancia} = 150 kHz$ no se puede superar.

a) $V_{out} = A_d v_{in} = 10 \cdot 0{,}6 = 6V < V_{max}$ ✓

$$SR = \omega V = 2\pi f V \rightarrow f = \frac{SR}{2\pi V} = \frac{0{,}8 \cdot 10^6}{2\pi \cdot 6} = 21{,}22 kHz < BW ✓$$

b) $f = 10 kHz \rightarrow V = \frac{SR}{2\pi f} = 1{,}273V < V_{max}$ ✓

$$V_{in\,max} = \frac{1{,}273}{10} = 0{,}1273V$$

c) $V_{in} = 50mV \rightarrow V_{out} = 10 \cdot 50 \times 10^{-3} = 0{,}5 V < V_{out\,max}$

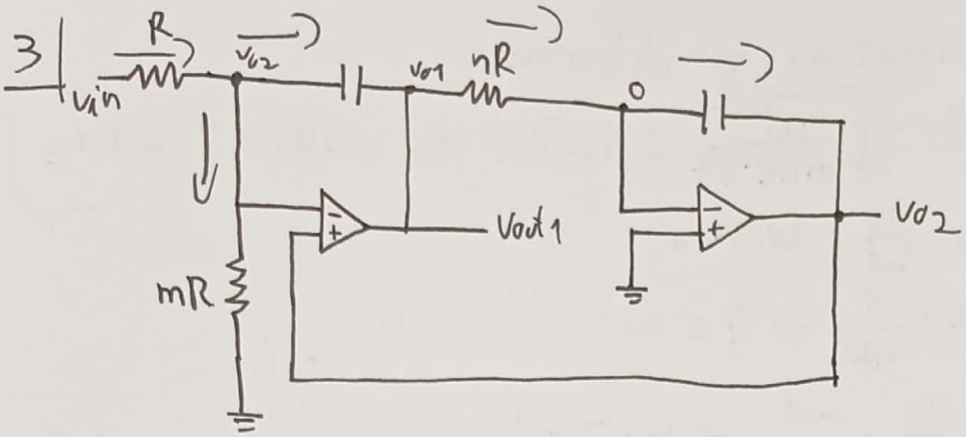
$f = \frac{SR}{2\pi V} = 254 kHz > BW$ El rango será hasta BW

d) $V_{max} = \frac{SR}{2\pi f} = \frac{0{,}8 \cdot 10^6}{2\pi \cdot 5 \cdot 10^3} = 25V > V_{out\,max}$ rango hasta +15V

$f = 5kHz$

$V_{in} = \frac{15}{10} = 1'5 \rightarrow$ rango útil de $0 \rightarrow 1{,}5V$

3



$$(1)\ \frac{V_{in}-V_{o2}}{R} = \frac{V_{o2}-0}{mR} + \frac{V_{o2}-V_{o1}}{1/CS}$$

$$(2)\ \frac{V_{o1}-0}{nR} = \frac{0-V_{o2}}{1/CS} \rightarrow V_{o1} = -nRCS\,V_{o2}$$

Despejamos 1 $\quad \frac{V_{in}}{R} = V_{o2}\left(\frac{1}{mR}+\frac{1}{R}+CS\right) - V_{o1}CS$

$$V_{in} = V_{o2}\left(\frac{1}{m}+1+RCS\right) - V_{o1}RCS =$$

$$= V_{o2}\left(\frac{1}{m}+1+RCS+nR^2C^2S^2\right) = V_{o2}\left(\frac{1+m+mRCS+mR^2C^2nS^2}{m}\right) =$$

$$= V_{o2}\left(\frac{\frac{1+m}{mnR^2C^2}+\frac{\cancel{RC}}{nR^2C^2}S+S^2}{\frac{1}{nR^2C^2}}\right) = \left(\frac{S^2+\frac{1}{nRC}S+\frac{1+m}{mnR^2C^2}}{\frac{1}{nR^2C^2}}\right)V_{o2}$$

$$G_2 = \frac{V_{o2}}{V_{in}} = \frac{\frac{1}{nR^2C^2}}{S^2+\frac{1}{nRC}S+\frac{1+m}{mnR^2C^2}}$$ Pasa baja

$$V_{o2} = -\frac{V_{o1}}{nRCS}$$

$$G_1 = \frac{V_{o1}}{V_{in}} \overset{?}{=} \frac{-\frac{1}{RC}S}{S^2+\frac{1}{nRC}S+\frac{1+m}{mnR^2C^2}}$$ Pasa banda

Calculemos sus parametros y diagramas

• $G_1 = \dfrac{\frac{H_0 w_0}{Q} s}{s^2 + \frac{w_0}{Q}s + w_0^2}$

$w_0 = \sqrt{\dfrac{m+1}{mnR^2C^2}} = 12567\ Hz \rightarrow \boxed{w_0 = 12567\ Hz}$

$\boxed{f_0 = \dfrac{w_0}{2\pi} = 2000\ Hz}$

$\dfrac{w_0}{Q} = \dfrac{1}{nRC} \rightarrow \boxed{Q = 10}$

$\dfrac{H_0 w_0}{Q} = \dfrac{-1}{RC} \rightarrow \boxed{H_0 = -100}$

Para el diagrama $BW = \dfrac{f_0}{Q} = f_2 - f_1 = 200$

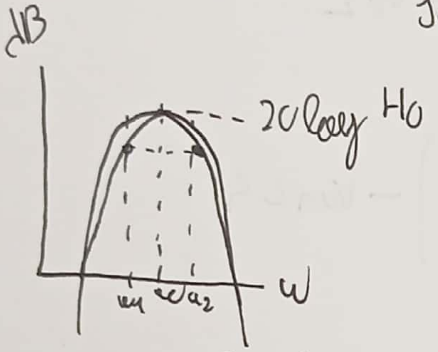
$f_0^2 = f_1 \cdot f_2$

$f_1^2 + \dfrac{f_0}{Q} f_1 - f_0^2 = 0$

$\hookrightarrow \boxed{f_1 = 1902\ Hz}$

$\downarrow$

$\boxed{f_2 = 2103\ Hz}$



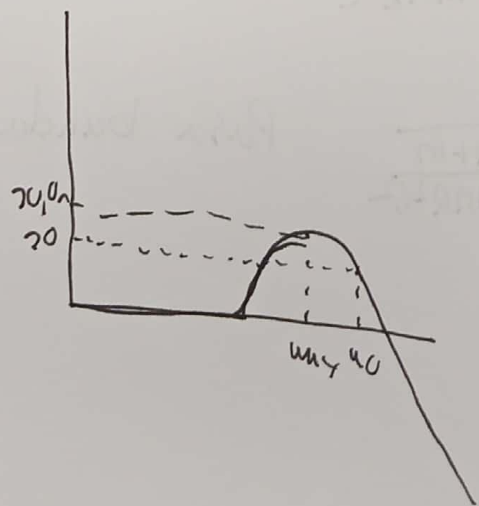
• G_2 w_0, f_0, Q iguales

$H_0 w_0^2 = \dfrac{1}{nR^2C^2} \rightarrow \boxed{H_0 = 1}$

$\boxed{w_{max} = w_0\sqrt{1 - \dfrac{1}{2Q^2}} = 12535\ Hz}$

$20\log_{10}|G(w_{max})| = 20\log_{10}\left|\dfrac{QH_0}{\sqrt{1 - \frac{1}{4Q^2}}}\right| = 20{,}01\ dB$

$20\log_{10}|G(w_0)| = 20\log_{10}|H_0 Q| = 20\ dB$



4) DA 3bits $V_{FSR} = 8V$

PSF 6

$V_o = \{0'05, 1'05, 2'03, 2'94, 3'95, 5'04, 6'00, 6'95\} V$

- Calculamos $V_{LSB} = \left| \frac{V_{FSR}}{2^n} \right| = \frac{8}{8} = 1$

- $E_{off} = \frac{V_{out}|_{000}}{V_{LSB}} = 0'05$

- $E_g = \left(\frac{V_{out}|_{111}}{V_{LSB}} - \frac{V_{out}|_{000}}{V_{LSB}} \right) - (2^n - 1) = -0,1$

- Compensamos los voltajes $V_{out\ comp} = \frac{V_{out}}{V_{LSB}} - E_{off} - \frac{i E_g}{2^n - 1}$ $i = 0, 1, 2 \ldots$

$V_{out\ comp} = \{0, 1,01, 2'01, 2'93, 3'96, 5'06, 6'04, 7\}$

- Calculamos $DNLE_j = \frac{V_{j+1} - V_j - V_{LSB}}{V_{LSB}} = V_{j+1} - V_j - \cancel{V_{LSB}}\ 1$

(Cabello dijo que el primer dato es 0 (se acepta y no se calcula))

Mención a Andrea que lo preguntó

$DNLE = \{\cancel{0, 0'01, 0'02}, 0, 0,01, 0, -0'08, 0'03, 0'1, -0'02, -0'04\}$

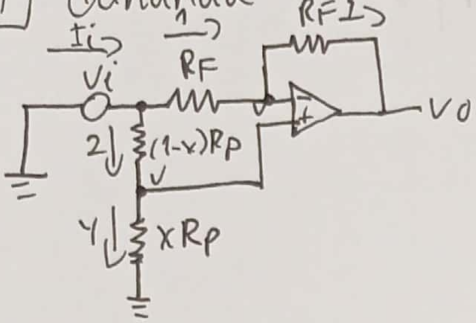
- Calculamos $INLE_k = \sum_{k=0}^{j} DNLE_k$

$INLE = \{0, 0'01, 0'01, -0'07, -0'04, 0'06, 0,04, 0\}$

Si empieza en 0 y acaba en 0 bien!

