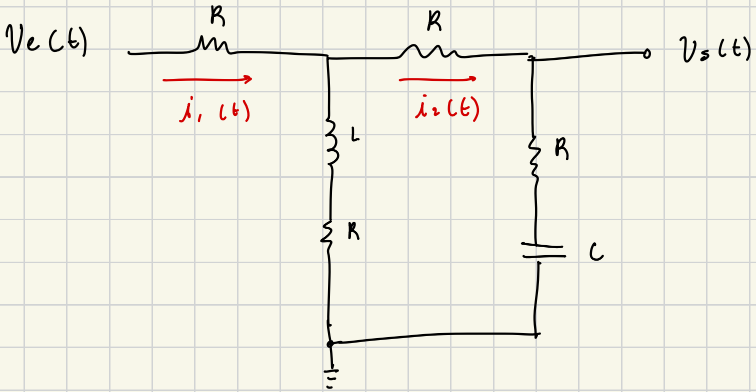
23/09/25



Ecuaciones Principales

$$V_e(t) = R\, i_1(t) + \frac{L\, d\left[i_1(t) + i_2(t)\right]}{dt} + R\left[i_1(t) + i_2(t)\right]$$

$$\frac{L\, d\left[i_1(t) - i_2(t)\right]}{dt} + R\left[i_1(t) - i_2(t)\right] = R\, i_2(t) + R\, i_2(t) + \frac{1}{C}\int i_2(t)\, dt$$

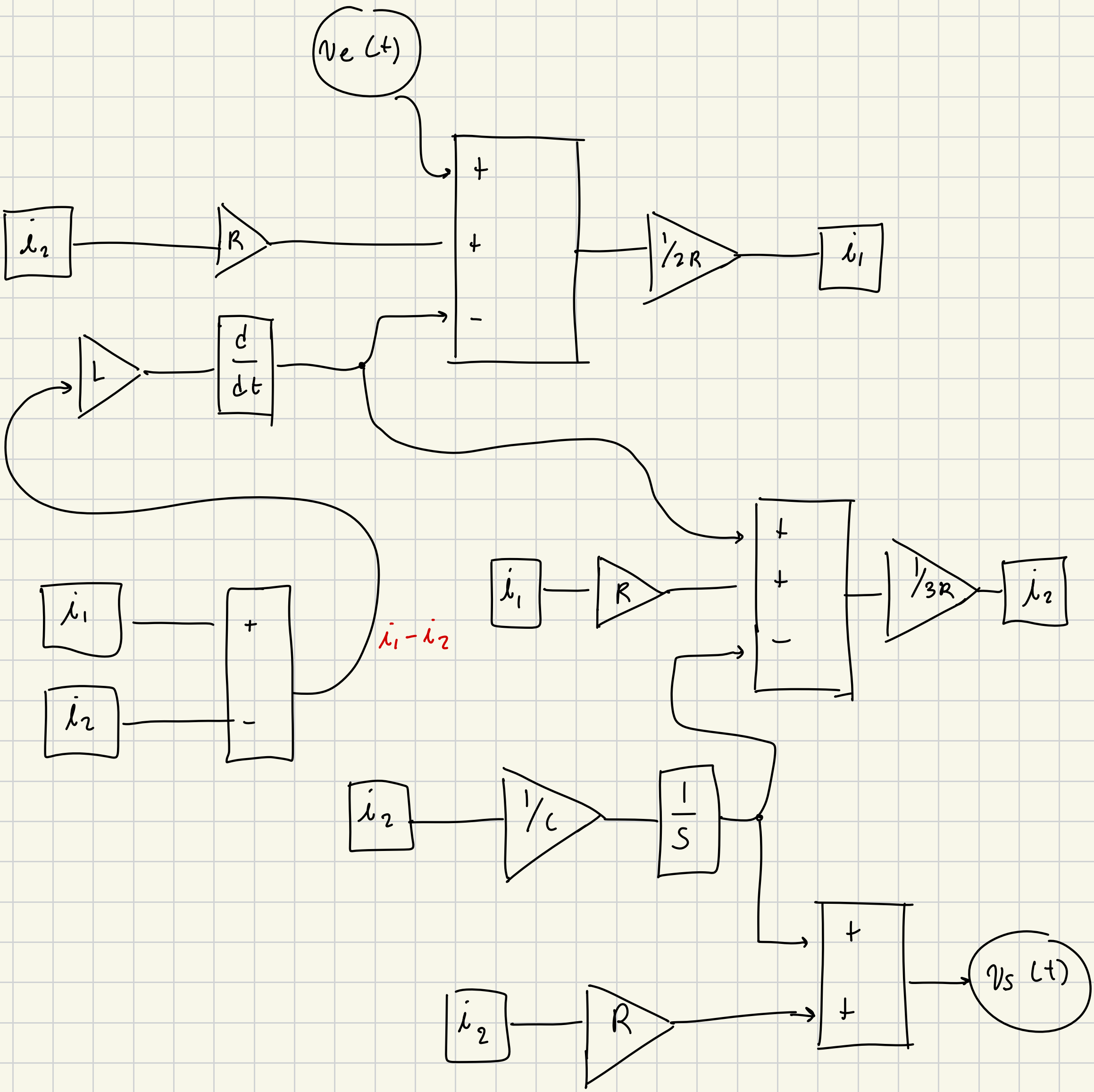
$$V_s(t) = R\, i_2(t) + \frac{1}{C}\int i_2(t)\, dt$$

