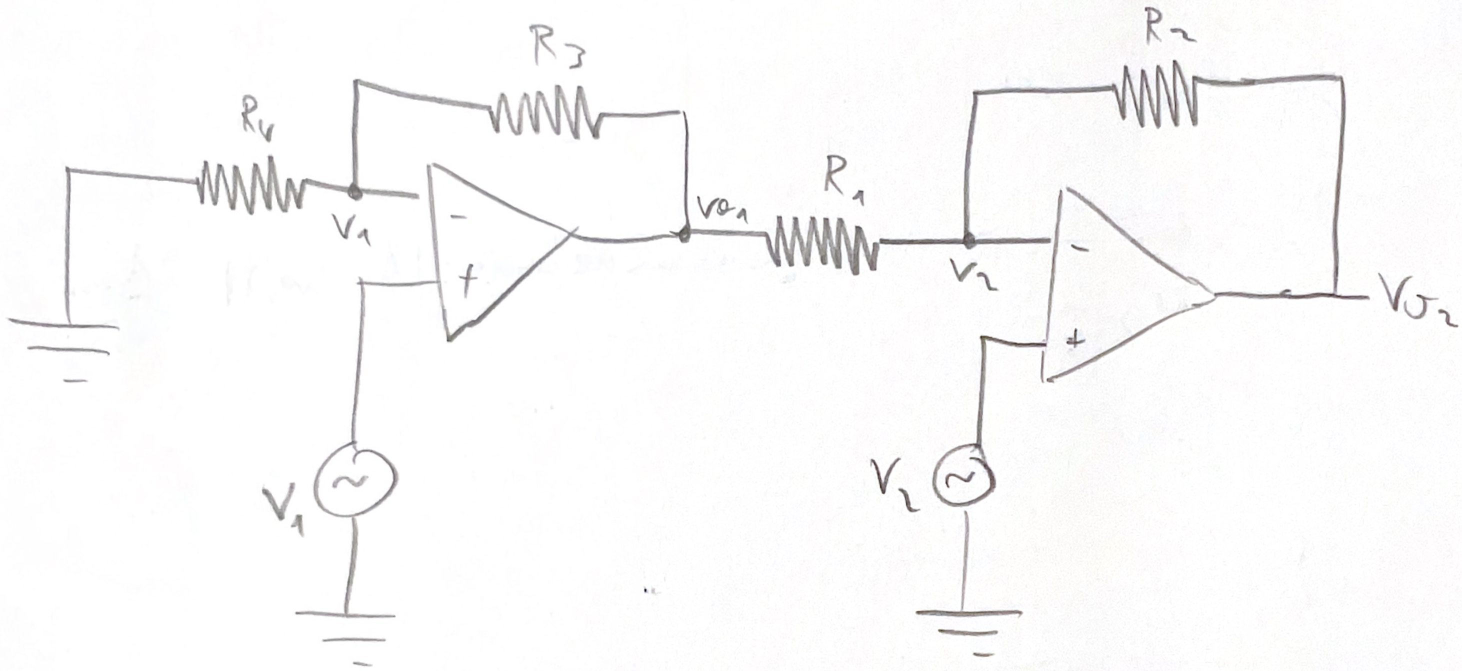
JUNIO 2018

(1)

Amplificador instrumentación implementado con dos A.O.s.

a) Condición para que el circuito implemente una verdadera operación de amplificación de diferencia de tensión. Bajo esta condición obtener expresión de V_o y de ~~tensión de~~ ganancia en tensión (A_d) del AI. Asumir A.O.Is.



$$\frac{0 - V_1}{R_4} = \frac{V_1 - V_{o1}}{R_3} \; ; \; \frac{V_{o1}}{R_3} = V_1\left(\frac{1}{R_3} + \frac{1}{R_4}\right) \Rightarrow V_{o1} = V_1\left(1 + \frac{R_3}{R_4}\right)$$

$$\frac{V_{o1} - V_2}{R_1} = \frac{V_2 - V_{o2}}{R_2} \; ; \; \frac{V_{o2}}{R_2} = V_2\left(\frac{1}{R_1} + \frac{1}{R_2}\right) - \frac{V_1}{R_1}\left(1 + \frac{R_3}{R_4}\right) \; ;$$

