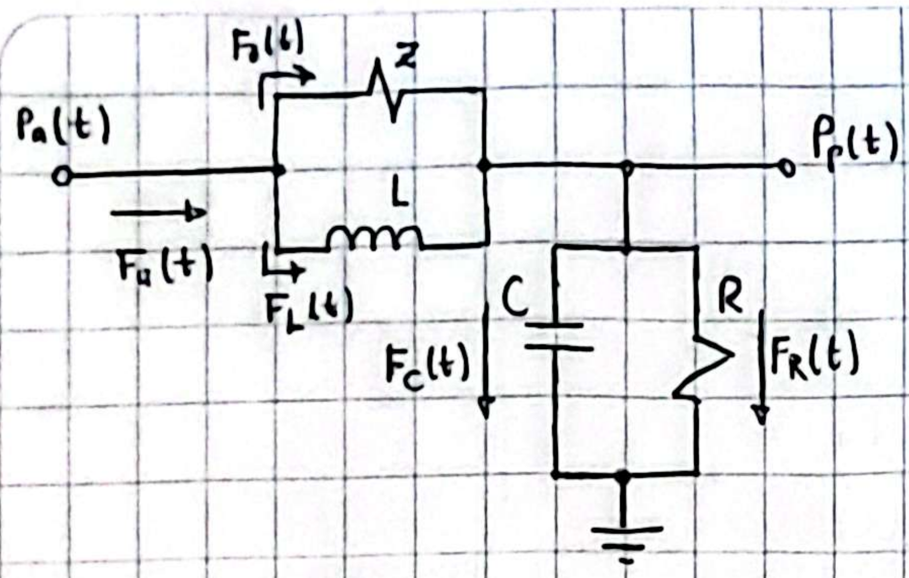
Práctica 5.4 : Sistema cardiovascular

10-Octubre



Ecuación principal

$$F_a(t) = F_z(t) + F_L(t) = F_C(t) + F_R(t)$$

$$F_z(t) = \frac{P_a(t) - P_p(t)}{z} \qquad F_C(t) = C\,\frac{\partial P_p(t)}{\partial t}$$

$$F_L(t) = \frac{1}{L}\int [P_a(t) - P_p(t)]\,dt \qquad F_R(t) = \frac{P_p(t)}{R}$$

Procedimiento algebraico

$$\frac{P_a(t)}{z} - \frac{P_p(t)}{z} + \frac{1}{L}\int [P_a(t) - P_p(t)]\,dt = C\,\frac{\partial P_p(t)}{\partial t} + \frac{P_p(t)}{R}$$

- Transformada de Laplace

$$\frac{P_a(s)}{z} - \frac{P_p(s)}{z} + \frac{P_a(s) - P_p(s)}{Ls} = Cs\,P_p(s) + \frac{P_p(s)}{R}$$

$$\left(\frac{1}{z} + \frac{1}{Ls}\right) P_a(s) = \left(Cs + \frac{1}{R} + \frac{1}{z} + \frac{1}{Ls}\right) P_p(s)$$

$$\frac{P_p(s)}{P_a(s)} = \frac{\left(\frac{1}{z} + \frac{1}{Ls}\right)}{\left(Cs + \frac{1}{R} + \frac{1}{z} + \frac{1}{Ls}\right)} = \left.\frac{\frac{z + Ls}{zLs}}{\frac{CRzLs^2 + zLs + RLs + Rz}{RzLs}}\right\}$$

$$= \frac{(z + Ls)\,R\cancel{zLs}}{(\cancel{zLs})(CRzLs^2 + zLs + RLs + Rz)} = \frac{Rz + RLs}{CRzLs^2 + (zL + RL)s + Rz}$$

Función de transferencia

$$\boxed{\frac{P_p(s)}{P_a(s)} = \frac{Rz + RLs}{CRzLs^2 + (zL + RL)s + Rz}}$$

Error en estado estacionario

$$e(s) = \lim_{s \to 0} sP_a(s)\left[1 - \frac{P_p(s)}{P_a(s)}\right]$$

$$e(s) = \lim_{s \to 0} s\left(\frac{1}{s}\right)\left[1 - \frac{RLs + Rz}{CLRzs^2 + (Lz + RL)s + Rz}\right]$$

$$e(s) = 1 - \frac{Rz}{Rz} = 0V$$

Estabilidad en lazo abierto

$$\lambda_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2ac} \qquad a = CLRz \quad b = Lz + RL \quad c = Rz$$

$$\lambda_{1,2} = \frac{-(Lz+RL) \pm \sqrt{(Lz+RL)^2 - 4(CLRz)(Rz)}}{2CLRz}$$

El sistema tiene una respuesta estable porque $Re\,\lambda_{1,2} < \emptyset$

Modelo de ecuaciones Integrodiferenciales

$$P_p(t)\left(\frac{1}{R} + \frac{1}{z}\right) = \frac{P_a(t)}{z} + \frac{1}{L}\int\left[P_a(t) - P_p(t)\right]dt - \frac{C\,\partial P_p(t)}{\partial t}$$

$$P_p(t) = \left(\frac{P_a(t)}{z} + \frac{1}{L}\int\left[P_a(t) - P_p(t)\right]dt - \frac{C\,\partial P_p(t)}{\partial t}\right)\frac{zR}{z+R}$$