Julio 2020

1] Ganancia en tensión. Impedancia de entrada, valor si $R_F = R_P = 10k\Omega$ en $x = 0, 0.5, 1$



$$I_i = \frac{V_i - V}{R_F} + \frac{V_i - V}{(1-x)R_P} \quad (1)$$

$$\frac{V_i - V}{R_F} = \frac{V - V_o}{R_F} \rightarrow (2)$$

$$\frac{V_i - V}{(1-x)R_P} = \frac{V - 0}{xR_P} (3) \rightarrow V\left(\frac{1}{xR_P} + \frac{1}{(1-x)R_P}\right) = \frac{V_i}{(1-x)R_P}$$

$$\rightarrow V = xV_i$$

Sust. 3 en 2 $\quad \frac{V_i - xV_i}{\cancel{R_F}} = \frac{xV_i - V_o}{\cancel{R_F}}$

$$V_i(1-2x) = V_o \rightarrow V_o = A_d V_i \rightarrow \boxed{A_d = 1 - 2x}$$ Ganancia en tensión

$$1)\ I_i = (V_i - V)\left(\frac{1}{R_F} + \frac{1}{(1-x)R_P}\right) = V_i(1-x)\left(\frac{1}{R_F} + \frac{1}{(1-x)R_P}\right) =$$

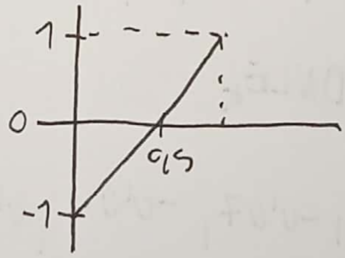
$$= V_i\left(\frac{(1-x)}{R_F} + \frac{1}{R_P}\right) = V_i\left(\frac{(1-x)R_P + R_F}{R_F R_P}\right) \underset{R_P = R_F = R}{=} V_i\left(\frac{\cancel{R}[(1-x)+1]}{R^{\cancel{2}}}\right) =$$

$$= V_i\left(\frac{2-x}{R}\right) \rightarrow \boxed{Z_i = \frac{V_i}{I_i} = \frac{R}{2-x}}$$

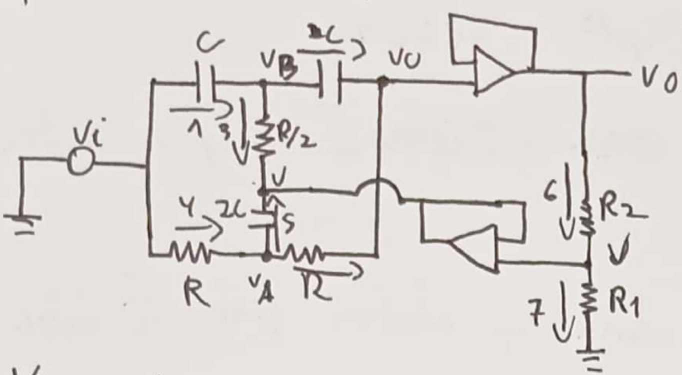
$Z_i(0) = 5k\Omega$

$Z_i(0{,}5) = 6{,}67k\Omega$

$Z_i(1) = 10k\Omega$



2| parametros y Bode



- $\frac{V_i - V_B}{1/Cs} = \frac{V_B - V_0}{1/2Cs} + \frac{V_B - V}{R/2}$ (1)
- $\frac{V_i - V_A}{R} = \frac{V_A - V_0}{R} + \frac{V_A - V}{1/2Cs}$ (2)
- $\frac{V_0 - V}{R_2} = \frac{V - 0}{R_1}$ (3)
- $\cancel{\frac{V_B - V}{R/2} + \frac{V_A - V}{1/2Cs} = 0}$ (4) $\frac{V_A - V_0}{R} + \frac{V_B - V_0}{1/Cs} = 0$

- $\frac{V_0}{R_2} = V\left(\frac{1}{R_1} + \frac{1}{R_2}\right) \Rightarrow V_0 = V\left(\frac{R_2}{R_1} + 1\right)$

$V = \frac{V_0}{\left(\frac{R_2}{R_1} + 1\right)}$

- Despejando (1) y sust. V obtenemos $V_B = \frac{Cs}{2(Cs + \frac{1}{R})} V_i + \frac{Cs + \frac{2}{R}\frac{1}{1 + \frac{R_2}{R_1}}}{2(Cs + \frac{1}{R})} V_0$

- Despejando (2) y sust. V $V_A = \frac{1}{R(2Cs + \frac{2}{R})} V_i + \frac{\frac{1}{R} + \frac{2Cs}{(1 + \frac{R_2}{R_1})}}{2Cs + \frac{2}{R}} V_0$

- Remix juntando todo en 4 y despejando $\frac{V_0}{V_i}$

$$\frac{V_0}{V_i} = \frac{s^2 + \frac{1}{(RC)^2}}{s^2 + \frac{4}{RC}\frac{R_2}{R_1 + R_2} s + \frac{1}{(RC)^2}}$$ banda eliminada

- Calculo de parametros

$w_0 = \frac{1}{RC} = 314,47$ rad/s $\to f_0 = 50,05$ Hz

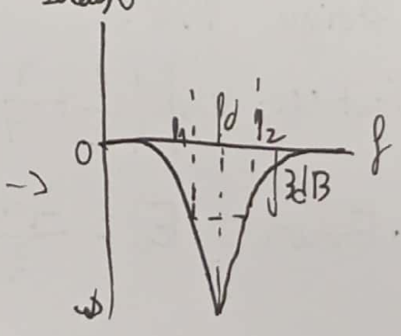
$\frac{w_0}{Q} = \frac{4}{RC}\frac{R_2}{R_1 + R_2} \to Q = \frac{R_1 + R_2}{4R_2} = 5$

$H_0 = 1$

- Calculo f_1 y f_2

$f_2 - f_1 = \frac{f_0}{Q}$ | $f_1^2 + \frac{f_0}{Q} f_1 - f_0^2 = 0$ | $f_1 = 45,29$ Hz

$f_0^2 = f_1 \cdot f_2$ | | $f_2 = 55,30$ Hz $\to$



3| ADC redist. de carga

$n = 4 \quad V_{ref} = 3V \quad C = 8pF \quad C_p = 4pF \quad V_i = 2'5V$

- Ciclo de muestreo: todos los cond. a tierra y C_p no afecta

$Q = V_i \cdot C_{eq} = 2C\, V_i$

- Ciclo de retención: abrimos SW_C, ahora C_p afecta pero Q debe mantenerse

$Q_1 = Q_2 \rightarrow 2C V_i = -V_p(2C + C_p) \rightarrow V_p = -\frac{2C}{2C+C_p} V_i = -2V$

- Ciclo de redist. de carga: Vamos ~~abriendo~~ poniendo a V_{ref} o tierra para cada bit.