$$V_{o2} = V_2\left(1 + \frac{R_2}{R_1}\right) - V_1\left(\frac{R_2}{R_1} + \frac{R_2 R_3}{R_1 R_4}\right) \Rightarrow 1 + \cancel{\frac{R_2}{R_1}} = \cancel{\frac{R_2}{R_1}} + \frac{R_2 R_3}{R_4} \; ;$$

$$R_2 R_3 = R_4 R_1 \; ; \; \frac{R_1}{R_2} = \frac{R_3}{R_4} \Rightarrow$$

$$V_{o_2} = \left(\frac{R_2}{R_1}+1\right)(V_2 - V_1) \Rightarrow A_d = \frac{R_2}{R_1}+1$$

(b) Si los A.O son reales en el sentido de que ambos poseen $f_{T1} = f_{T2} = 1\,MHz$ e ideales en todos los demás términos, determina:

i) Ancho de banda con el que el amplificador procesa la señal V_2.

ii) " " " " " " " " " " V_1.

$R_3 = R_1 = 1\,k\Omega$, $R_4 = R_2 = 9\,k\Omega$

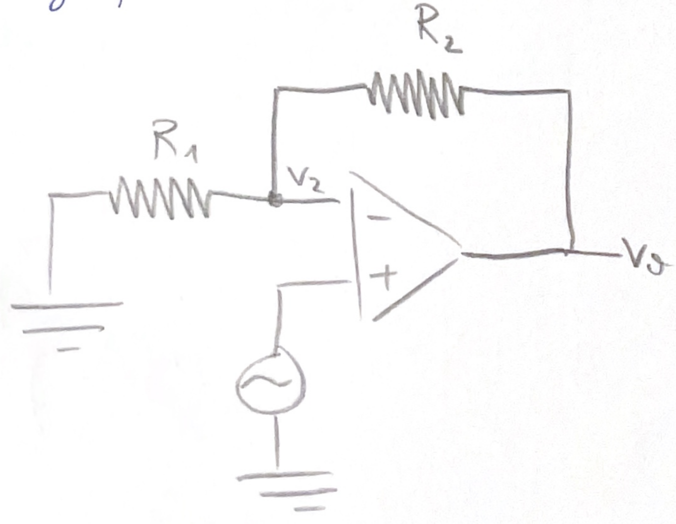
APARTADO RARO
DEL MISMO ESTILO QUE JUNIO 2024

$f_{T1} = f_{T2} = 6\,MHz$

$$A_{CL} = \frac{A_{CL0}}{1+j\frac{w}{w_c}} \Rightarrow \text{A la frecuencia de corte: } |A_{CL}(w_0)| = \frac{A_{CL0}}{\sqrt{2}}$$

$BW = f_T \cdot \beta$

i)

