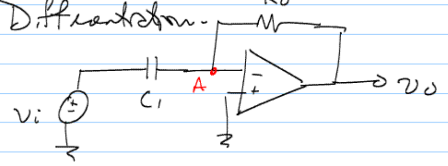
INEL 3105 10th Lecture

Note Title 9/25/2009

OP-AMPS

Differentiator:

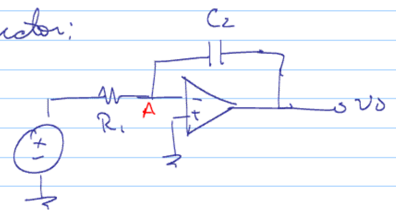


KCL @ A: current across a capacitor:

$$C_1 \frac{d(v_i - v^-)}{dt} = \frac{v^- - v_0}{R_0}$$

$$C_1 \frac{dv_1}{dt} = \frac{-v_0}{R_0} \; ; \; v_0(t) = -R_0 C_1 \frac{dv_1(t)}{dt}$$

Integrator:

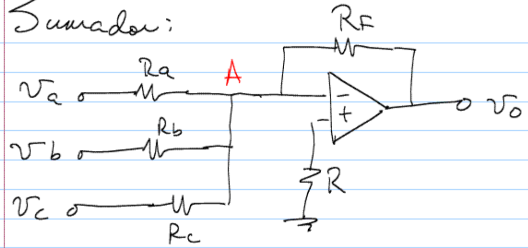


KCL @ A:

$$\frac{v_1}{R_1} = C_2 \frac{d(0 - v_0)}{dt} \; ;$$

$$\frac{-v_1}{R_1 C_2} = \frac{d\, v_0(t)}{dt} \; ; \; v_0(t) = \frac{-1}{R_1 C_2} \int v_1(t)\, dt$$

Sumador:



$$v^- = 0 = v^+$$

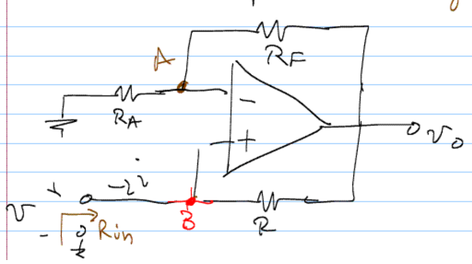
KCL @ A:

$$\frac{v_a}{R_a} + \frac{v_b}{R_b} + \frac{v_c}{R_c} = \frac{-v_0}{R_F}$$

$$v_0 = -R_F\left(\frac{v_a}{R_a} + \frac{v_b}{R_b} + \frac{v_c}{R_c}\right) = -R_F \sum_{j=a}^{c} \frac{v_j}{R_j}$$

Si hacemos $R_a = R_B = R_C = R$; $v_0 = \frac{-R_F}{R}(v_a + v_b + v_c)$

Circuito con impedancia negativa??...



$$R_{in} = \frac{v}{i} = \frac{v^+}{i} \; ; \quad \text{KCL @ A}$$

$$\frac{0 - v^-}{R_A} = \frac{v^- - v_0}{R_F}$$

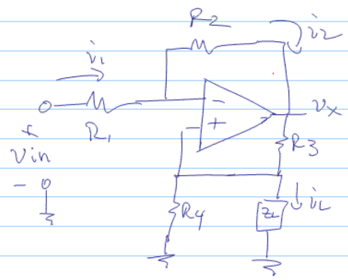
$$\frac{v_0}{R_F} = v^-\left(\frac{1}{R_A} + \frac{1}{R_F}\right)$$

$v_o = v^-\left(\frac{R_F}{R_a}+1\right)$;

$v_o = v\left(\frac{R_F}{R_a}+1\right)$; $i = \frac{v - v_o}{R} = \frac{v - v\left(\frac{R_F}{R_a}+1\right)}{R} = \frac{v\left(1 - \frac{R_F}{R_a} - 1\right)}{R}$

$i = \frac{-v R_F}{R_a R}$; $R_{in} = \frac{v}{i} = -\frac{R_a R}{R_F}$

Otra aplicación de OP-AMPs ... Fuentes de corriente



$i_1 = i_2$

(1) $i_1 = \frac{v_{in} - i_L z_L}{R_1} = i_2$

$i_2 = \frac{i_L z_L - v_x}{R_2}$

KCL @ entrada no-inversora (+)

(2) $\frac{v_x - i_L z_L}{R_3} = i_L + \frac{i_L z_L - 0}{R_4}$

Resolviendo (1) para $v_x - i_L z_L$ y sustituyendo en (2) se obtiene:

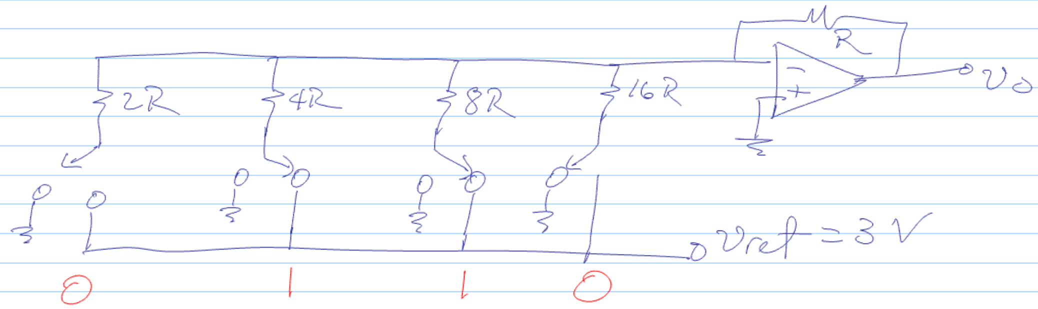
$\frac{-R_2(v_{in} - i_L z_L)}{R_1 R_3} = i_L + \frac{i_L z_L}{R_4}$;

Resolviendo para i_L se obtiene:

$i_L\left(1 + \frac{z_L}{R_4} - \frac{R_2 z_L}{R_1 R_3}\right) = \frac{-R_2 v_{in}}{R_1 R_3}$;

Si seleccionamos $\frac{1}{R_4} = \frac{R_2}{R_1 R_3}$, logramos que la corriente de salida sea independiente de la carga Z_L : $i_L = \frac{v_{in}}{R_4}$

Otra aplicación DAC's (Digital-to-Analog-converters).



Cual es el voltaje de salida para el DAC cuando la entrada es 0 1 1 0.

$$v_o = 0\left[\frac{-R}{2R} V_{ref}\right] + 1\left[\frac{-R}{4R} V_{ref}\right] + 1\left[\frac{-R}{8R} V_{ref}\right] + 0\left[\frac{-R}{16R} V_{ref}\right]$$

$$= -1.125\ V$$

Suponga que el input cambia a: 1001

$$v_o = 1\left[\frac{-R}{2R} V_{ref}\right] + 0\left[\frac{-R}{4R} V_{ref}\right] + 0\left[\frac{-R}{8R} V_{ref}\right] + 1\left[\frac{-R}{16R} V_{ref}\right]$$

$$= -1.688$$

Suponga que el OP-AMP utilizado en el DAC tiene un offset de 5mV y el feedback resistor tiene un valor de 1.05R, en vez de R.

Cual es el error de offset?

Para una entrada de 0000,

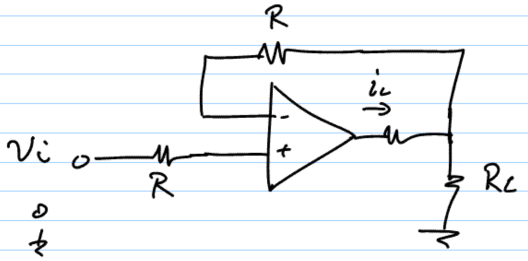
$$V_o = V_{offset}\left(1 + \frac{1.05R}{R_{eq}}\right) \; ; \; R_{eq} = 16R // 8R // 4R // 2R$$

$$R_{eq} = .9375R$$

$$V_o = .005V\left(1 + \frac{1.05R}{.9375R}\right) = 10.6mV$$

El DAC tiene entonces un voltaje de offset de 10.6mV

Convertidor voltaje-corriente:

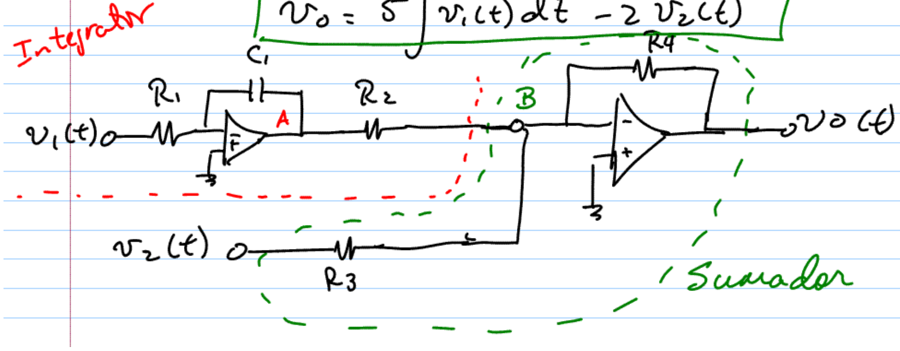


$i_L = ?$

$$i_L = \frac{v_i}{R_L}$$

Design an op-amp with the following v_o:

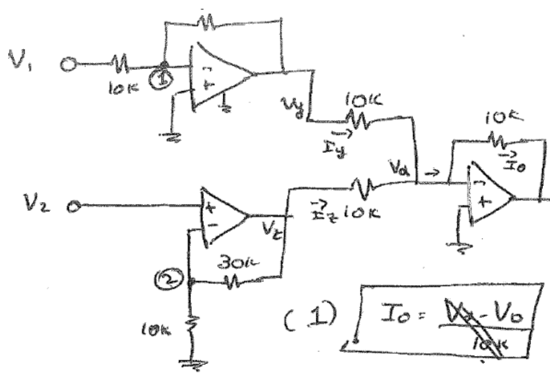
$$v_o = 5\int v_1(t)\,dt - 2v_2(t)$$



$$V_A = \frac{-1}{R_1 C_1}\int_0^{t'} v_1(t)\,dt \quad ; \quad KCL\ @\ B:\ \frac{V_A(t)}{R_2} + \frac{V_2(t)}{R_3} = \frac{-V_0(t)}{R_4}$$

$$V_0 = \left[\frac{-V_A(t)}{R_2} - \frac{V_2(t)}{R_3}\right] R_4 \quad ; \quad \boxed{V_0(t) = \frac{R_4}{R_2 R_1 C_1}\int_0^{t'} v_1(t)\,dt - \frac{R_4}{R_3} v_2(t)}$$

$$\frac{R_4}{R_3} = 2 \quad ; \quad \frac{R_4}{R_2 R_1 C_1} = 5$$



$\boxed{I_o = -\frac{V_o}{10K}}$

(1) $\boxed{I_o = \frac{V_\alpha - V_o}{10K}}$; KCL @ V_α; $I_o = I_y + I_z$

$I_y = \frac{V_y - V_\alpha}{10K}$; $I_z = \frac{V_z - V_\alpha}{10K}$; $\boxed{I_o = \frac{V_y}{10K} + \frac{V_z}{10K} - \frac{2V_\alpha}{10K}}$ (2)

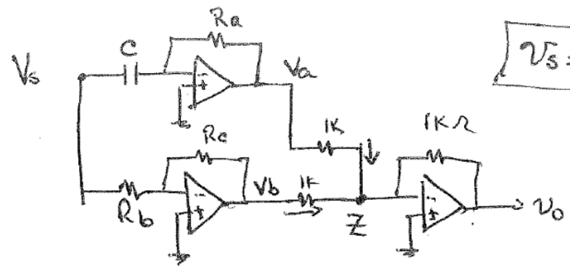
KCL @ 1: $\frac{V_1}{10K} = \frac{-V_y}{80K}$; $\boxed{V_y = -V_1(8)}$ (3)

KCL @ 2: $-\frac{V_z}{10K} = \frac{V_2 - V_z}{30K}$; $\frac{V_z}{30K} = V_2\left(\frac{1}{10K} + \frac{1}{30K}\right)$; $V_z = -V_2(3+1)$ $\boxed{V_z = -4V_2}$ (4)

$\boxed{V_\alpha = 0!!}$

$I_o = \frac{1}{10K}(V_y + V_z) = \frac{1}{10K}(-8V_1 - 4V_2) = \frac{4}{10K}(-2V_1 - V_2)$;

$V_o = -I_o(10K) = 4(-2V_1 - V_2) = -8V_1 - 4V_2$ //



$$v_s = \alpha x$$

$$V_a = -R_a C_1 \frac{d(v_s)}{dt} \; ; \; \frac{V_s}{R_b} = \frac{-V_b}{R_c} \; ; \; V_b = \frac{-R_c}{R_b} V_s$$

KCL@Z:

$$\frac{V_b}{1K} + \frac{V_a}{1K} = -\frac{V_o}{1K} \; ; \quad V_o = -V_b - V_a$$

$$= \frac{R_c}{R_b} V_s + R_a C_1 \frac{d\,v_s(t)}{dt}$$

$$V_s = \alpha x \; ;$$

$$V_o = \frac{R_c}{R_b} \alpha x(t) + R_a C_1 \alpha \left(\frac{dx}{dt}\right)$$