Modelo de ecuaciones integro - diferenciales

$$i_1(t) = \left[V_e(t) - \frac{L\, d\left[i_1(t) - i_2(t)\right]}{dt} + R\, i_2(t)\right]\frac{1}{2R}$$

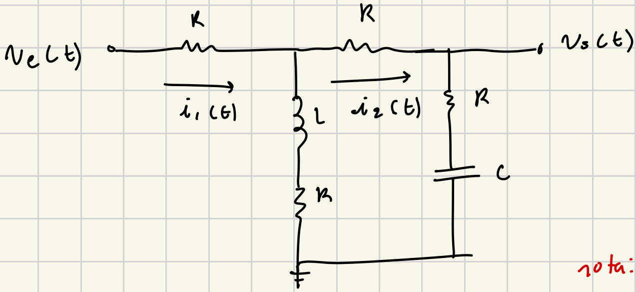
$$i_2(t) = \left[\frac{L\, d\left[i_1(t) - i_2(t)\right]}{dt} + R\, i_1(t) - \frac{1}{C}\int i_2(t)\, dt\right]\frac{1}{3R}$$

$$V_s(t) = R\, i_2(t) + \frac{1}{C}\int i_2(t)\, dt$$



$v_e(t)$
i_2
R
+
+
−
$1/2R$
i_1
L
$\frac{d}{dt}$
i_1
+
i_2
−
$i_1 - i_2$
i_1
R
+
+
−
$1/3R$
i_2
i_2
$1/C$
$\frac{1}{S}$
+
i_2
R
+
$v_S(t)$

26/09/25



$$\frac{V_s(s)}{V_e(s)} = \frac{?\ I_2(s)}{?\ I_2(s)}$$

nota: sin términos negativos

Función de Transferencia

$$v_e(t) = R\,i_1(t) + \frac{L\,d\,[i_1(t) + i_2(t)]}{dt} + R\,[i_1(t) + i_2(t)]$$

$$\frac{L\,d\,[i_1(t) - i_2(t)]}{dt} + R\,[i_1(t) - i_2(t)] = R\,i_2(t) + R\,i_1(t) + \frac{1}{C}\int i_2(t)\,dt$$

$$v_s(t) = R\,i_2(t) + \frac{1}{C}\int i_2(t)\,dt$$

Transformada de Laplace

$$LS\,I_1(s) - LS\,I_2(s) + R\,I_1(s) - R\,I_2(s)$$

$$V_e(s) = R\,I_1(s) + LS\,[I_1(s) - I_2(s)] + R\,[I_1(s) - I_2(s)]$$

$$LS\,[I_1(s) - I_2(s)] + R\,[I_1(s) - I_2(s)] = R\,I_2(s) + R\,I_2(s) + \frac{I_2(s)}{CS}$$