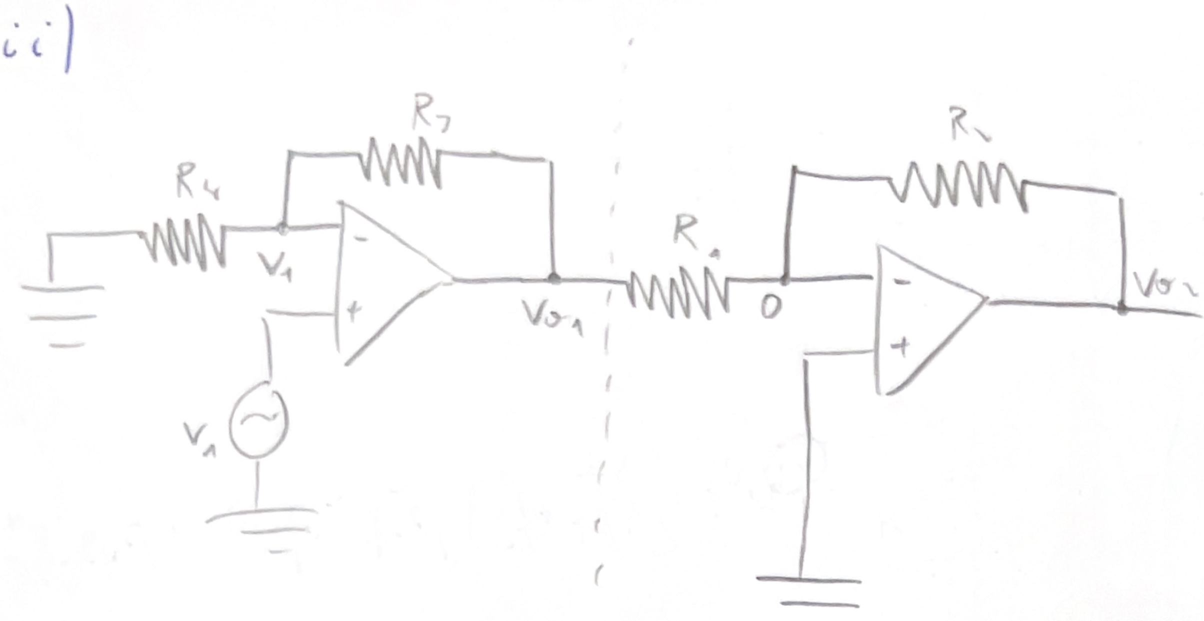


$$\frac{0-V_2}{R_1} = \frac{V_2 - V_o}{R_2} ;\ V_o = V_2\left(\frac{1}{R_1}+\frac{1}{R_2}\right)\cdot R_2 = V_2\left(1+\frac{R_2}{R_1}\right) = V_2\,\frac{R_1+R_2}{R_1}$$

$$\beta_2 = \frac{R_1}{R_1+R_2} = \frac{1}{1+9} = 0'1$$

$$\Rightarrow BW_2 = f_{T1}\cdot\beta_2 = 0'1\cdot 10^6 = \underline{100\,kHz}$$

ii)



ETAPA 1:

$$\frac{0-V_1}{R_4} = \frac{V_1 - V_{o1}}{R_3} \; ; \; V_{o1} = V_1 \frac{R_3+R_4}{R_4} \Rightarrow |A_{CLo1}| = \frac{R_3+R_4}{R_4} = \frac{9+1}{9} = \frac{10}{9}$$

$$\beta_1 = \frac{R_4}{R_3+R_4} = \frac{9}{10} = 0'9$$

ETAPA 2:

$$\frac{V_{o1}-0}{R_1} = \frac{0-V_{o2}}{R_2} \; ; \; V_o = -\frac{R_2}{R_1} v_{o1} \Rightarrow |A_{CLo2}| = 9$$

$\beta_2 = 0'1$ (ya calculado antes), $BW_1 = 0'1 \cdot 10^6 = 100kHz$

$$A_{CL} = |A_{CLo1}| \cdot |A_{CLo2}| = 9 \cdot \frac{10}{9} = 10$$

→ Para calcular la f_c usamos: $|A_{CL}(w_o)| = \frac{|A_{CLo}|}{\sqrt{2}}$

$\quad ||$

$\quad f_o$

$$\frac{10/9}{\sqrt{1+\left(\frac{\omega_0}{\beta_1\omega_{T1}}\right)^2}}\cdot\frac{9}{\sqrt{1+\left(\frac{\omega_0}{\beta_2\omega_{T2}}\right)^2}}=\frac{10}{\sqrt{2}};$$

$$\left(1+\frac{f_0^2}{\beta_1^2 f_{T1}^2}\right)\left(1+\frac{f_0^2}{\beta_2^2 f_{T2}^2}\right)=2;\ (\beta_1^2 f_T^2+f_0^2)(\beta_2^2 f_T^2+f_0^2)=2\beta_1^2\beta_2^2 f_T^4;$$

$$f_0^4+(\beta_1^2+\beta_2^2)f_T^2 f_0^2+\beta_1^2\beta_2^2 f_T^4=2\beta_1^2\beta_2^2 f_T^4;$$

$$f_0^4+(\beta_1^2+\beta_2^2)f_T^2 f_0^2-\beta_1^2\beta_2^2 f_T^4=0;$$

$$f_0^4+8'2\cdot10^{11}f_0^2-8'1\cdot10^{21}=0\Rightarrow \underline{\underline{f_0=98\,kHz}}$$

