

$$N_1 \quad \frac{V_i - V_1}{R_1} = \frac{V_1 - V_2}{R_2} + C_2 \frac{d(V_1 - V_0)}{dt}$$

$$N_2 \quad \frac{V_1 - V_2}{R_2} = C_1 \frac{dV_2}{dt}$$

$$N_3 \quad \frac{V_0 - V_3}{R_4} = \frac{V_3 - 0}{R_3}$$

Expandiendo C_2

$$\frac{V_i - V_1}{R_1} = \frac{V_1 - V_2}{R_2} + C_2 \frac{dV_0}{dt} - C_2 \frac{dV_1}{dt}$$

Despejando V_i

$$\frac{V_i}{R_1} - \frac{V_1}{R_1} = \frac{V_1}{R_2} - \frac{V_2}{R_2} + C_2 \frac{dV_0}{dt} - C_2 \frac{dV_1}{dt} \rightarrow \frac{V_i}{R_1} = \frac{V_1}{R_2} - \frac{V_2}{R_2} + C_2 \frac{dV_0}{dt} - C_2 \frac{dV_1}{dt} + \frac{V_1}{R_1}$$

$$\rightarrow V_i = \frac{R_1}{R_2} V_1 - \frac{R_1}{R_2} V_2 + R_1 C_2 \frac{dV_0}{dt} - R_1 C_2 \frac{dV_1}{dt} + V_1$$

Despejando V_3 de N_3

$$\frac{V_0}{R_4} - \frac{V_3}{R_4} = \frac{V_3}{R_3} \rightarrow \frac{R_3}{(R_4 + R_3)} V_0 = V_3 \quad \dot{V}_3 = \frac{R_3}{(R_4 + R_3)} \frac{dV_0}{dt}$$

$$\left(\frac{V_0}{R_4} = \frac{V_3}{R_3} + \frac{V_3}{R_4} \right) R_4 R_3$$

$$R_3 V_0 = V_3 R_4 + V_3 R_3$$

$$R_3 V_0 = (R_4 + R_3) V_3$$

$V_3 = V_2 \rightarrow$ Por el op ideal

Despejando V_1 de N_2

$$\frac{V_1}{R_2} - \frac{V_2}{R_2} = C_1 \frac{dV_2}{dt}$$

$$\left(\frac{V_1}{R_2} = C_1 \frac{dV_2}{dt} + \frac{V_2}{R_2} \right) R_2$$

$$V_1 = C_1 R_2 \frac{dV_2}{dt} + V_2$$

Sustituyendo V_3 en V_2

$$V_1 = C_1 R_2 \left(\frac{R_3}{(R_4 + R_3)} \frac{dV_0}{dt} \right) + \frac{R_3}{(R_4 + R_3)} V_0$$

$$\dot{V}_1 = C_1 R_2 \left(\frac{R_3}{(R_4 + R_3)} \frac{d^2 V_0}{dt^2} \right) + \frac{R_3}{(R_4 + R_3)} \frac{dV_0}{dt}$$

$$v_i = \underbrace{\frac{R_1}{R_2} v_1 - \frac{R_1}{R_2} v_2}_{-} + R_1 C_2 \frac{dv_o}{dt} + \underbrace{-R_1 C_2 \frac{dv_1}{dt} + v_1}_{+}$$

$$v_i = v_1 + \frac{R_1}{R_2} (v_1 - v_2) - R_1 C_2 \dot{v}_o + R_1 C_2 \dot{v}_1$$

