

$$V_e(t) = RI_1(t) + L \frac{d[I_1(t) - I_2(t)]}{dt} + R[I_1(t) - I_2(t)]$$

$$L \frac{d[I_1(t) - I_2(t)]}{dt} + R[I_1(t) - I_2(t)] = RI_2(t) + RI_2 t \frac{1}{C} \int I_2 dt$$

$$V_s(t) = RI_2(t) + \frac{1}{C} \int I_2(t) dt$$

Transformación de la variable

$$V_e(s) = RI_1(s) + LS(I_1(s) - I_2(s))$$

$$LS(I_1(s) - I_2(s)) + R[I_1(s) - I_2(s)] = 2RI_2(s) + \frac{I_2(s)}{Cs}$$

$$V_s(s) = RI_2(s) + \frac{I_2(s)}{Cs}$$

Procedimiento algebraico

$$V_s(s) = \frac{(CRs + 1)}{Cs} I_2(s)$$

Se despeja $I_1(s)$ y se agrupa $I_2(s)$ en la ecuación de la siguiente forma

$$LS I_1 - LS I_2 + RI_1(s) - RI_2(s) = 2RI_2(s) + \frac{I_2(s)}{Cs}$$

$$LS I_1(s) + RI_1 = 2RI_2(s) + \frac{I_2(s)}{Cs} + LS I_2(s) + RI_2(s)$$

$$(LS + R) I_1(s) = (3R \frac{1}{Cs} + LS) I_2(s)$$

$$(LS + R)(I_1(s)) = \frac{(CLs^2 + 3CRs + 1)}{Cs} I_2(s)$$

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

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

$$V_{cl}(s) = RI_1(s) + LS I_1(s) - LS I_2(s) + RI_1(s) - RI_2(s)$$

$$V_{cl}(s) = (R + LS + R) I_1(s) - (LS + R) I_2(s)$$

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

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

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

$$V_{cl}(s) = \left[\frac{3CLR_0^2 + 5CR^2s + (s + 2R)}{Cs(Ls + R)} I_2(s) \right]$$

Funcióñ de transferencia.

$$R = 10\text{ k}\Omega \quad L = 330\text{ mH} \quad C = 470\text{ nF}$$

$$\frac{Vs(s)}{V_{cl}(s)} = \frac{\frac{CRs + 1}{Cs} I_2(s)}{\frac{3CLRs^2 + (5CR^2L)s + 2R}{Cs(Ls + R)} I_2(s)} = \frac{(CRs + 1)(Ls + R)}{3CLRs^2 + (5CR^2L)s + 2R}$$

$$\frac{Vs(s)}{V_{cl}(s)} = \frac{CLRs^2 + (CR^2 + L)s + R}{3CLRs^2 + (3CR^2 + L)s + 2R}$$

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

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

$$V_C(t) = R I_1(t) + L \frac{d(I_1(t) - I_2(t))}{dt} + R [I_1(t) - I_2(t)] = R F_2(t) + R I_1(t) + \frac{1}{C} \int I_2(t) dt$$

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

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

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

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

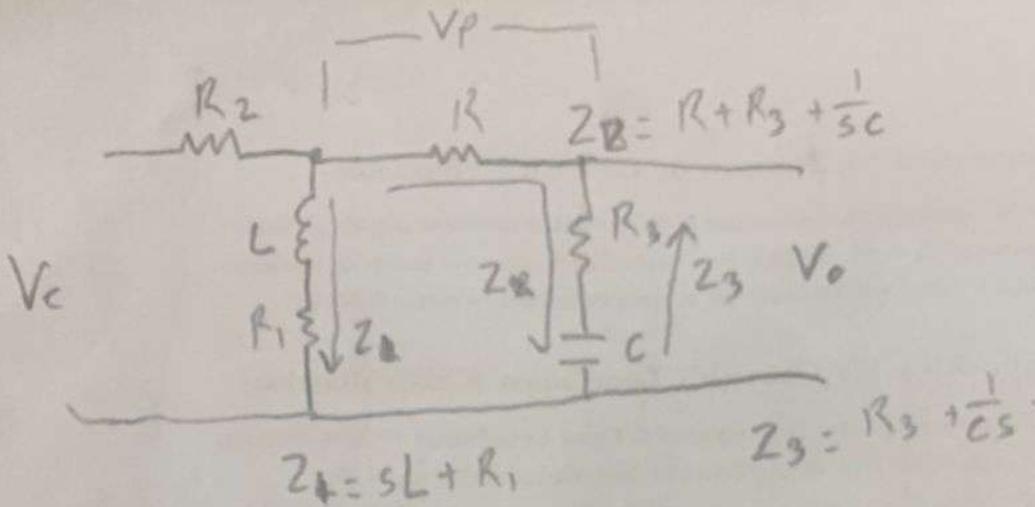
$$e(s) = \lim_{s \rightarrow 0} s \sqrt{e(s)} \left[1 - \frac{V_S(s)}{\sqrt{e(s)}} \right] = \lim_{s \rightarrow 0} s \frac{1}{s} \left[1 - \frac{3CLR^2 + (CR^2 + L)s + 2R}{3CR^2s^2 + 4s(CR^2 + L)s + 2R} \right]$$

$$\begin{cases} e(s) = \frac{R}{2R} = \frac{1}{2} \\ e(1) = 0.5V \end{cases} \quad V_S(t) = 1 \quad \text{por lo tanto } V_C(s) = \frac{1}{s}$$

Para de terminar la estabilidad

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

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



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

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

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

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

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

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

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

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

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

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

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

...

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

$$\left(\frac{1.551e^{-6}s^2 + 0.01733s + 10}{4.653e^{-6}s^2 + 0.23533s + 20} \right)$$

$$\frac{7.75e^{-8}s^2 + 0.00236s + 0.5}{2.32e^{-7}s^2 + 0.01176s + 1}$$

$H(s)$