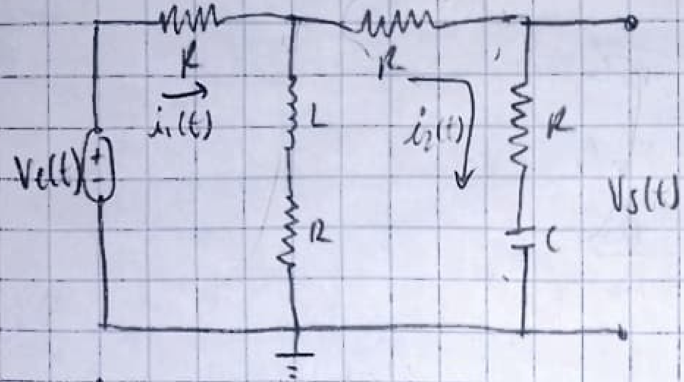
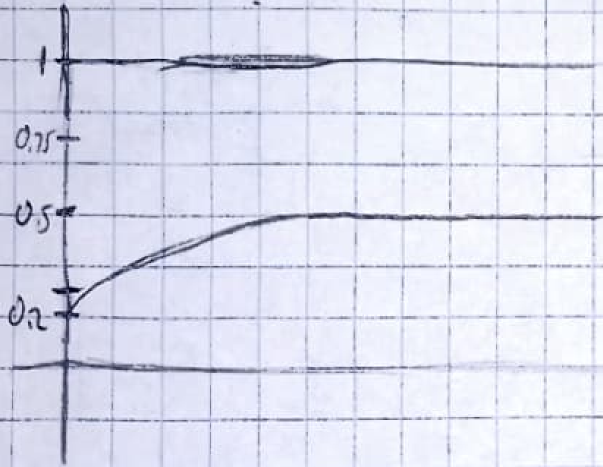
Práctica 1.



$R = 15\,k\Omega$
$C = 340\,\mu F$
$L = 560\,\mu H$



Ecuaciones principales

①

$$V_e(t) = R\,i_1(t) + \frac{L\,d(i_1(t) - i_2(t))}{dt} + R(i_1(t) - i_2(t))$$

②

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

③

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

[redacted]

[redacted]

Modelo de Ecuaciones Integro-Diferenciales

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

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

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

Transformada de Laplace

$$\begin{aligned} Ve(s) &= R\,i_1(s) + Ls\,[i_1(s) - i_2(s)] + R(i_1(s) - i_2(s)) \\ &= 2R\,i_1(s) + Ls\,i_1(s) - Ls\,i_2(s) - R\,i_2(s) \\ &= \underline{(2R + Ls)\,i_1(s) - (Ls + R)\,i_2(s)} \quad (1) \end{aligned}$$

$$Ls\,(i_1(s) - i_2(s)) + R\,(i_1(s) - i_2(s)) = 2R\,i_2(s) + \frac{i_2(s)}{Cs}$$

$$Ls\,i_1(s) - Ls\,i_2(s) + R\,i_1(s) - R\,i_2(s) = 2R\,i_2(s) + \frac{i_2(s)}{Cs}$$

$$Ls\,i_1(s) + R\,i_1(s) = Ls\,i_2(s) + R\,i_2(s) + 2R\,i_2(s) + \frac{i_2(s)}{Cs}$$

$$(Ls + R)\,i_1(s) = \left(Ls + 3R + \frac{1}{Cs}\right) i_2(s)$$

$$i_1(s) = \frac{CLs^2 + 3CRs + 1}{Cs(Ls + R)}\,i_2(s) \quad (2)$$

$$\begin{aligned} Vs(s) &= \left(R + \frac{1}{Cs}\right) i_2(s) \\ &= \frac{(RCs + 1)}{Cs}\,i_2(s) \end{aligned}$$

Procedimiento algebraico

$$V_e(s) = (2R + Ls)\left(\frac{CLs^2 + 3CRs + 1}{Cs(Ls + R)}\right) i_2(s) - (Ls + R)\, i_2(s)$$

$$V_e(s) = \left[\frac{(2R + Ls)(CLs^2 + 3CRs + 1)}{Cs(Ls + R)} - (Ls + R)\right] i_2(s)$$

$$= \left[\frac{(2R + Ls)(CLs^2 + 3CRs + 1) - \overbrace{Cs(Ls + R)}^{CLs^2 + CRs}(Ls + R)}{Cs(Ls + R)}\right] i_2(s)$$

$$= \frac{\cancel{2CLRs^2} + 6CR^2s + 2R + \cancel{L^2s^2} + 3CLRs^2 + Ls - \cancel{L^2s^2} - \cancel{CLRs^2} - \cancel{CLRs^2} - CR^2s}{Cs(Ls + R)}\, i_2(s)$$

$$V_e(s) = \frac{3CLRs^2 + (5CR^2 + L)s + 2R}{Cs(Ls + R)}\, i_2(s)$$

$$\frac{V_s(s)}{V_e(s)} = \frac{\dfrac{CRs + 1}{\cancel{Cs}}\, \cancel{i_2(s)}}{\dfrac{3CLRs^2 + (5CR^2 + L)s + 2R}{\cancel{C}s(Ls + R)}\, \cancel{i_2(s)}}$$

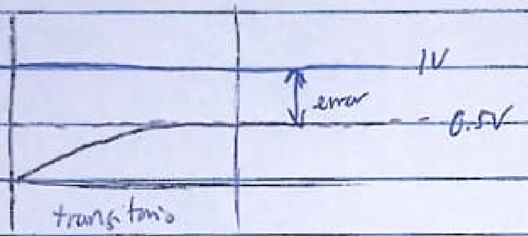
$$\frac{V_s(s)}{V_e(s)} = \frac{[CRs + 1][Ls + R]}{3CLRs^2 + [5CR^2 + L]s + 2R} = \frac{CLRs^2 + (CR^2 + L)s + R}{3CLRs^2 + [5CR^2 + L]s + 2R}$$

Error en estado estacionario (escalón unitario)

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

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

$$= \frac{R}{2R} = \frac{1}{2}\ V$$



Estabilidad en lazo abierto

- Calcular las raíces del denominador (Polos)

$$3CLRs^2 + (5CR^2+L)s + 2R = 0$$

$C = 340\ \mu F$
$L = 560\ \mu H$
$R = 15\ k\Omega$

$\lambda_1 = -4.464285713 \times 10^{7}$
$\lambda_2 = -7.843137257 \times 10^{-2}$

Con base a las raíces, se concluye que el sistema es estable con una respuesta sobreamortiguada