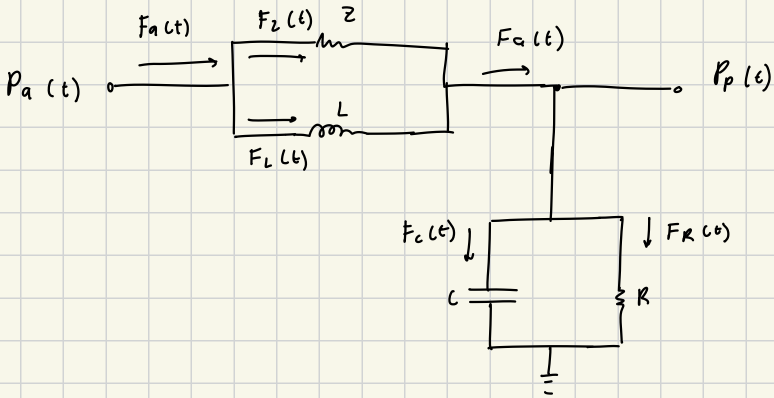
Práctica 5.4: Sistema Cardiovascular

10/10/25



Ecuación principal

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

$$F_C(t) = C\frac{dP_p(t)}{dt}$$

$$F_Z(t) = \frac{P_a(t) - P_p(t)}{Z}$$

$$F_R(t) = \frac{P_p(t)}{R}$$

$$F_L(t) = \frac{1}{L}\int\left[P_a(t) - P_p(t)\right]dt$$

Procedimiento algebraico

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

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

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

$$\left(\frac{Ls + Z}{(Ls)(Z)}\right)P_a(s) = \left(\frac{CRLZs^2 + LZs + RLs + RZ}{RLZs}\right)P_p(s)$$

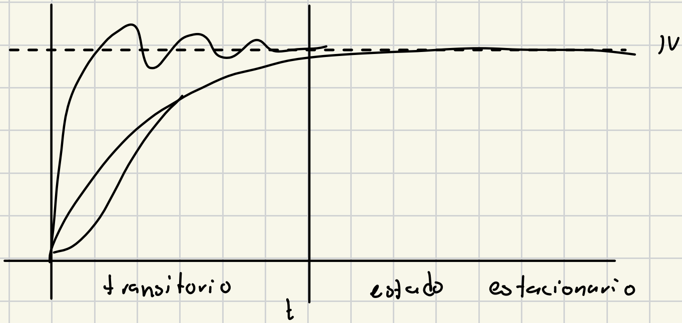
$$\frac{P_p(s)}{P_a(s)} = \frac{\frac{Ls+Z}{Ls\cdot Z}}{\frac{CRLZs^2 + (LZ+RL)s + RZ}{RLZs}} = \frac{RLs + RZ}{CLRZs^2 + (LZ+RL)s + RZ}$$

Error en estado estacionario

$$e(s) = \lim_{s \to 0} s \; Pa(s) \left[1 - \frac{Pp(s)}{Pa(s)} \right]$$

$$= \lim_{s \to 0} \cancel{s} \cdot \frac{1}{\cancel{s}} \left[1 - \frac{R\cancel{Ls} + RZ}{\cancel{CLRZ\, s^2} + \cancel{(LZ+RZ)s} + RZ} \right]$$