• C a V_{ref}, resto a tierra $\quad (V_{ref} - V_1)C = (C + C_p)V_1 \rightarrow V_1 = \frac{C}{2C+C_p} V_{ref} = 1,2V$

$V_p + V_1 = -1 < 0 \rightarrow \boxed{b_3 = 1}$

• C y $\frac{C}{2}$ a V_{ref}, resto tierra $\quad (V_{ref} - V_2)(C + \frac{C}{2}) = (\frac{C}{4} + \frac{2C}{8} + C_p) V_2 \rightarrow V_2 = \frac{C + \frac{C}{2}}{2C+C_p} V_{ref} = 1,8V$

$V_p + V_2 = -0,5 < 0 \rightarrow \boxed{b_2 = 1}$

• C y $\frac{C}{2}$ y $\frac{C}{4}$ a V_{ref} $\quad (V_{ref} - V_3)(C + \frac{C}{2} + \frac{C}{4}) = (\frac{2C}{8} + C_p) V_3 \rightarrow V_3 = \frac{(C + \frac{C}{2} + \frac{C}{4})}{2C+C_p} V_{ref} = 2,1$

$V_p + V_3 = +0,1 > 0 \rightarrow b_1 = 0$

• C, $\frac{C}{2}$ y $\frac{C}{8}$ a V_{ref} $\quad (V_{ref} - V_4)(C + \frac{C}{2} + \frac{C}{8}) = (\frac{C}{4} + \frac{C}{8} + C_p) V_4 \rightarrow V_4 = \frac{(C + \frac{C}{2} + \frac{C}{8})}{2C+C_p} V_{ref} = 1,95$

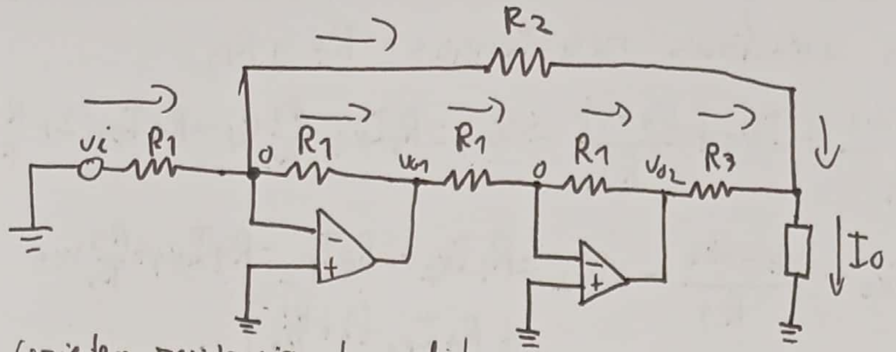
$V_p + V_4 = -0,05 < 0 \rightarrow b_0 = 1$

• Codigo 1101

• Vout $V_C = V_{ref}\left(\frac{1}{2} + \frac{1}{4} + \frac{0}{8} + \frac{1}{16}\right) = 2,44V$

• Error $\quad E_C = \frac{2,44 - 2,5}{3/2^4} = -0,34 LSB$

4|



a) Corriente y resistencia de salida, condición resistencia infinita

- $\frac{vi-0}{R_1} = \frac{0-Vo}{R_2} + \frac{0-Vo_1}{R_1} \rightarrow Vo_1 = -vi - \frac{R_1}{R_2} Vo$

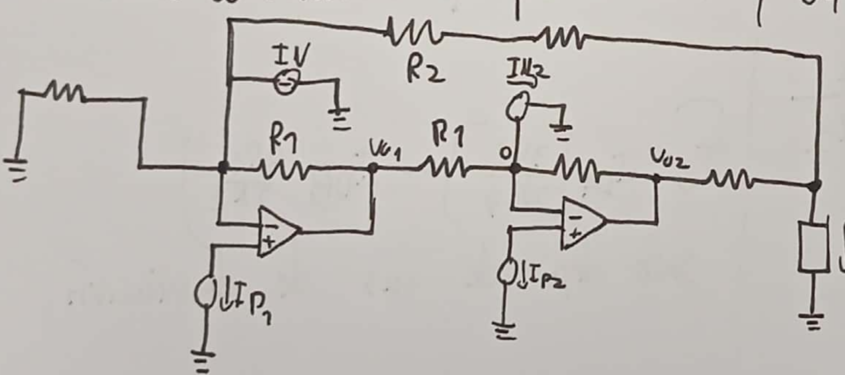
- $\frac{Vo_1-0}{R_1} = \frac{0-Vo_2}{R_1} \rightarrow Vo_1 = -Vo_2 \rightarrow Vo_2 = vi + \frac{R_1}{R_2} vo$

- $\frac{Vo_2 - Vo}{R_3} = \frac{0-Vo}{R_2} + Io \rightarrow \frac{Vo_2}{R_3} = vo\left(\frac{1}{R_3} - \frac{1}{R_2}\right) + Io$

$Io = \frac{vi}{R_3} + \left(\frac{R_1}{R_2R_3} - \frac{1}{R_2} - \frac{1}{R_3}\right) Vo \rightarrow \boxed{Ro = \frac{1}{\frac{R_1}{R_2R_3} - \frac{1}{R_2} - \frac{1}{R_3}} = \frac{R_2R_3}{R_1-(R_2+R_3)}}$

Cond. $Ro = \infty \rightarrow \boxed{R_1 = R_2 + R_3}$

b) añadimos corrientes de polarización, V_1 a tierra



Las corrientes I_N e I_P siempre dirección a la tierra

Las corrientes I_P no contribuyen debido a que no entra corriente por + así que está entre 2 tierras

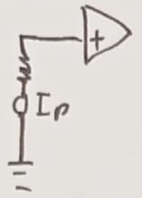
$I_{N1} - \frac{Vo_1}{R_1} - \frac{Vo}{R_2} = 0 \quad \rightarrow Vo_1 = R_1 I_{N1} - \frac{R_1}{R_2} Vo$

$\frac{Vo_1}{R_1} = I_{N2} - \frac{Vo_2}{R_1} \quad \rightarrow Vo_2 = R_1(I_{N2} - I_{N1}) + \frac{R_1}{R_2} Vo$

$\frac{Vo_2 - Vo}{R_3} = Io + \frac{Vo}{R_2} \quad \rightarrow Io = \frac{R_1}{R_3}(I_{N2} - I_{N1}) + Vo\underbrace{\left(\frac{R_1}{R_2R_3} - \frac{1}{R_2} - \frac{1}{R_3}\right)}_{\overset{Ro\to\infty}{=0}}$

$$\boxed{Io = \frac{R_1}{R_3}(I_{N2} - I_{N1})}$$

c) Ahora a las I_p les añadimos resistencias R_A y R_B



$$\frac{V_A}{R_1} = \frac{V_A - V_{o1}}{R_1} + I_{N1} + \frac{V_A - V_o}{R_2} \rightarrow V_{o1} = R_1 I_{N1} - \frac{R_1}{R_2} v_o - R_A I_{P1}\left(2+\frac{R_1}{R_2}\right)$$

$$\frac{V_{o1}-V_B}{R_1} = I_{N2} + \frac{V_B - V_{o2}}{R_1} \rightarrow V_{o2} = R_1 I_{N2} - 2R_B I_{P2} - R_1 I_{N1} + \frac{R_1}{R_2} v_o + R_A I_{P1}\left(2+\frac{R_1}{R_2}\right)$$

$$\frac{V_{o2}-V_o}{R_3} + \frac{V_A - V_o}{R_2} = I_o \rightarrow I_o = I_{P1} R_A\left(\frac{2}{R_3}+\frac{R_1}{R_2R_3} \mp \frac{1}{R_2}\right) - \frac{2R_B}{R_3} I_{P2} + \frac{R_1}{R_3}\left(I_{N2}-I_{N1}\right)$$

$$V_A = -R_A I_{P1}$$

$$V_B = -R_B I_{P2}$$

Ahora escojo R_A y R_B de forma que anulen $I_{Pi} = \frac{I_{Ni}+I_{Pi}}{2}$

$$I_o = \frac{I_{PA}}{2}\left[\underbrace{R_A\left(\frac{2}{R_3}+\frac{R_1}{R_2R_3}-\frac{1}{R_3}\right)}\right] + \frac{I_{PB}}{2}\left[\underbrace{\frac{R_1}{R_3}-\frac{2R_B}{R_3}}_{0}\right] + I_{DA}\left[R_A\left(\frac{2}{R_3}+\frac{R_1}{R_2R_3}-\frac{1}{R_3}\right)+\frac{R_1}{2R_2}\right]$$

$$+ I_{DB}\left[-\overset{0}{\frac{2R_B}{R_3}} - \frac{R_1}{2R_3}\right]$$

con $I_D = I_P - I_N$ $\begin{cases} I_P = I_P + \frac{I_D}{2} \\ I_N = I_P - \frac{I_D}{2} \end{cases}$