2 ENERO 2016

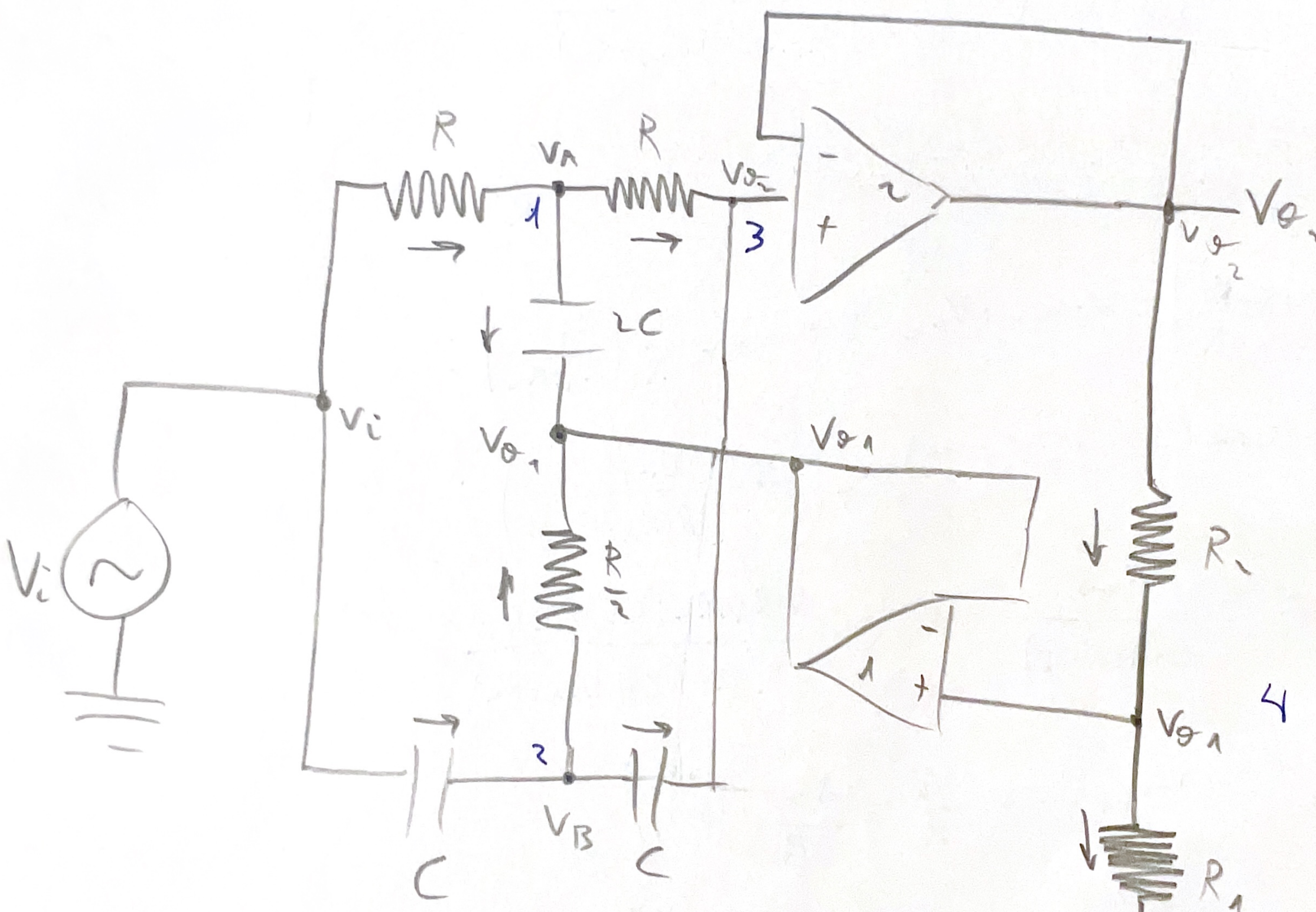
③

El circuito implementa un término cuadrático. Suponiendo A.O.Is, obtener función transferencia e indica el término que implementa.

Obtener H_0, f_0, Q. Esboza diagrama Bode.

