5.4. Sistema cardiovascular

Ecuación principal

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

$$F_z(t) = \frac{P_a(t) - P_p(t)}{Z} \qquad F_c(t) = \frac{C\,dP_p(t)}{dt}$$

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

Procedimiento algebraico

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

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

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

$$\frac{Ls + z}{LZs} P_a(s) = \frac{\overset{CRLZs^2}{CLs^2} + RLs + Rz}{RLZs} P_p(s)$$

$$\frac{P_p(s)}{P_a(s)} = \frac{\frac{Ls+z}{Lzs}}{\frac{CLs^2 + (Lz + RL)s + Rz}{RLzs}}$$

$$\frac{P_p(s)}{P_a(s)} = \frac{RLs + Rz}{CLRzs^2 + (Lz + RL)s + Rz}$$ func. transferencia

Error en estado estacionario

$$e(s) = \lim_{s\to 0} s\,P_a(s)\left[1 - \frac{P_p(s)}{P_a(s)}\right] = \lim_{s\to 0} \cancel{s}\cdot\frac{1}{\cancel{s}}\left[1 - \frac{RLs^2 + \cancel{Rz}}{(L\cancel{Rz}\,s^2 + (Lz + \cancel{RL})s + Rz}\right] = 1 - \frac{Rz}{Rz}$$

Estabilidad en lazo abierto

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

- El sist. tiene respuesta estable porque $Re\,\lambda_{1,2} < 0$

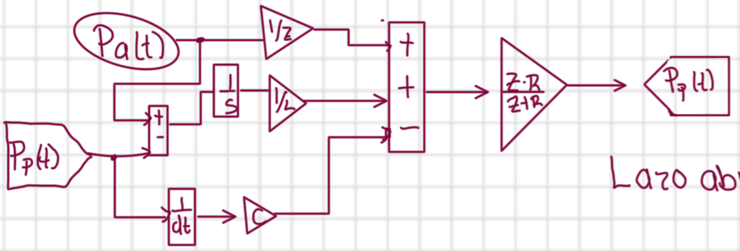
$a = CLRz$
$b = Lz + RL$
$c = Rz$

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

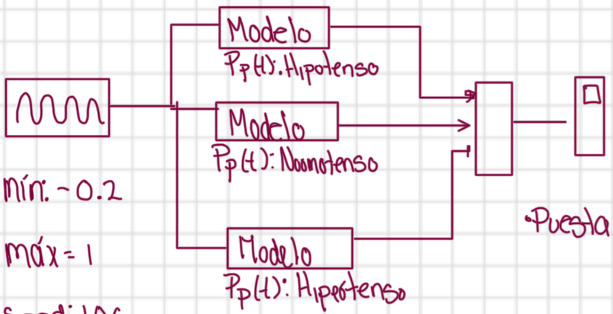
Modelo de ec. integro-diferenciales

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

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



Lazo abierto



mín: -0.2

máx = 1

Seed: 106

• Puesta estable