$$V_s(s) = R\,I_2(s) + \frac{I_2(s)}{CS}$$

Procedimiento algebraico

$$V_e(s) = (R + LS + R)\,I_1(s) - (LS + R)\,I_2(s)$$

$$= (LS + 2R)\,I_1(s) - (LS + R)\,I_2(s)$$

$$LS\,I_1(s) - LS\,I_2(s) + R\,I_1(s) - R\,I_2(s) = 2R\,I_2(s) + \frac{I_2(s)}{CS}$$

$$LS\,I_1(s) + R\,I_1(s) = 3R\,I_2(s) + LS\,I_2(s) + \frac{I_2(s)}{CS}$$

$$(LS + R)\,I_1(s) = \left(3R + LS + \frac{1}{CS}\right) I_2(s)$$

$$I_1(s) = \frac{3CRS + CLS^2 + 1}{CS\,(LS + R)}\,I_2(s) = \frac{CLS^2 + 3CRS + 1}{CS\,(LS + R)}\,I_2(s)$$

$$V_s(s) = R\,I_2(s) + \frac{I_2(s)}{CS} = \frac{CRS + 1}{CS}\,I_2(s)$$

$$V_c(s) = \frac{(Ls+2R)(CLs^2+3CRs+1)}{Cs(Ls+R)} I_2(s) - (Ls+R) I_2(s)$$

$$Ls^2 + 2LRs + R^2$$

$$= \left[\frac{(Ls+2R)(CLs^2+3CRs+1) - Cs(Ls+R)(Ls+R)}{Cs(Ls+R)}\right] I_2(s)$$

$$\cancel{CL^2s^3} + 3CLRs^2 + Ls + \cancel{2CLRs^2} + 6CR^2s + 2R$$
$$- \cancel{CL^2s^3} - \cancel{2CLRs^2} - CR^2s \quad 5CR^2s$$

$$V_c(s) = \left[\frac{3CLRs^2 + (5CR^2+L)s + 2R}{Cs(Ls+R)}\right] I_2(s)$$

$$V_s(s) = \frac{\dfrac{CRs+1}{\cancel{Cs}} \cancel{I_2(s)}}{\dfrac{3CLRs^2+5(CR^2+L)s+2R}{\cancel{Cs}(Ls+R)} \cancel{I_2(s)}}$$

$$(CRs+1)(Ls+R) = CLRs^2 + CR^2s + Ls + R$$

$$\frac{V_s(s)}{V_c(s)} = \frac{CLRs^2 + (CR^2+L)s + R}{3CLRs^2 + (5CR^2+L)s + 2R}$$

Estabilidad en lazo abierto

- Calcular los polos de la función de transferencia.

$$\frac{V_s(s)}{V_e(s)} = \frac{CLRs^2 + (CR^2+L)s + R}{3CLRs^2 + (5CR^2+L)s + 2R}$$

den = [3 * C * L * R, 5 * C * R ** 2 + L, 2 * R]

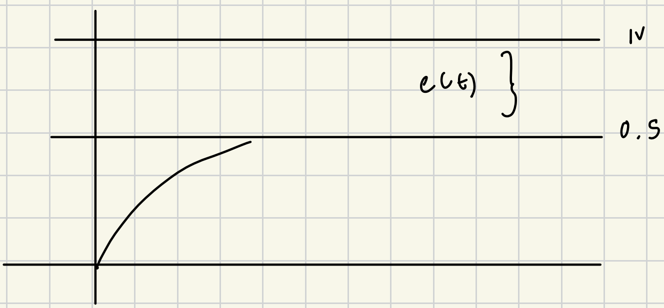
L = np.roots(den)

fprint: Las raices son {L[0]} y {L[1]}

$\lambda_1 = -106382.911$
$\lambda_2 = -0.404$

$\therefore$

El sistema presenta una respuesta estable y sobreamortiguada



$V_e(t) = 1V$

$V_e(s) = \frac{1}{s}$

Error en estado estacionario

$$e(s) = \lim_{s \to 0} s\, V_e(s) \left[1 - \frac{V_s(s)}{V_e(s)} \right]$$

$$= \lim_{s \to 0} s * \frac{1}{s} \left[1 - \frac{CLRs^2 + (CR^2+L)s + R}{3CLRs^2 + (5CR^2+L)s + 2R} \right]$$

$$= \frac{R}{2R}$$

$$e(t) = \frac{1}{2}\ V$$