$C = 0'1\,\mu F$, $R = 26'5\,k\Omega$, $R_1 = 99\,k\Omega$, $R_2 = 1\,k\Omega$

Buscamos $G(s) = \frac{V_o}{V_i}$



$$\begin{cases} \frac{V_i - V_A}{R} = \frac{V_A - V_{o2}}{R} + (V_A - V_{o1})2Cs \quad (1) \\ (V_i - V_B)Cs = (V_B - V_{o2})Cs + \frac{(V_B - V_{o1})2}{R} \quad (2), \quad \frac{V_{o2} - V_{o1}}{R_2} = \frac{V_{o1}}{R_1} \quad (4) \\ \cancel{(V_A - V_{o1})2Cs = + \frac{(V_B - V_{o1})2}{R}} \quad \frac{V_A - V_{o2}}{R} \pm (V_B - V_{o2})Cs = 0 \end{cases}$$

④

$$I_2 = I_1 \Rightarrow \frac{V_{o_2} - V_{o_1}}{R_2} = \frac{V_{o_1}}{R_1}; \quad V_{o_1} = V_{o_2} \frac{R_1}{R_1+R_2} = V_{o_2}\alpha$$

$$\frac{V_i - V_A}{R} = \frac{V_A - V_{o_2}}{R} + (V_A - V_{o_1})2Cs;$$

$$\frac{V_i}{\cancel{R}} = \frac{2V_A}{\cancel{R}} - \frac{V_{o_2}}{\cancel{R}} + \frac{V_A 2RCs}{\cancel{R}} - \frac{V_{o_1}R2Cs}{\cancel{R}};$$

$$V_i = 2V_A(1+RCs) - V_{o_2}\Big(1 + \underbrace{\frac{R_1}{R_1+R_2}}_{\alpha} 2RCs\Big);$$

$$V_A = V_i \frac{1}{2(1+RCs)} + V_{o_2} \frac{1+2\alpha RCs}{2(1+RCs)}$$

$$(V_i - V_B)Cs = (V_B - V_{o_2})Cs + 2\frac{V_B - V_{o_1}}{R};$$

$$V_i Cs - V_B Cs = V_B Cs - V_{o_2} Cs - \frac{2V_B}{R} - \frac{2V_{o_1}}{R};$$

$$V_i RCs - V_B RCs = V_B RCs - V_{o_2} RCs + 2V_B - 2V_{o_1};$$

$$V_B\, 2(1+RCs) = V_i RCs + V_{o_2} RCs + 2V_{o_2}\alpha = V_i RCs + V_{o_2}(RCs + 2\alpha);$$

$$V_B = V_i \frac{RCs}{2(1+RCs)} + V_{o_2} \frac{RCs + 2\alpha}{2(1+RCs)}$$

$$\frac{V_A - V_{o_2}}{R} + (V_B - V_{o_2})Cs = 0; \quad V_A - V_{o_2} + V_B RCs - V_{o_2} RCs = 0;$$

$$V_A + V_B RCs = V_{o_2}(1+RCs);$$

$$V_i \frac{1}{2(1+RCs)} + V_{o_2} \frac{1+2\alpha RCs}{2(1+RCs)} + V_i \frac{R^2C^2s^2}{2(1+RCs)} + V_{o_2} \frac{R^2C^2s^2 + 2\alpha RCs}{2(1+RCs)} = V_{o_2}(1+RCs)$$

$$V_i + V_{o_2}(1+2\alpha RCs) + V_i R^2C^2s^2 + V_{o_2}(R^2C^2s^2 + 2\alpha RCs) = 2V_{o_2}(1+RCs)^2;$$

$$V_i(1+R^2C^2s^2) = V_{o_2}(2 + 4RCs + 2R^2C^2s^2 - 1 - 2\alpha RCs - R^2C^2s^2 - 2\alpha RCs);$$

$$V_i(1+R^2C^2s^2) = V_{o_2}(R^2C^2s^2 + 4RCs(1-\alpha) + 1); \quad V_{o_2} = \frac{1+R^2C^2s^2}{R^2C^2s^2 + 4RCs(1-\alpha)+1} \Rightarrow$$

$$V_{o_2} = V_i \frac{1+R^2C^2s^2}{R^2C^2s^2+4RCs(1-\alpha)+1} = V_i \frac{\frac{1+R^2C^2s^2}{R^2C^2}}{s^2+\frac{4(1-\alpha)}{RC}s+\frac{1}{R^2C^2}} \Rightarrow$$

$$\Rightarrow G(s) = \frac{V_{o_2}}{V_i} = \frac{s^2+\frac{1}{R^2C^2}}{s^2+\frac{4(1-\alpha)}{RC}s+\frac{1}{R^2C^2}}$$

