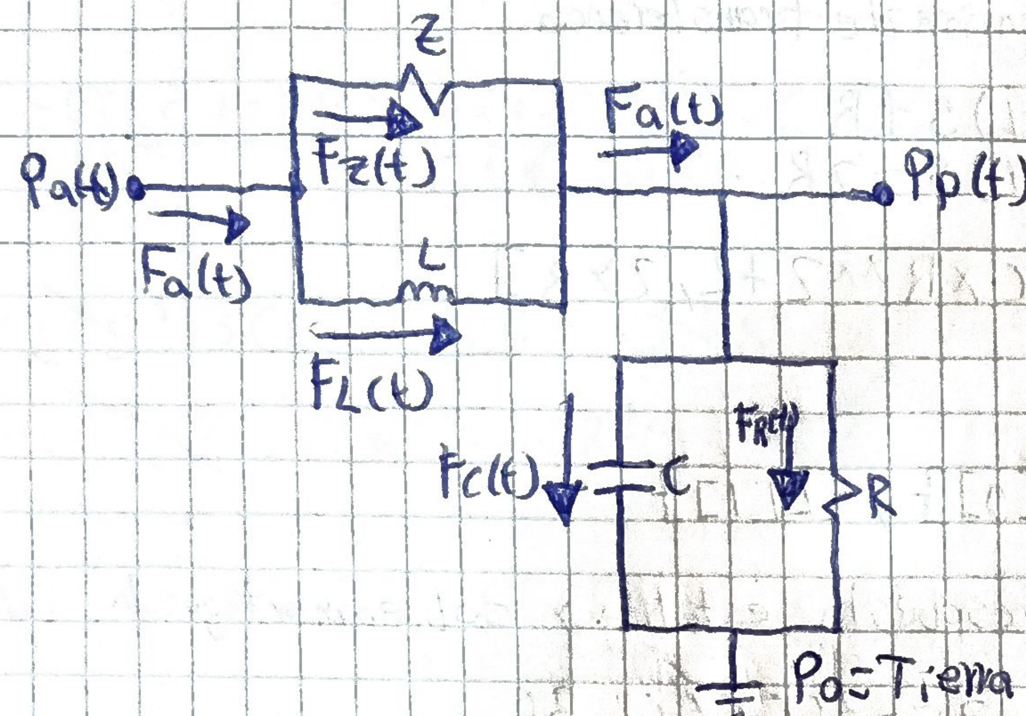
Practica 5.4: Sistema Cardiovascular



Ecuación principal

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

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

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

Procedimiento algebraico

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

$$\frac{P_a(S)}{Z} - \frac{P_p(S)}{Z} + \frac{P_a(S) - P_p(S)}{LS} = CSP_p(S) + \frac{P_p(S)}{R}$$

$$\left(\frac{1}{Z} + \frac{1}{LS}\right)P_a(S) = \left(CS + \frac{1}{R} + \frac{1}{Z} + \frac{1}{LS}\right)P_p(S)$$

$$\frac{LS+Z}{LZS}P_a(S) = \left(\frac{CRLZS^2 + LZS + LSR + RZ}{RLZS}\right)P_p(S)$$

$$\frac{P_o(s)}{P_s(s)} = \left(\frac{\frac{LS+Z}{LZS}}{\frac{CRLZS^2+LZS+LSR+RZ}{RLZS}} \right)$$

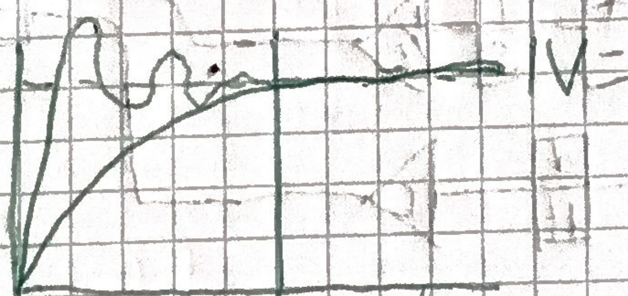
$$\frac{P_o(s)}{P_s(s)} = \frac{RLS+RZ}{CLRZS^2+(LZ+RL)S+RZ}$$

