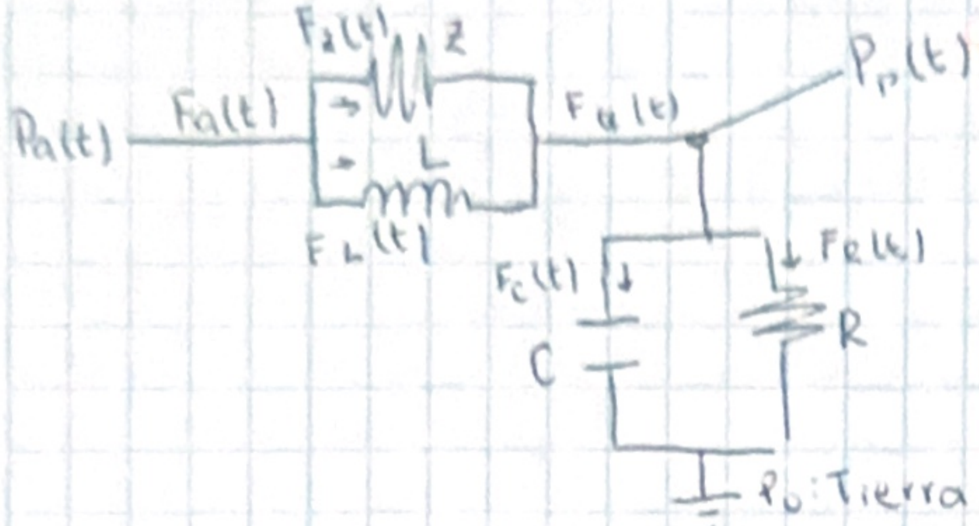
10/10/25

PRACTICA 5.4 sistema cardiovascular



Ecuación principal

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

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

$$F_c(t) = C\frac{d\,P_p(t)}{dt}$$

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

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

Procedimiento algebraico

$$\frac{P_a(t)}{Z} - \frac{P_p(t)}{Z} + \frac{1}{L}\int [P_a(t) - P_p(t)\,dt \ldots$$

$$\ldots = C\frac{d\,P_p(t)}{dt} + \frac{P_p(t)}{R}$$

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

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

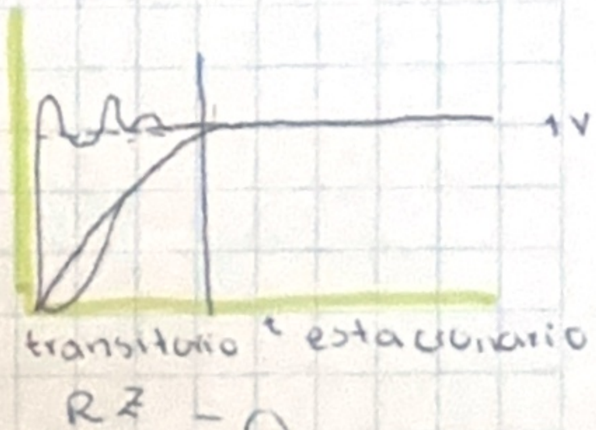
$$\frac{LS + Z}{LZS}\,P_a(s) = \frac{RLZS^2 + LZS + RLS + RZ}{RLZS}\,P_p(s)$$

$$\frac{P_p(s)}{P_a(s)} = \frac{\frac{LS+Z}{XSZ}}{\frac{RLZS^2 + (LZ + RL)S + RZ}{RLZS}} = \frac{RLS + RZ}{CLRZS^2 + (LZ + RL)S + RZ}$$

Error en estado estacionario

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

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



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 para $Re\lambda_{1,2} < 0$

Modelo de ecuaciones integro-diferenciales

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

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

Diagrama de bloques