$\Rightarrow$ FILTRO BANDA ELIMINADA

$$\frac{H_0(s^2+w_m^2)}{s^2+\frac{w_0}{Q}s+w_0^2}$$

$$w_0 = \frac{1}{RC} = 377'36 \text{ rad/s}$$

$$f_0 = \frac{w_0}{2\pi} = 60'05 \text{ Hz}$$

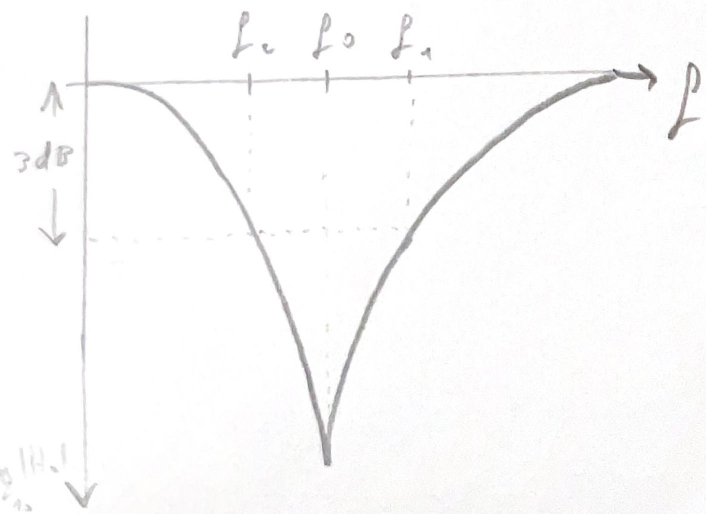
$$\frac{w_0}{Q} = \frac{4(1-\alpha)}{RC} \; ; \; Q = \frac{w_0 RC}{4(1-\alpha)} = \frac{1}{4(1-\alpha)} = 25 \qquad \alpha = \frac{R_1}{R_1+R_2}$$

$$H_0(s^2+w_m^2) = s^2+\frac{1}{R^2C^2} = s^2+w_0^2 \Rightarrow H_0 = 1$$

$$\left.\begin{aligned} f_1 \cdot f_2 &= f_0^2 = 3606 \; ; \; f_1 = \frac{f_0^2}{f_2} \\ f_1 - f_2 &= \frac{f_0}{Q} = 2'402 \end{aligned}\right\} \quad \frac{f_0^2}{f_2} - f_2 = 2'402 \; ; \; f_0^2 - f_2^2 = 2'402 f_2 \; ;$$

$$f_2^2 + 2'402 f_2 - 3606 \; ; \; f_2 = \frac{-2'402+\sqrt{2'402^2+4\cdot 3606}}{2} = 58'86 \text{ Hz}$$

$$f_1 = \frac{3606}{58'86} = 61'26 \text{ Hz}$$



4

Convertidor ADC 3 bits tipo "flash" con cuantificación uniforme de $V_{REF} = 5V$.

$V_o = \{0'25,\ 0'90,\ 1'46,\ 2'25,\ 2'92,\ 3'57,\ 4'43\}$ V

¿ Error cero, error de ganancia, DNLE e INLE ?

$$V_{LSB} = \frac{V_{REF}}{2^n} = \frac{5}{8} = 0'625$$

$$E_{off} = \frac{V_o|_{001}}{V_{LSB}} - \frac{1}{5} = -0'1 \text{ LSB}$$

$$E_g = \frac{V_o|_{111} - V_o|_{001}}{V_{LSB}} - (2^n - 2) = 0'688 \text{ LSB}$$

$$V_o|_{comp} = \frac{V_o}{V_{LSB}} - E_{off} - \frac{i E_g}{2^n - 2}$$

$$V_o|_{comp} = \{0'5,\ 1'425,\ 2'207,\ 3'356,\ 4'313,\ 5'239,\ 6'5\} \text{ LSB}$$

$$DNLE = V_{j+1} - V_j - 1$$

$$DNLE = \{0,\ -0'075,\ -0'218,\ 0'149,\ -0'043,\ -0'074,\ 0'261\} \text{ LSB}$$

$$INLE = \sum_{k=0}^{j} DNLE_j$$

$$INLE = \{0,\ -0'075,\ -0'293,\ -0'144,\ -0'187,\ -0'261,\ 0\} \text{ LSB}$$