- $R_A = \dfrac{R_1/R_3}{\frac{2R_2+R_1-R_2}{R_2R_3}} = \dfrac{R_1R_2}{R_1+R_2}$

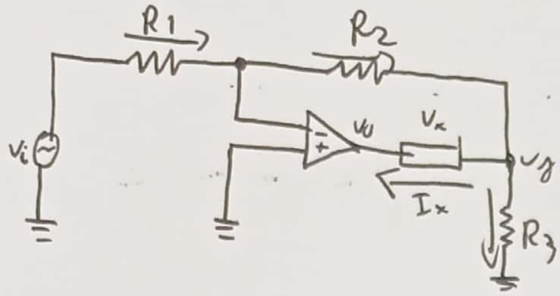
- $R_B = \dfrac{R_1}{2}$

$$\boxed{I_o = I_{DA}\left[\frac{3R_1}{2R_3}\right] - I_{DB}\frac{3R_1}{2R_2}}$$

solo dep. de las de desviación

2019 Enero

1|



Cierva

- No ideal $V_o = (V_+ - V_-)A = -AV_-$
- Queremos $Z = \frac{V_x}{I_x}$

$-V_x = V_y - (-A_d V_-) \rightarrow V_y = -A_d V + V_x$

- Ponemos $V_i = 0$

$$\frac{0 - V_-}{R_1} = \frac{V_- - V_y}{R_2} \rightarrow V_y = V\left(\frac{R_1 + R_2}{R_1}\right) \rightarrow V = V_y\left(\frac{R_1}{R_1 + R_2}\right)$$

$$\frac{V_- - V_y}{R_2} = I_x + \frac{V_y - 0}{R_3} \rightarrow I_x = \frac{V}{R_2} - V_y\left(\frac{R_2 + R_3}{R_2 R_3}\right)$$

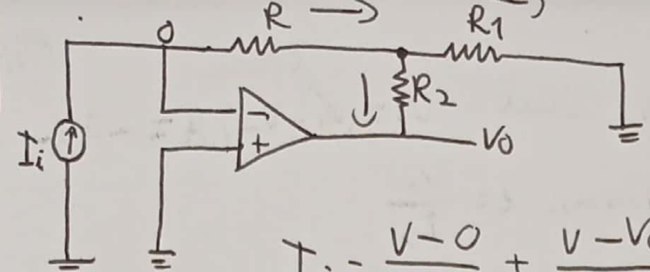
$$I_x = V_y\left(\frac{R_1}{R_2(R_1 + R_2)}\right) - V_y\left(\frac{R_2 + R_3}{R_2 R_3}\right) = V_y\left(\frac{R_1}{R_2(R_1 + R_2)} - \frac{R_2 + R_3}{R_2 R_3}\right)$$

Cambiando ~~of~~ V_y (me dio pereza y se lo copie a yayo):

$$I_x = \frac{V_x}{R_1(1 + A_d) + R_2}\left(\frac{R_1}{R_2} - \frac{(R_1 + R_2)(R_2 + R_3)}{R_2 R_3}\right)$$

$$Z = \frac{V_x}{I_x} = \frac{R_3 R_2\left[R_1(1 + A_d) + R_2\right]}{R_3 R_1 - (R_1 + R_2)(R_2 + R_3)} = \boxed{-500\ k\Omega}$$

2



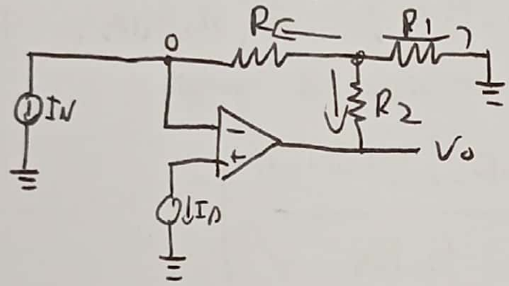
a) $I_i = \frac{V-0}{R_1} + \frac{V-V_0}{R_2} \to I_i = \frac{-I_iR}{R_1} - \frac{I_iR}{R_2} - \frac{V_0}{R_2}$ (1)

$I_i = \frac{0-V}{R} \to V = -I_iR$

(1) $-I_i\left(1+\frac{R}{R_1}+\frac{R}{R_2}\right) = \frac{V_0}{R_2} \to \boxed{V_0 = -I_i\left(R_2+\frac{RR_2}{R_1}+R\right)}$

$\frac{V_{out}}{I_i} = G = -\left(R_2+\frac{RR_2}{R_1}+R\right)$

b) Eliminamos Ii poniendo circuito abierto y añadimos IN e Ip



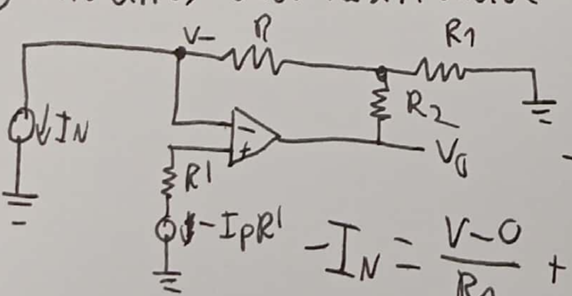
No puede entrar corriente en el operacional por lo que Ip no influye $V_-=0$

$-I_N = \frac{0-V}{R} \to V = +I_NR$

$-I_N = \frac{V-0}{R_1}+\frac{V-V_0}{R_2} \to \frac{V_0}{R_2} = I_N\left(1+\frac{R}{R_1}+\frac{R}{R_2}\right)$

$V_0 = I_N R_2\left(1+\frac{R}{R_1}+\frac{R}{R_2}\right)$

c) Añadimos una resistencia R'



$V(+)=V(-)=-I_pR'$

$-I_N = \frac{-I_pR'-V}{R}$ (Creo que IN debería llevar un - por la definición)

$-I_N = \frac{V-0}{R_1}+\frac{V-V_0}{R_2}$

Sustituimos, despejamos Vo

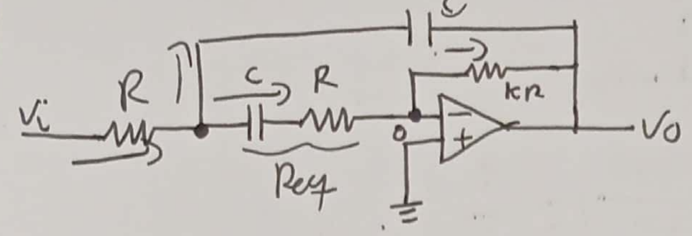
$V_0 = I_N\left(R_2+\frac{RR_2}{R_1}+R\right) - I_p\left(\frac{R'R_2}{R_1}+1\right)$

$\left(R_2+\frac{RR_2}{R_1}+R\right) = \frac{R'R_2}{R_1}+1$

Despejamos R'

$\boxed{R' = \frac{R_2R_1+RR_2+RR_1}{R_2+R_1}}$

3)



PSF 10

$$R_{eq} = \frac{1}{Cs} + R = \frac{1+RCs}{Cs}$$

1) $$\frac{V_i - V}{R} = \frac{V - V_o}{1/Cs} + \frac{V-0}{R_{eq}}$$

2) $$\frac{V-0}{R_{eq}} = \frac{0-V_o}{kR} \rightarrow V = -V_o \frac{R_{eq}}{kR} = -V_o \frac{1+RCs}{kRCs}$$

$$\frac{V_i}{R} = V\left(\frac{1}{R} + Cs + \frac{1}{R_{eq}}\right) - V_o Cs$$

$$V_i = V\left(1 + RCs + \frac{R}{R_{eq}}\right) - V_o RCs \rightarrow V_i = -V_o\left(\frac{1+RCs}{kRCs}\left(\left(1+RCs+\frac{R}{R_{eq}}\right) + RCs\right)\right)$$

$$V_{in} = -V_o\left(\frac{(k+1)R^2C^2s^2 + 3RCs + 1}{kRCs}\right) = -V_o\left(\frac{s^2 + \frac{3}{(k+1)RC}s + \frac{1}{(k+1)R^2C^2}}{\frac{k}{(k+1)RC}s}\right)$$

$$\frac{V_o}{V_{in}} = G(s) = \frac{-\frac{k}{(k+1)RC}s}{s^2 + \frac{3}{(k+1)RC}s + \frac{1}{(k+1)R^2C^2}}$$ Pasa banda $$G(s) = \frac{\frac{H_o w_o}{Q}s}{s^2 + \frac{w_o}{Q}s + w_o^2}$$

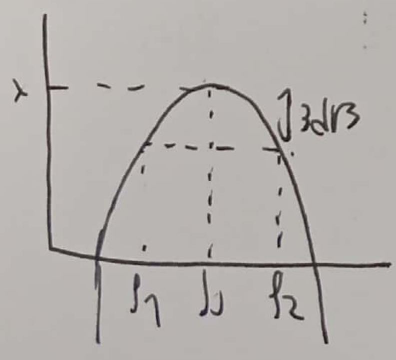
- Calculamos los parametros

- $w_o = \sqrt{\frac{1}{k+1}}\,\frac{1}{RC} = 6298'81\ rad/s \rightarrow f_o = 1002\ Hz$

