N_1

$$\frac{V_i - V_1}{R1} = \frac{V_1 - V_2}{R2} + C_2 \frac{d(V_0 - V_1)}{dt}$$

$V_1 - V_0$

N_2

$$\frac{V_1 - V_2}{R2} = C_1 \frac{dV_2}{dt}$$

V_1

N_3

$$\frac{V_0 - V_3}{R4} = \frac{V_3 - 0}{R3}$$

$V_2 = V_3$

Expandiendo C2

$$\frac{V_i - V_1}{R1} = \frac{V_1 - V_2}{R2} - C_2 \frac{dV_0}{dt} + C_2 \frac{dV_1}{dt}$$

Despejando V_i

$$\frac{V_i}{R1} - \frac{V_1}{R1} = \frac{V_1}{R2} - \frac{V_2}{R2} - C_2 \frac{dV_0}{dt} + C_2 \frac{dV_1}{dt} \rightarrow \frac{V_i}{R1} = \frac{V_1}{R2} - \frac{V_2}{R2} - C_2 \frac{dV_0}{dt} + C_2 \frac{dV_1}{dt} + \frac{V_1}{R1}$$

$$\rightarrow V_i = \frac{R1}{R2} V_1 - \frac{R1}{R2} V_2 - R1 C_2 \frac{dV_0}{dt} + R1 C_2 \frac{dV_1}{dt} + V_1$$

Despejando V_3 de N_3

$$\frac{V_0}{R4} - \frac{V_3}{R4} = \frac{V_3}{R3}$$

$$\left(\frac{V_0}{R4} = \frac{V_3}{R3} + \frac{V_3}{R4}\right) R4\,R3$$

$$R3\,V_0 = V3\,R4 + V3\,R3$$

$$R3\,V_0 = (R4 + R3)\,V3$$

$$\rightarrow \frac{R3}{(R4+R3)} V_0 = V3 \qquad \dot{V}_3 = \frac{R3}{(R4+R3)} \frac{dV_0}{dt}$$

$V_3 = V_2 \rightarrow$ Por el op ideal

Despejando V_1 de N_2

$$\frac{V_1}{R2} - \frac{V_2}{R2} = C_1 \frac{dV_2}{dt}$$

$$\left(\frac{V_1}{R2} = C_1 \frac{dV_2}{dt} + \frac{V_2}{R2}\right) R2$$

$$V_1 = C_1 R2 \frac{dV_2}{dt} + V_2$$

Sustituyendo V_3 en V_2

$$V_1 = C_1 R2 \left(\frac{R3}{(R4+R3)} \frac{dV_0}{dt}\right) + \frac{R3}{(R4+R3)} V_0$$

$$\dot{V}_1 = C_1 R2 \left(\frac{R3}{(R4+R3)} \frac{d^2 V_0}{dt}\right) + \frac{R3}{(R4+R3)} \frac{dV_0}{dt}$$

$$v_i = \frac{R1}{R2} v_1 - \frac{R1}{R2} v_2 + R1C2 \frac{dv_o}{dt} - R1C2 \frac{dv_1}{dt} + v_1$$

$$v_i = v_1 + \frac{R1}{R2}(v_1 - v_2) - R1C2\,\dot{v}_o + R1C2\,\dot{v}_1$$

Sustituyendo v_1 y $\dot{v}_1$ en v_i

$$v_i = \overbrace{\frac{C1R2R3}{R4+R3}\dot{v}_o + \frac{R3}{R4+R3} v_o}^{v_1} +$$

$$\frac{R1}{R2}\left[\overbrace{\left(\frac{C1R2R3}{R4+R3}\dot{v}_o + \frac{R3}{R4+R3} v_o\right)}^{v_1} - \overbrace{\frac{R3}{R4+R3} v_o}^{v_2}\right] - R1C2\,\dot{v}_o$$

$$+ R1C2\left[\frac{C1R2R3}{R4+R3}\ddot{v}_o + \frac{R3}{R4+R3}\dot{v}_o\right]$$

Eliminando y agrupando

$$v_i = \frac{C1R2R3}{R4+R3}\dot{v}_o + \frac{R3}{R4+R3} v_o + \frac{R1R3C1}{R4+R3}\dot{v}_o - R1C2\,\dot{v}_o$$

$$+ \frac{R1R2R3C1C2}{R4+R3}\ddot{v}_o + \frac{R1R3C2}{R4+R3}\dot{v}_o$$

Terminos semejantes $\frac{R3}{R4+R3} = A$

$$v_i = C1R2A\,\dot{v}_o + A v_o + R1C1A\,\dot{v}_o - R1C2\,\dot{v}_o + R1R2C1C2A\,\ddot{v}_o$$

$$+ R1C2A\,\dot{v}_o$$

Despejando $\ddot{V}_o$

$$R1R2C1C2A\ddot{V}_o = V_i - C1R2A\dot{V}_o - AV_o - R1C1A\dot{V}_o + R1C2\dot{V}_o - R1C2A\dot{V}_o$$

$$\ddot{V}_o = \frac{1}{R1R2C1C2A}\left[V_i - C1R2A\dot{V}_o - AV_o - R1C1A\dot{V}_o + R1C2\dot{V}_o - R1C2A\dot{V}_o\right]$$

$$= \frac{V_i}{R1R2C1C2A} - \frac{\dot{V}_o}{R1C2} - \frac{V_o}{R1R2C1C2} - \frac{\dot{V}_o}{R2C2} + \frac{\dot{V}_o}{R2C1A} - \frac{V_o}{R2C1}$$

Agrupando

$$V_i = R1R2C1C2A\ddot{V}_o + (C1R2A + R1C1A - R1C2 + R1C2A)\dot{V}_o + AV_o$$

Despejando

$$\ddot{V}_o R1R2C1C2A = V_i - (C1R2A + R1C1A - R1C2 + R1C2A)\dot{V}_o - AV_o$$

$$\ddot{V}_o = \frac{V_i}{R1R2C1C2A} - \frac{(C1R2A + R1C1A - R1C2 + R1C2A)\dot{V}_o}{R1R2C1C2A} - \frac{1}{R1R2C1C2}V_o$$

Esp estados

$x_1 = V_o \qquad \dot{x}_1 = \dot{V}_o$

$x_2 = \dot{V}_o \qquad \dot{x}_2 = \ddot{V}_o =$

$$\frac{V_i}{R1R2C1C2A} - \frac{(C1R2A + R1C1A - R1C2 + R1C2A)\dot{V}_o}{R1R2C1C2A} - \frac{1}{R1R2C1C2}V_o$$

Función de transferencia

$$V_i = R1R2C1C2A\ddot{V}_o + (C1R2A + R1C1A - R1C2 + R1C2A)\dot{V}_o + AV_o$$

$$\mathcal{L}\{V_i = R1R2C1C2A\ddot{V}_o + (C1R2A + R1C1A - R1C2 + R1C2A)\dot{V}_o + AV_o\}$$

$$\rightarrow V_i(s) = R1R2C1C2A\,S^2V_o(s) + (C1R2A + R1C1A - R1C2 + R1C2A)\,sV_o(s) + AV_o(s)$$

Factorizando $V_o(s)$

$$\rightarrow V_i(s) = V_o(s)\left[R1R2C1C2As^2 + (C1R2A + R1C1A - R1C2 + R1C2A)s + A\right]$$

$$\frac{V_o(s)}{V_i(s)} = \frac{1}{R1R2C1C2As^2 + (C1R2A + R1C1A - R1C2 + R1C2A)s + A}$$