

$$V_e(t) = R I_1(t) + L \frac{d[I_1(t) - I_2(t)]}{dt} + R [I_1(t) - I_2(t)]$$

$$L \frac{d[I_1(t) - I_2(t)]}{dt} + R [I_1(t) - I_2(t)] = R I_2(t) + R I_2(t) + \frac{1}{C} \int I_2 dt$$

$$V_s(t) = R I_2(t) + \frac{1}{C} \int I_2(t) dt$$

Transformada de Laplace

$$V_e(s) = R I_1(s) + L s (I_1(s) - I_2(s))$$

$$L s [I_1(s) - I_2(s)] + R [I_1(s) - I_2(s)] = 2 R I_2(s) + \frac{I_2(s)}{C s}$$

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

Procedimiento algebraico

$$V_s(s) = \frac{(R s + 1)}{C s} I_2(s)$$

Se despeja $I_1(s)$ y se agrega $I_2(s)$ en la ecuacion de la segunda malla

$$L s I_1 - L s I_2 + R I_1(s) - R I_2(s) = 2 R I_2(s) + \frac{I_2(s)}{C s}$$

$$L s I_1(s) + R I_1 = 2 R I_2(s) + \frac{I_2(s)}{C s} + L s I_2(s) + R I_2(s)$$

$$(L s + R) I_1(s) = (3 R \frac{1}{C s} + L s) I_2(s)$$

$$(L s + R) (I_1(s)) = \frac{(L s^2 + 3 R C s + 1)}{C s} I_2(s)$$

$$I_1(s) = \frac{(L s^2 + 3 R C s + 1)}{C s (L s + R)} I_2(s)$$

Se sustituye $I_1(s)$ en la ecuación de la primera malla

$$V_e(s) = R I_1(s) + L s I_1(s) - L s I_2(s) + R I_1(s) - R I_2(s)$$

$$V_e(s) = (R + L s + R) I_1(s) - (L s + R) I_2(s)$$

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

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

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

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

Función de transferencia.

$$R = 10K\Omega \quad L = 330\mu F \quad C = 470\mu F$$

$$\frac{V_s(s)}{V_e(s)} = \frac{\left[\frac{CRs + 1}{Cs} I_2(s) \right]}{\left[\frac{3CLR s^2 + (5CR^2 + L)s + 2R}{Cs(Ls + R)} I_2(s) \right]} = \frac{(CRs + 1)(Ls + R)}{[3CLR s^2 + (5CR^2 + L)s + 2R]}$$

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

$$V_s(s) = \frac{(470\mu \cdot 330\mu \cdot 10K) s^2 + (470\mu \cdot 10K^2 + 330\mu) s + 10K}{(3)(470\mu)(330\mu)(10K) s^2 + 5(470\mu \cdot 10K^2 + 330\mu) s + 2 \cdot 10K}$$

Cuando se realiza el análisis por malla se deben despejar las variables dependientes, es decir, las corrientes recordando que solamente se puede despejar términos donde no se estén derivando o integrando además se sugiere que el voltaje de entrada sea un término positivo

Modelo de ecuaciones integro diferenciales.

- Ecuaciones principales

$$V_0(t) = R I_1(t) + L \frac{d(I_1(t) - I_2(t))}{dt} + R [I_1(t) - I_2(t)]$$

$$L \frac{d(I_1(t) - I_2(t))}{dt} + R [I_1(t) - I_2(t)] = R I_2(t) + R I_1(t) + \frac{1}{C} \int I_2(t) dt$$

$$V_s(t) = R I_2(t) + \frac{1}{C} \int I_2(t) dt$$

Se despeja $I_1(t)$ de la ecuación de la malla

$$I_1(t) = \left[V_0(t) - L \frac{d(I_1(t) - I_2(t))}{dt} + R I_2(t) \right] \frac{1}{2R}$$

Por lo tanto se despeja $I_2(t)$ de la ecuación de la malla

$$I_2(t) = \left[L \frac{d(I_1(t) - I_2(t))}{dt} + R I_1(t) - \frac{1}{C} \int I_2(t) dt \right] \frac{1}{3R}$$

Con la siguiente expresión como salida.

$$V_s(t) = R I_2(t) + \frac{1}{C} \int I_2(t) dt$$

Error estacionario se calcula mediante el siguiente límite

$$e(s) = \lim_{s \rightarrow 0} s \sqrt{e(s)} \left[1 - \frac{V_s(s)}{V_e(s)} \right] = \lim_{s \rightarrow 0} s \frac{1}{s} \left[1 - \frac{CLR s^2 + (CR^2 + L)s + R}{3CLs^2 + 4s(CR^2 + L)s + 2R} \right]$$