- $\frac{w_o}{Q} = \frac{3}{(k+1)RC} \rightarrow Q = 5$

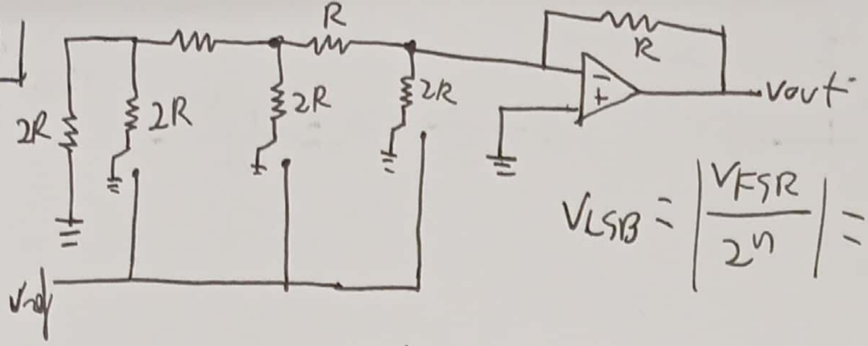
- $\frac{H_o w_o}{Q} = -\frac{k}{RC(k+1)} \rightarrow H_o = -75$

b) Diagrama $\left.\begin{array}{l} BW = \frac{f_o}{Q} = f_2 - f_1 \\ f_o^2 = f_1 f_2 \end{array}\right\}$ $f_1^2 + \frac{f_o}{Q} f_1 - f_o^2 = 0$ $\left\{\begin{array}{l} f_1 = 906'6\ Hz \\ f_2 = 1107\ Hz \end{array}\right.$



$x = 20\log_{10}|H_o| = 37'75\ dB$

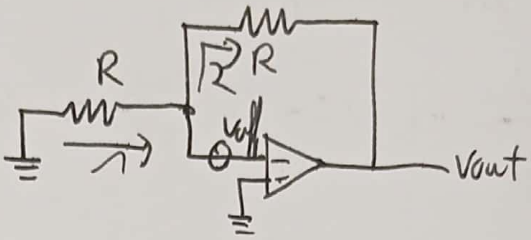
4|



$V_{LSB} = \left| \frac{V_{FSR}}{2^n} \right| = \frac{1}{8}$

- $E_{off} = \frac{V_{out}|_{000}}{V_{LSB}}$ Todos a tierra

Calculamos $R_{eq} = R \rightarrow$



$V_o = (V_+ - V_-) A_d = -V_- A_d$

$V_A = V_{off} + V_-$; $V_- = -\frac{V_o}{A_d}$

$I_1 = I_2$

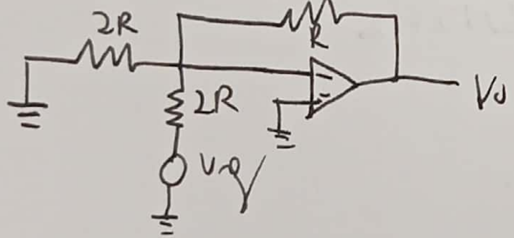
$\frac{0 - V_A}{R} = \frac{V_A - V_{out}}{R} \rightarrow V_{out} = V_{off}\left(2 - \frac{2}{A_d}\right)$

Entonces $E_{off} = \frac{V_{out}|_{000}}{V_{LSB}} = 0{,}11\ LSB$

- Buscamos calcular $E_g = \left(\frac{V_{out}|_{111}}{V_{LSB}} - \frac{V_{out}|_{000}}{V_{LSB}} \right) - (2^n - 1)$

Calculamos $V_{out}|_{111} = V_{out}|_{100} + V_{out}|_{010} + V_{out}|_{001} + V_{out}|_{000}$

- Conectamos el primero a Vref

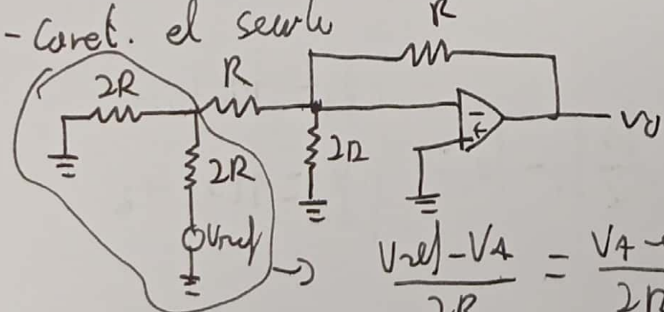


$\frac{V_{ref} - V_-}{2R} = \frac{V_- - 0}{2R} + \frac{V_- - V_{out}}{R}$

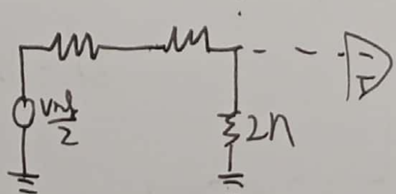
$\hookrightarrow V_{out}|_{100} = -\frac{A_d}{2(2 + A_d)} \cdot V_{ref} = -\frac{100}{2(2+100)} \cdot 7 \cdot 10^{-3}$

- Conect. el segundo

Se hace Thevenin

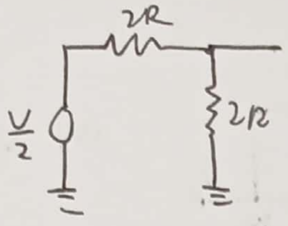


$\frac{V_{ref} - V_A}{2R} = \frac{V_A - 0}{2R} \rightarrow V_A = \frac{V_{ref}}{2} \rightarrow$



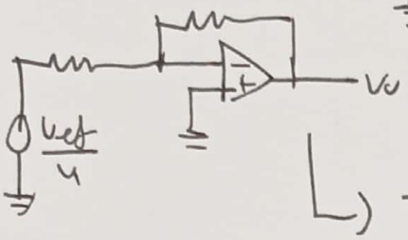
$Z_{eq} = \frac{1}{\frac{1}{2R} + \frac{1}{2R}} = R$

Repetimos thevenin



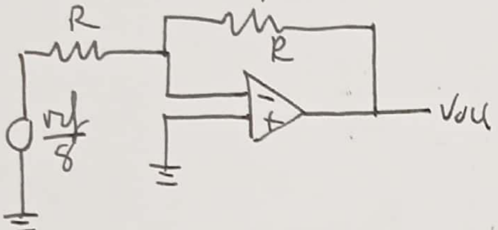
$$\frac{\frac{V_{ref}}{2} - V_A}{2R} = \frac{V_A}{2R}$$

$$\boxed{V_A = \frac{V_{ref}}{4}}$$



$$\frac{\frac{V_{ref}}{4} - V_-}{\cancel{R}} = \frac{V_- - V_{out}}{R} \rightarrow V_{out}\big|_{010} = -V_{ref}\frac{A_d}{4(2+A_d)}$$

- Por ultimo repetimos pero con la ult resistencia y haciendo thevenin nos queda



$$\rightarrow \frac{\frac{V_{ref}}{8} - V_-}{\cancel{R}} = \frac{V_- - V_{out}}{\cancel{R}}$$

$$V_{out}\big|_{001} = -V_{ref}\left(\frac{A_d}{8(2+A_d)}\right)$$

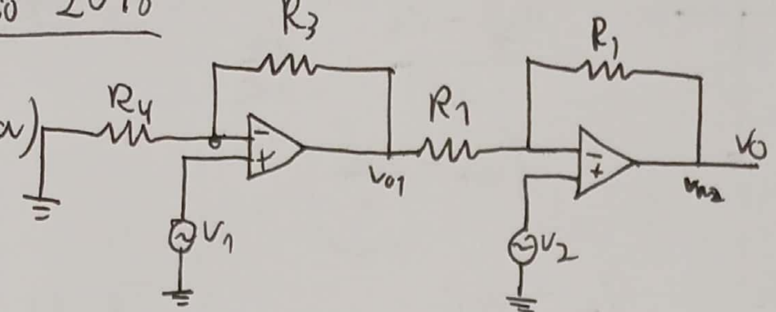
Sumamos todo $\rightarrow V_{111} = 0{,}87\,V$

$$E_g = \left(\frac{V_o|_{111}}{V_{LSB}} - \frac{V_o|_{000}}{V_{LSB}}\right) - (2^n - 1) = -0{,}15\,LSB$$

(No me gusta este ejercicio).