Substituyendo v_1 y \dot{v}_1 en v_i

$$v_i = \underbrace{\frac{C_1 R_2 R_3}{R_4 + R_3} \dot{v}_o + \frac{R_3}{R_4 + R_3} v_o}_{v_1} +$$

$$\frac{R_1}{R_2} \left[\underbrace{\left(\frac{C_1 R_2 R_3}{R_4 + R_3} \dot{v}_o + \frac{R_3}{R_4 + R_3} v_o \right)}_{v_1} - \underbrace{\frac{R_3}{R_4 + R_3} v_o}_{v_2} \right] - R_1 C_2 \dot{v}_o$$

$$+ R_1 C_2 \left[\frac{C_1 R_2 R_3}{R_4 + R_3} \ddot{v}_o + \frac{R_3}{R_4 + R_3} \dot{v}_o \right]$$

Eliminando y agrupando

$$v_i = \frac{C_1 R_2 R_3}{R_4 + R_3} \dot{v}_o + \frac{R_3}{R_4 + R_3} v_o + \frac{R_1 R_3 C_1}{R_4 + R_3} \dot{v}_o - R_1 C_2 \dot{v}_o$$

$$+ \frac{R_1 R_2 R_3 C_1 C_2}{R_4 + R_3} \ddot{v}_o + \frac{R_1 R_3 C_2}{R_4 + R_3} \dot{v}_o$$

Terminos semejantes $\frac{R_3}{R_4 + R_3} = A$

$$v_i = \underbrace{C_1 R_2 A \dot{v}_o}_{+} + A v_o + \underbrace{R_1 C_1 A \dot{v}_o}_{+} - \underbrace{R_1 C_2 \dot{v}_o}_{-} + \underbrace{R_1 R_2 C_1 C_2 A \ddot{v}_o}_{+} + R_1 C_2 A \dot{v}_o$$

Despejando \ddot{V}_0

$$R_1 R_2 C_1 C_2 A \ddot{V}_0 = V_i - C_1 R_2 A \dot{V}_0 - A V_0 - R_1 C_1 A \dot{V}_0 + R_1 C_2 \dot{V}_0 - R_1 C_2 A \dot{V}_0$$

$$\ddot{V}_0 = \frac{1}{R_1 R_2 C_1 C_2 A} \left[V_i - C_1 R_2 A \dot{V}_0 - A V_0 - R_1 C_1 A \dot{V}_0 + R_1 C_2 \dot{V}_0 - R_1 C_2 A \dot{V}_0 \right]$$
$$= \frac{V_i}{R_1 R_2 C_1 C_2 A} - \frac{\dot{V}_0}{R_1 C_2} - \frac{V_0}{R_1 R_2 C_1 C_2} - \frac{\dot{V}_0}{R_2 C_2} + \frac{\dot{V}_0}{R_2 C_1 A} - \frac{V_0}{R_2 C_1}$$

Agrupando

$$V_i = R_1 R_2 C_1 C_2 A \ddot{V}_0 + (C_1 R_2 A + R_1 C_1 A - R_1 C_2 + R_1 C_2 A) \dot{V}_0 + A V_0$$

Despejando

$$\ddot{V}_0 R_1 R_2 C_1 C_2 A = V_i - (C_1 R_2 A + R_1 C_1 A - R_1 C_2 + R_1 C_2 A) \dot{V}_0 - A V_0$$

$$\ddot{V}_0 = \frac{V_i}{R_1 R_2 C_1 C_2 A} - \frac{(C_1 R_2 A + R_1 C_1 A - R_1 C_2 + R_1 C_2 A) \dot{V}_0}{R_1 R_2 C_1 C_2 A} - \frac{1}{R_1 R_2 C_1 C_2} V_0$$

Esp estados

$$x_1 = V_0$$

$$\dot{x}_1 = \dot{V}_0$$

$$x_2 = \dot{V}_0$$

$$\dot{x}_2 = \ddot{V}_0 =$$

$$\frac{V_i}{R_1 R_2 C_1 C_2 A} - \frac{(C_1 R_2 A + R_1 C_1 A - R_1 C_2 + R_1 C_2 A) \dot{V}_0}{R_1 R_2 C_1 C_2 A} - \frac{1}{R_1 R_2 C_1 C_2} V_0$$