$$= 1 - \frac{RZ}{RZ} = 0 \text{ V}$$



Estabilidad en lazo abierto

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

$a = CLRZ$

$b = LZ + RL$

$c = RZ$

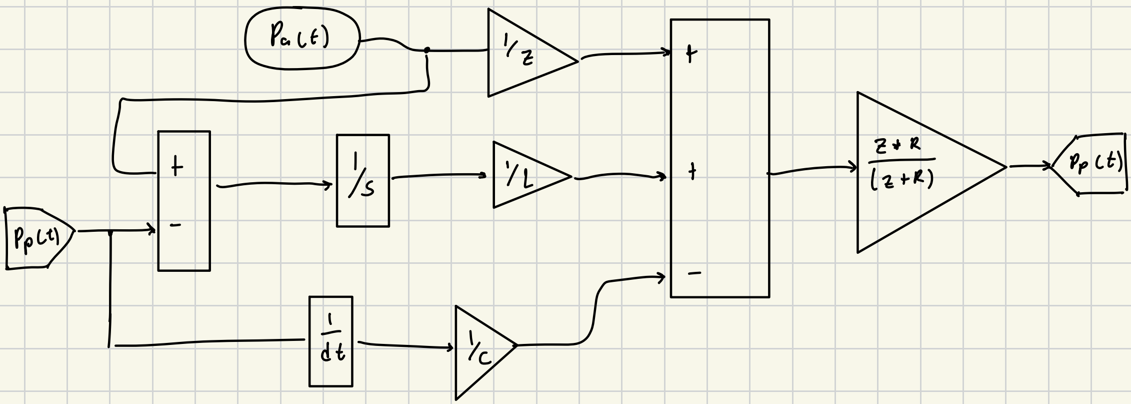
$$\lambda_{1,2} = \frac{-(LZ+RL) \pm \sqrt{(LZ+RL)^2 - 4CLR^2Z^2}}{2CLRZ} = \frac{(-)(\;)}{+}$$

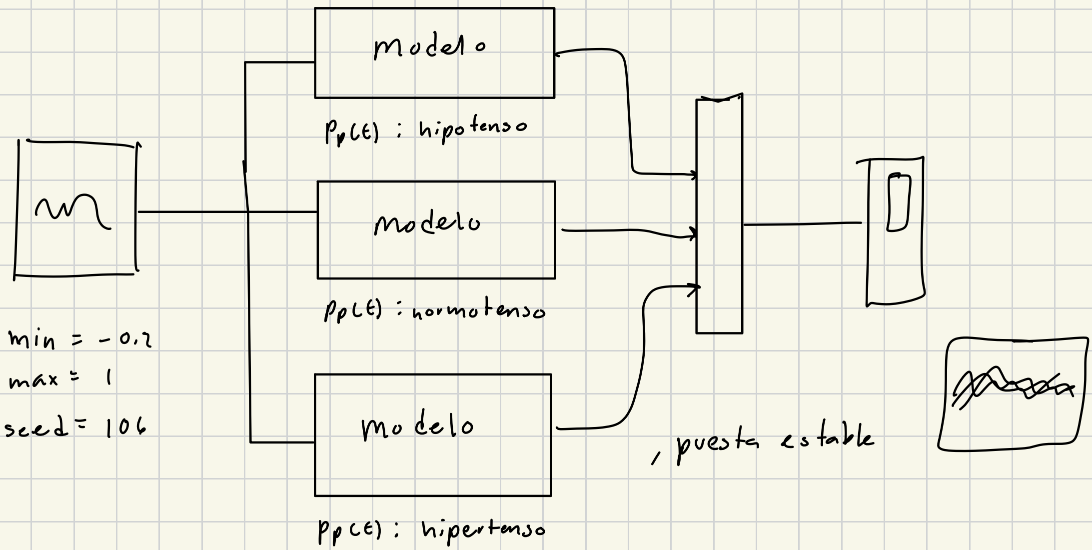
El sistema tiene una respuesta estable porque $\underline{Re\, \lambda_{1,2} < 0}$

Modelo de ecuaciones integro-diferenciales

$$Pp(t)\left(\frac{1}{R} + \frac{1}{Z}\right) = \frac{Pa(t)}{Z} + \frac{1}{L}\int [Pa(t) - Pp(t)]\, dt - C\frac{dPp(t)}{dt}$$

$$Pp(t) = \left(\frac{Pa(t)}{Z} + \frac{1}{L}\int [Pa(t) - Pp(t)]\, dt - C\frac{dPp(t)}{dt}\right)\frac{ZR}{(Z+R)}$$


Pa(t)
1/Z
+
+
-
Pp(t)
1/s
1/L
1/dt
1/C
Z + R
(Z+R)
Pp(t)


modelo
Pp(t) : hipotenso
modelo
Pp(t) : normotenso
modelo
Pp(t) : hipertenso
min = -0.2
max = 1
seed = 106
, puesta estable