Junio 2018

1| a)



a) $V_0 = A_d (V_2 - V_1)$

$$\frac{0-V_1}{R_4} = \frac{V_1 - V_{o1}}{R_3} \rightarrow \frac{V_{o1}}{R_3} = V_1\left[\frac{1}{R_4}+\frac{1}{R_3}\right] \rightarrow V_{o1} = V_1\left(\frac{R_3}{R_4}+1\right)$$

$$\frac{V_{o1}-V_2}{R_1} = \frac{V_2-V_0}{R_2} \rightarrow \frac{V_0}{R_2} = V_2\left(\frac{1}{R_1}+\frac{1}{R_2}\right) - \frac{V_{o1}}{R_1}$$

$$\rightarrow V_0 = V_2\left(\frac{R_2}{R_1}+1\right) - \frac{R_2}{R_1}V_{o1}$$

$$\rightarrow V_0 = V_2\left(\frac{R_2}{R_1}+1\right) - V_1\frac{R_2}{R_1}\left(\frac{R_3}{R_4}+1\right)$$

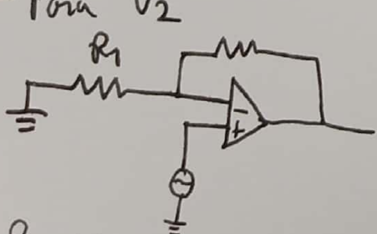
$$\frac{R_2}{R_1}+1 = \frac{R_2}{R_1}\left(\frac{R_3}{R_4}+1\right) \rightarrow \cancel{1}+\frac{R_1}{R_2} = \frac{R_3}{R_4}\cancel{+1} \rightarrow \frac{R_1}{R_2} = \frac{R_3}{R_4}$$

$$\boxed{V_0 = \left(\frac{R_2}{R_1}+1\right)(V_2 - V_1)} \qquad \boxed{A_d = \frac{R_2}{R_1}+1}$$

b) Este apartado es raro

$$|A_{CL}(\omega_0)| = \frac{A_{CLO}}{\sqrt{1+\left|\frac{\omega_0}{\omega_c}\right|^2}} = \frac{A_{CLO}}{\sqrt{2}}$$

- Para V_2



$$\frac{0-V_-}{R_1} = \frac{V_- - V_0}{R_2} \Rightarrow V_- = V_0 \overbrace{\left[\frac{R_1}{R_1+R_2}\right]}^{\beta}$$

$$\beta = \frac{R_1}{R_1+R_2} = \frac{1}{1+9} = 0{,}1 \qquad BW_2 = 0{,}1 \cdot f_T = 0{,}1 \cdot 10^6 = 100\,kHz$$

- Para V_1

1ª $\left\{ \frac{0-V_1}{R_4} = \frac{V_1 - V_0}{R_3} \rightarrow V_{o1} = V_1\left[1+\frac{R_2}{R_1}\right] \rightarrow G_1 = \frac{10}{9} \rightarrow \beta = \frac{9}{10} = 0{,}9 \right.$

2ª $\left\{ \frac{V_1' - 0}{R_1} = \frac{0 - V_0}{R_2} \rightarrow V_0 = -\frac{R_2}{R_1}V_1' \rightarrow G_2 = -9 \rightarrow \beta = 0{,}1 \right.$

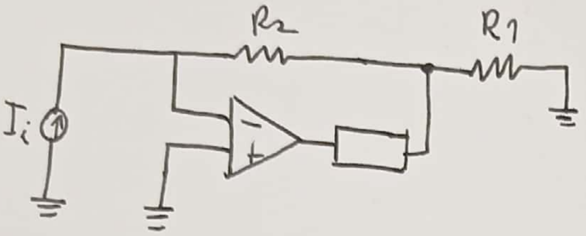
$|A_{CLO}| = |G_2||G_1| = 10//$

$$\frac{10/4}{\sqrt{1+\left(\frac{w_0}{\beta_1 w_{t_1}}\right)^2}} \cdot \frac{0'1}{\sqrt{1+\left(\frac{w_0}{\beta_2 w_{t_2}}\right)^2}} = \frac{10}{\sqrt{2}}$$

$$\left(1+\frac{f_0^2}{B_1^2 f_t^2}\right)\left(1+\frac{f_0^2}{B_2^2 f_t^2}\right) = 2$$ (Despejando y todo eso

$f_0^4 + 8'2\cdot 10^{11} f_0^2 - 8'1\cdot 10^{21} = 0$ $\boxed{f_0 = 98\,kHz}$

2)



$I_i = \frac{0-V}{R_2} \to V = -I_i R_2$

$I_i = \frac{V-0}{R_1} + I_0 \to I_i\left(1+\frac{R_2}{R_1}\right) = I_0$

$\boxed{I_0 = \left(1+\frac{R_2}{R_1}\right) I_i}$

b) $I_i = \frac{V_- - V}{R_2}$ $\quad V_{out} = -A_d V_-$

$I_{in} = \frac{V-0}{R_1} + I_0 \ (1)$ $\quad V_L = V - V_{out} = V + A_d V_-$

$V_- = I_i R_2 + V$ $\to V_L - V = I_i R_2 A_d + V A_d \cdot \cancel{2V(1+A_d) = V_L - I_{in} R_2 A_d}$

$V_- = \frac{V_L - V}{A_d}$ $\quad \cancel{V = \frac{V_L}{1+A_d} - I_i \frac{R_2 A_d}{1+A_d}}$

$\to V(1+A_d) = V_L - I_i R_2 A_d$

$V = \frac{V_L}{1+A_d} - I_{in}\frac{R_2 A_d}{1+A_d}$; $\quad V_- = \frac{V_L}{1+A_d} + I_{in}\frac{R_2}{1+A_d}$

Sust. en 1

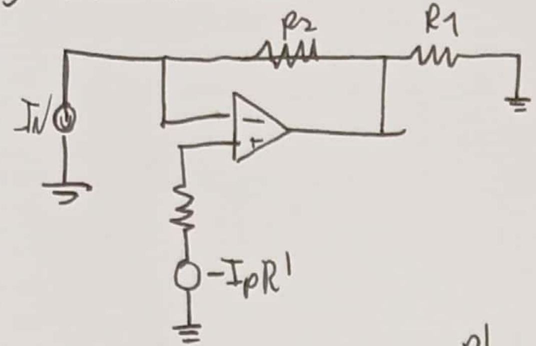
$$I_0 = I_{in} - \frac{V_L}{R_1(1+A_d)} + I_{in}\frac{R_2 A_d}{R_1(1+A_d)}$$

$$I_0 = I_{in}\left(1+\frac{R_2 A_d}{R_1(1+A_d)}\right) - \frac{V_L}{R_1(1+A_d)}$$

$G_m = \frac{R_1(1+A_d) + R_2 A_d}{R_1(1+A_d)}$

$R_L = R_1(1+A_d)$

c) Introducimos las corrientes de pol. y la resistencia extra



$$V(-)=V(+)=-I_p R'$$

$$I_1 = I_0 + I_N \to I_0 = \frac{0-V_A}{R_1} - I_N$$

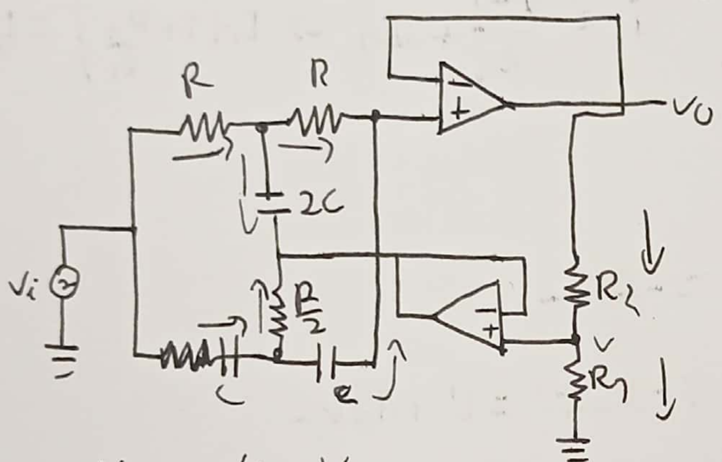
$$I_N = \frac{V_A + I_p R'}{R_2} \to V_A = I_N R_2 - I_p R'$$

$$I_0 = I_p \frac{R'}{R_1} - I_N \left(1+\frac{R_2}{R_1}\right)$$

$$\frac{R'}{R_1} = 1+\frac{R_2}{R_1} \to R' = R_1\left(1+\frac{R_2}{R_1}\right)$$

$$I_0 = \left(1+\frac{R_2}{R_1}\right)(I_p - I_N)$$

3|



- $$\frac{V_i - V_A}{R} = \frac{V_A - V}{1/2Cs} + \frac{V_A - V_o}{R} \to V_A = \frac{V_i}{2RCs+2} + V_o \frac{1+2Cs2R}{2(RCs+1)}$$
- $$\frac{V_i - V_B}{1/Cs} = \frac{V_B - V}{R/2} + \frac{V_B - V_o}{1/Cs} \to V_B = V_i \frac{RCs}{2(1+RCs)} + V_{out} \frac{RCs+2\alpha}{2(1+RCs)}$$
- $$\frac{V_A - V_o}{R} + \frac{V_B - V_o}{1/Cs} = 0 \quad (1)$$
- $$\frac{V_o - V}{R_2} = \frac{V-0}{R_1} \to \frac{V_o}{R_2} = V\left(\frac{1}{R_2}+\frac{1}{R_1}\right) \to \frac{V_o}{\left(1+\frac{R_2}{R_1}\right)} = V \to V = \alpha V_o$$