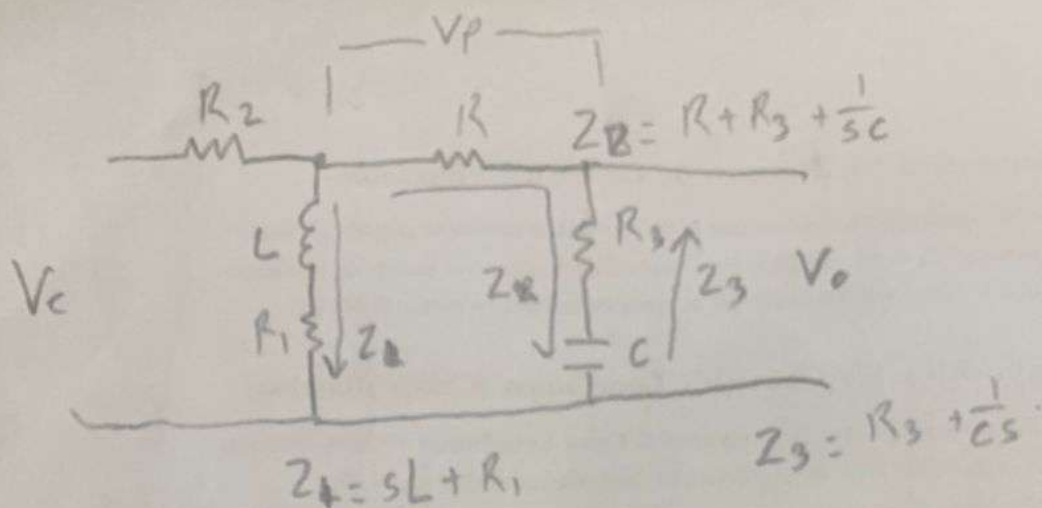
$$\begin{aligned} e(s) &= \frac{R}{3R} = \frac{1}{3} \\ e(1) &= 0.5 \end{aligned}$$

$$V_e(t) = 1 \quad (\text{por lo tanto } V_e(s) = \frac{1}{s})$$

Para determinar la estabilidad

$$3CLR s^2 + 4s(CR^2 + L)s + 2R = 0$$

$$\lambda_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$



$$Z_1 || Z_2 = \frac{Z_1 \cdot Z_2}{Z_1 + Z_2}$$

$$V_p = V_c(s) \frac{Z_1 || Z_2}{R_2 + Z_1 || Z_2}$$

$$V_o(s) = V_p(s) \frac{Z_3}{Z_2}$$

$$H(s) = \frac{V_o(s)}{V_c(s)} = \frac{V_p(s) (a)}{\frac{V_p(s)}{(b)}} = ab$$

$$= \left(\frac{Z_1 || Z_2}{R_2 + Z_1 || Z_2} \right) \left(\frac{Z_3}{Z_2} \right)$$

$$= \frac{\frac{Z_1 Z_2}{Z_1 + Z_2}}{R_2 + \frac{Z_1 Z_2}{Z_1 + Z_2}} \left(\frac{Z_3}{Z_2} \right) = \frac{Z_1 Z_2}{R_2(Z_1 + Z_2) + Z_1 + Z_2} \left(\frac{Z_3}{Z_2} \right)$$

$$H(s) = \frac{Z_1 Z_3}{R_2(Z_1 + Z_2) + Z_1 + Z_2}$$

$$H(s) = \frac{Z_1 Z_3}{R_2(Z_1 + Z_2) + Z_1 + Z_2}$$

$$Z_1 = R + sL$$

$$Z_2 = 2R + \frac{1}{sC}$$

$$Z_3 = R_3 + \frac{1}{sC}$$

$$= \frac{(R + sL)(R + \frac{1}{sC})}{R(Ls + R + 2R + \frac{1}{sC}) + Ls + R + 2R + \frac{1}{sC}}$$

...

$$\frac{LRCs^2 + (L + R^2C)s + R}{3LRCs^2 + (L + 5R^2C)s + 2R}$$

$$\left(\frac{1.551e^{-6}s^2 + 0.001733s + 10}{4.653e^{-6}s^2 + 0.23533s + 20} \right)$$

$\div 20$

$$7.75e^{-8}s^2 + 0.00236s + 0.5$$

$$2.32e^{-7}s^2 + 0.01176s + 1$$

$H(s)$