Error en estado estacionario

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

$$= \lim_{s \to 0} s * \frac{1}{s} \left[1 - \frac{RLS+RZ}{CLRZS^2+(LZ+RL)S+RZ} \right]$$

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



Estabilidad en lazo abierto

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

$a = CLRZ$
$b = LZ+RL$
$c = RZ$

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

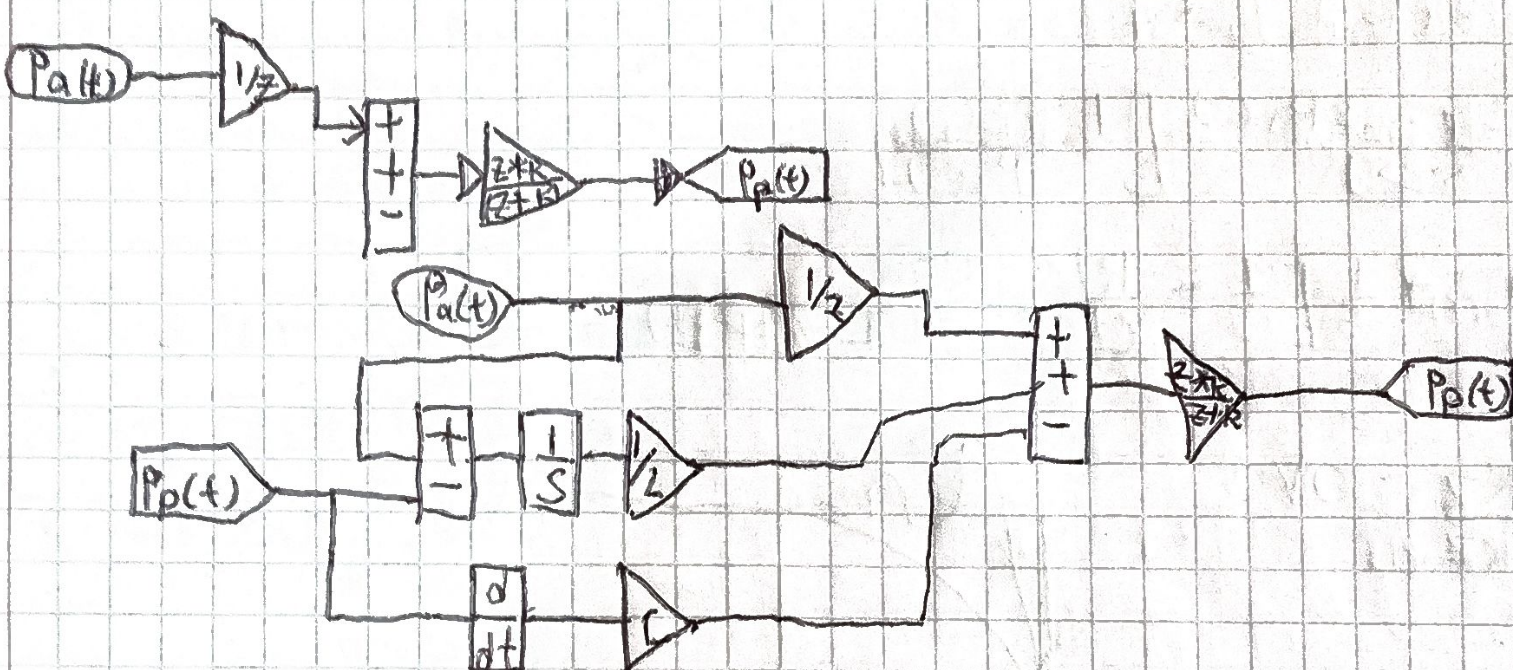
El sistema tiene una respuesta estable porque $Re\,\lambda_{1,2} < 0$

Modelo de ecuaciones integro-diferenciales

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

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

Modelo de ecuaciones



Lazo abierto

min = 0.2
max = 1
seed = 106

Hipo: Z = 0.020
C = 0.250
R = 0.600
L = 0.005

Normo: Z = 0.033
C = 1.500
R = 0.950
L = 0.010

Hiper: Z = 0.050
C = 2.500
R = 1.400
L = 0.020