Juntamos todo en 3 y despejamos $\frac{V_{out}}{V_i}$

$$G = \frac{V_{out}}{V_{in}} = \frac{s^2 + \frac{1}{R^2C^2}}{s^2 + \frac{4(1-\alpha)s}{RC} + \frac{1}{R^2C^2}}$$

banda eliminada

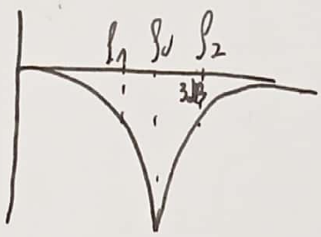
Calculamos los parametros $G(s) = \frac{H_0(s^2+w_n^2)}{s^2+\frac{w_0}{Q}s+w_0^2}$

$w_0 = \frac{1}{RC} = 377'36 \to f_0 = \frac{w_0}{2\pi} = 60\,Hz$

$H_0 = 1$ $\qquad \frac{w_0}{Q} = \frac{4(1-\alpha)}{RC} \to Q = 25$

Calculamos f_1 y f_2

$$\left.\begin{array}{l} f_1 f_2 = f_0^2 \\ BW = \frac{f_0}{Q} = f_2 - f_1 \end{array}\right\} \quad f_1^2 + \frac{f_0}{Q} f_1 - f_0^2 = 0 \quad \left\{\begin{array}{l} f_2 = 61'21\,Hz \\ f_1 = 58'81\,Hz \end{array}\right.$$



4/ ADC 3 bits $\quad ref = 5V \quad V_0 = \{0{,}29,\ 0{,}90,\ 1{,}46,\ 2{,}25,\ 2{,}92,\ 3{,}57,\ 4{,}43\}$

$V_{LSB} = \frac{V_{ref}}{2^3} = 0'625$

$E_{off} = \frac{V_0|_{001}}{V_{LSB}} - \frac{1}{2}LSB = \frac{0'25}{0'625} - \frac{1}{2} = -0'1\,LSB$

$E_g = \left(\frac{V_0|_{111}}{V_{LSB}} - \frac{V|_{001}}{V_{LSB}}\right) - (2^n - 2) = 0'688\,LSB$

Compensar $\to V_{out}|_{comp} = V_{out} - E_{off} - \frac{iE_g}{2^n-2}$

$V_{comp} = \{0'5,\ 1'426,\ 2'268,\ 3'358,\ 4'326,\ 5'242,\ 6'504\}$

$DNLE_j = \frac{V_{j+1} - V_j - V_{LSB}}{V_{LSB}} = V_{j+1} - V_j - 1$

$DNLE = \{0,\ -0{,}074,\ -0'218,\ 0'15,\ -0{,}042,\ -0'074,\ 0'262\}\,LSB$

$INLE_j = \sum_{k=0}^{j} DNLE_k$

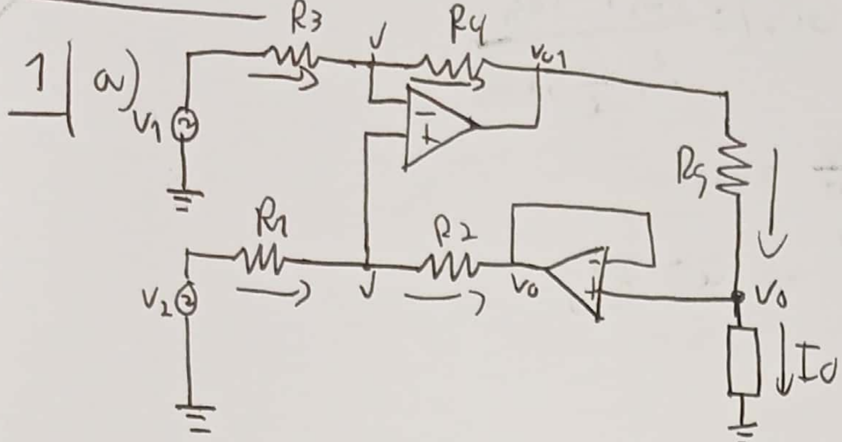
$INLE = \{0,\ -0{,}074,\ -0'292,\ -0'142,\ -0'184,\ -0'258,\ 0'004\}\,LSB$

$\downarrow$

Debería ser 0

Enero 2018

1| a)



$$\frac{V_1 - V}{R_3} = \frac{V - V_{o1}}{R_4} \quad (1)$$

$$\frac{V_2 - V}{R_1} = \frac{V - V_o}{R_2} \quad (2)$$

$$\frac{V_{o1} - V_o}{R_5} = I_o \quad (3)$$

1) $V = V_1 \frac{R_4}{R_3+R_4} + \frac{R_3}{R_3+R_4} V_{o1}$

2) $V = V_o \frac{R_1}{R_1+R_2} + V_2 \frac{R_2}{R_1+R_2}$

$V_{o1} = V_o \frac{R_1(R_3+R_4)}{R_3(R_1+R_2)} + V_2 \frac{R_2(R_3+R_4)}{R_3(R_1+R_2)} - \frac{R_4}{R_3} V_1$

$$I_o = \frac{V_{out}}{R_5}\left(\frac{R_1(R_3+R_4)}{R_3(R_1+R_2)} - 1\right) + V_2 \frac{R_2(R_3+R_4)}{R_5R_3(R_1+R_2)} - V_1 \frac{R_4}{R_5R_3}$$

$$I_o = A_2V_2 - A_1V_1 - \frac{V_{out}}{R_o}$$

$$\frac{1}{R_5}\left(1 - \frac{R_1(R_3+R_4)}{R_3(R_1+R_2)}\right) = 0 \rightarrow \boxed{\frac{R_2}{R_1} = \frac{R_4}{R_3}}$$

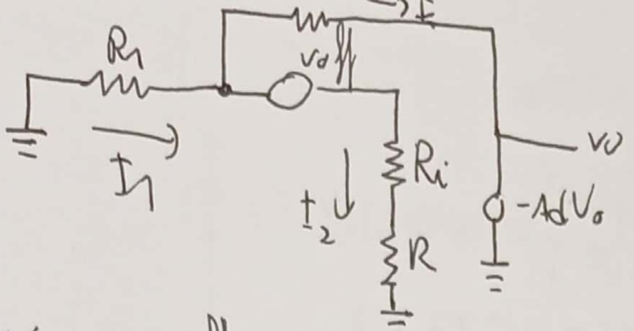
Por lo que

$$I_o = \frac{R_2}{R_5R_1}(V_2 - V_1)$$

b) Pereza, meter corrientes pol y resolver

PSF 14

2|



$$I_1 = I_2 + I$$

$$I_2 = \frac{V_d}{R_i} = \frac{V - V_{off}}{R_i + R}$$

$$\frac{0 - V}{R_1} = \frac{V - V_{off}}{R_i + R} + \frac{V - V_{out}}{R_2} \rightarrow V = V_{off} + V_d \frac{R_i + R}{R_i} = V_{off} - V_{out}\frac{R_i + R}{A_d R_i}$$

$$\hookrightarrow V\left(\frac{1}{R_1} + \frac{1}{R_i + R} + \frac{1}{R_2}\right) = \frac{V_{off}}{R_i + R} + \frac{V_{out}}{R_2}$$

Juntas $V_{out} = \dfrac{A_d R_i (R_1 + R_2)}{R_1 R_i A_d + (R_i + R)(R_2 + R_1) + R_1 R_2}$

Si $A_d = \infty \rightarrow V_{out} = \dfrac{R_1 + R_2}{R} V_{off}$

3| Metemos v_x al principio

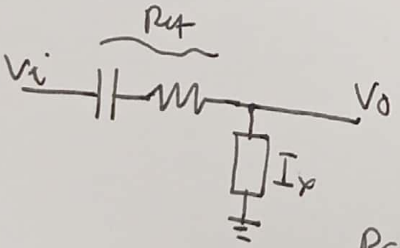
$- I_4 = I_5$

$$\frac{V_1 - V_x}{R_4} = \frac{V_x - 0}{R_5} \rightarrow V_1 = V_x\left(1 + \frac{R_4}{R_5}\right)$$

