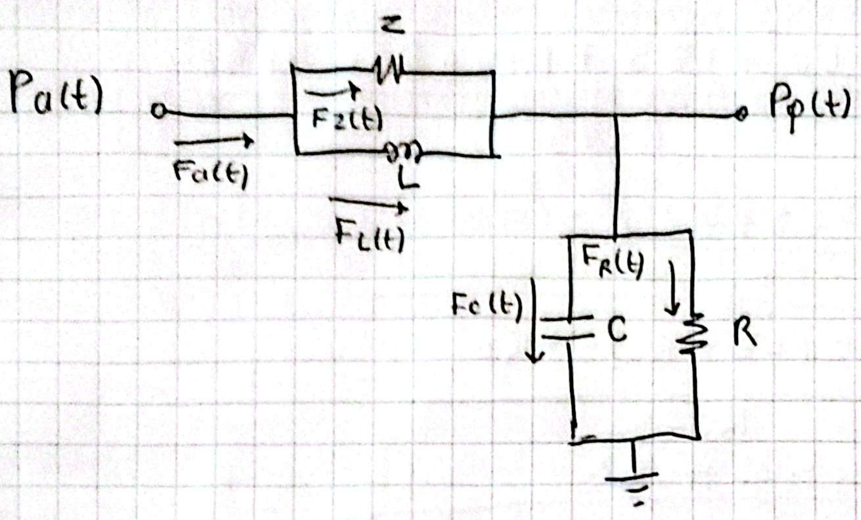
Práctica 5.4: Sistema cardiovascular



Ecuación principal

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

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

$\rightarrow F_L(t) = \dfrac{1}{L}\int [P_a(t) - P_p(t)]\,dt$

$\rightarrow F_C(t) = \dfrac{C\,d\,P_p(t)}{dt}$

$\rightarrow F_R(t) = \dfrac{P_p(t)}{R}$

Procedimiento algebraico

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

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

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

$$\frac{LS+Z}{LZS} Pa(s) = \frac{CLS^2 + LZS + RLS + RZ + CRLZS^2}{RLZS}$$

$$\frac{Pp(s)}{Pa(s)} = \frac{\frac{LS+Z}{LZS}}{\frac{CLS^2 + (LZ + RL)S + RZ}{RLZS}}$$

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

Error en estado estacionario

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

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

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

Estabilidad en lazo abierto

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

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

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

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

Modelo de ecuaciones integro - diferenciales

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

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