$- I_2 = I_3$

$$\frac{V_2 - V_x}{R_2} = (V_x - V_1) C_3 s \rightarrow V_2 = \left(1 - \frac{R_2 R_4}{R_5} C_3 s\right) V_x$$

$$- I_x = (V_x - V_2) C_1 s \rightarrow I_x = V_x \frac{R_2 R_4 C_3 C_1 s^2}{R_5} \rightarrow \boxed{Z_{eq} = \frac{V_x}{I_x} = \frac{R_5}{R_2 R_4 C_3 C_1 s^2}}$$



$$\rightarrow (V_{in} - V_o)\frac{Cs}{RCs + 1} = V_o \frac{R_2 R_4 C_3 C_1 s^2}{R_5}$$

$$\downarrow$$

$$V_{in} = V_{out}\left(\frac{s^2 + \frac{1}{RC}s + \frac{R_5}{R R_2 R_4 C_1 C_3}}{\frac{R_5}{R R_2 R_4 C_1 C_3}}\right)$$

$$\frac{V_{out}}{V_{in}} = G = \frac{\frac{R_5}{R R_2 R_4 C_1 C_3}}{s^2 + \frac{1}{RC}s + \frac{R_5}{R R_2 R_4 C_1 C_3}}$$ pasa baja

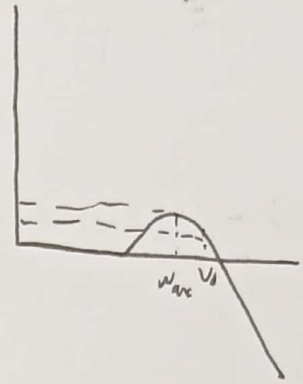
$$\omega_0 = \sqrt{\frac{R_5}{R R_2 R_4 C_1 C_3}} = 5034 \rightarrow f_0 = \frac{\omega}{2\pi} = 802\,Hz \; ; \; H_0 = 1$$

$$\frac{\omega_0}{Q} = \frac{1}{RC} \rightarrow Q = 3'42 \simeq 4$$

b) $w_{max} = w_0 \sqrt{1 - \frac{1}{2Q^2}} = 4958'43 Hz$

$$20 \log_{10} |G(jw_{max})| = 20 \log_{10} \left| \frac{H_0 Q_0}{\sqrt{1 - \frac{1}{4Q^2}}} \right| = 12'04 dB$$

$$20 \log_{10} |G(jw)| = 20 \log_{10} |H_0 Q| = 11'97 dB$$

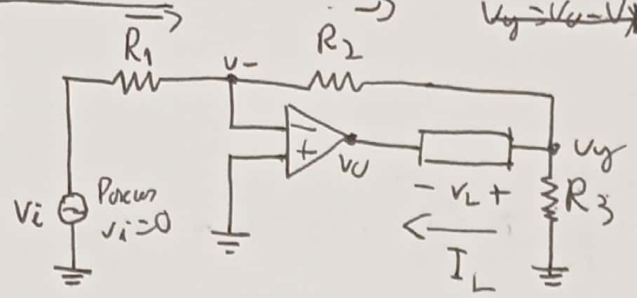


4) El mismo que el anterior

Enero 2023

PSF 7s

1)



$\cancel{V_L = V_y - V_o}$ $\cancel{V_y = V_o - V_L}$

$V_o = (V_+ - V_-)\,A_d = -A_d V_- \rightarrow V_- = -\frac{V_o}{A_d}$

1) $\frac{0 - V_-}{R_1} = \frac{V_- - V_y}{R_2}$

2) $\frac{V_- - V_y}{R_2} = I_L + \frac{V_y - 0}{R_3}$

$V_L = V_y - V_o \rightarrow V_y = V_L + V_o = V_L - A_d V_-$

1) $\frac{-V_-}{R_1} = \frac{V_-}{R_2} - \frac{V_y}{R_2} \rightarrow \frac{V_L}{R_2} = V_-\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{A_d}{R_2}\right]$

$V_L = V_-\left[\frac{R_2}{R_1} + 1 + A_d\right] = \cancel{V_- \frac{R_1(1+A_d)+R_2}{R_1 R_2}}$

$V_- = V_L \frac{1}{\left[\frac{R_2}{R_1} + 1 + A_d\right]}$

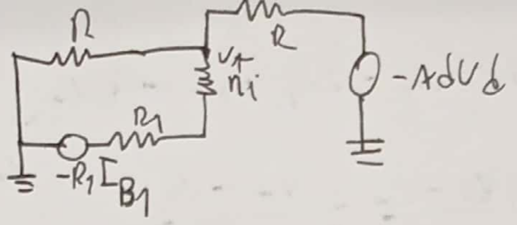
$V_y = V_L - A_d V_- = V_L\left[1 - \frac{A_d}{\left[\frac{R_2}{R_1} + 1 + A_d\right]}\right]$

$I_L = +\frac{V_-}{R_2} - V_y\left[\frac{1}{R_2} - \frac{1}{R_3}\right] = \frac{V_L}{\left[\frac{R_2}{R_1} + 1 + A_d\right]R_2} - V_L\left[1 - \frac{A_d}{\left[\frac{R_2}{R_1} + 1 + A_d\right]}\right]\cdot\left[\frac{1}{R_2} - \frac{1}{R_3}\right]$

$I_L = V_L\left[\frac{1}{R_2\left[\frac{R_2}{R_1} + 1 + A_d\right]} - \left[1 - \frac{A_d}{\left[\frac{R_2}{R_1} + 1 + A_d\right]}\right]\left[\frac{1}{R_2} - \frac{1}{R_3}\right]\right]$

$Z_L = \frac{V_L}{I_L} = -\frac{R_3\left[R_1(1+A_d) + R_3\right]}{R_3 + R_2 + R_1} = -507\ k\Omega$

2



$$\frac{0-V_1}{R} = \frac{V_1 - V_0}{R} + \frac{V_d}{R_i} \to \frac{V_0}{R} = \frac{2V_1}{R} + \frac{V_d}{R_0} \to V_0 = 2V_1 + \frac{V_d}{R_i}R$$

$$\frac{V_d}{R_i} = \frac{V_1 - (-R_1 I_{B1})}{R_1 + R_i} = \frac{R_1 + R_1}{-A_d R_1} V_1 - R_1 I_{B1}$$

$$V_0 = \frac{-2R_1 R_i A_d}{A_d R_i + 2(R_1 + R_i + R)} I_{B1}$$

3 ADC $n=4$ $V_{ref}=3V$ $C=8pF$ $C_p=4pF=\frac{C}{2}$ $V_i=2,4V$

- Ciclo de muestreo
  Todos a tierra y a V_i

  $Q = C_{eq}\Delta V = 2CV_i$

- Ciclo de retención abrimos SW0 por lo que C_p afecta.
  La carga se conserva

  $Q_1 = Q_p \to 2CV_i = -(2C+C_p)V_p \to V_p = -\frac{2C}{2C+C_p}V_i = -1,92V$

- Ciclo de redist. de carga
  - Conectamos C a V_{ref} $\quad (V_{ref}-V_1)C = C_{eq}V_1 \to V_1 = \frac{C}{2C+C_p}V_{ref} = 1,2$

    $V_p + V_1 = -0,72V < 0 \to b_0 = 1$
  - Conectamos C y $\frac{C}{2}$ a V_{ref} $\quad (V_{ref}-V_2)(C+\frac{C}{2}) = C_{eq}V_2 \to V_2 = \frac{C+\frac{C}{2}}{2C+C_p}V_{ref} = 1,8V$

    $V_p + V_2 = -0,12V \to b_1 = 1$
  - Conectamos C, $\frac{C}{2}$ y $\frac{C}{4}$ a V_{ref} $\quad (V_{ref}-V_3)(C+\frac{C}{2}+\frac{C}{4}) = C_{eq}V_3 \to V_3 = \frac{C+\frac{C}{2}+\frac{C}{4}}{2C+C_p}V_{ref} = 2,$

    $V_p + V_3 = 0,18V > 0 \to b_2 = 0$
  - Conectamos C, $\frac{C}{2}$, $\frac{C}{8}$ a V_{ref} $\quad V_4 = \frac{C+\frac{C}{2}+\frac{C}{8}}{2C+C_p}V_{ref} = 0,03V > 0 \to b_3 = 0$

$V_{out} = V_{ref}\left(\frac{1}{2}+\frac{1}{4}+\frac{0}{8}+\frac{0}{16}\right) = 2,25V$ Código 1100 $\to E = \frac{V_0 - V_i}{\frac{3}{2^4}} = -0,8LSB$