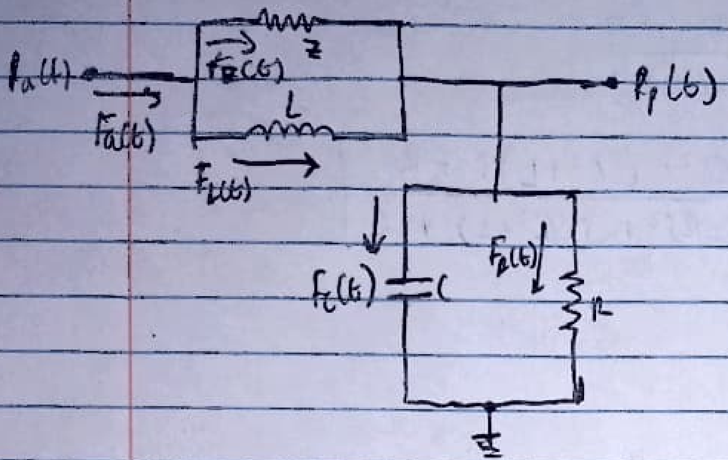
Práctica 2. Sistema cardiovascular.



Ecuación principal

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

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

$$F_C(t) = C\frac{dP_p(t)}{dt} \quad ; \quad F_R(t) = \frac{P_p(t)}{R}$$

Transformada de Laplace

$$F_Z(s) + F_L(s) = F_C(s) + F_R(s)$$

$$F_Z(s) = \frac{P_a(s) - P_p(s)}{Z} \quad ; \quad F_L(s) = \frac{P_a(s) - P_p(s)}{LS}$$

$$F_C(S) = CS\, P_p(s) \quad ; \quad F_R(S) = \frac{P_p(S)}{R}$$

Sustituyendo

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

Procedimiento algebraico

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

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

$$Pa(s)\left[\frac{LS+Z}{LSZ}\right] = Pp(s)\left[\frac{CLRS^2Z+LSZ+LRS+RZ}{LRSZ}\right]$$

$$\frac{Pp(S)}{Pa(S)} = \frac{\frac{LS+Z}{\cancel{LSZ}}}{\frac{[CLRZ]S^2+[LZ+LR]S+RZ}{\cancel{LRSZ}}}$$

$$\boxed{\frac{Pp(S)}{Pa(S)} = \frac{LRS+RZ}{[CLRZ]S^2+[LZ+LR]S+RZ}} \longrightarrow \text{Función de transferencia}$$

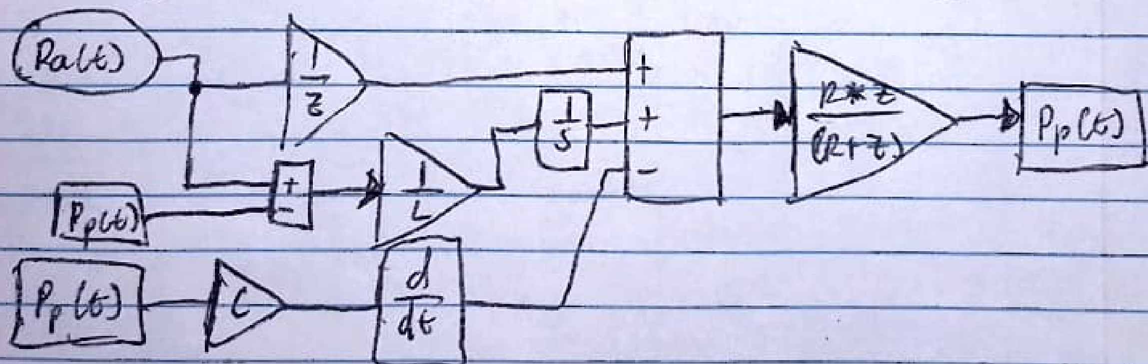
Modelo de Ecuaciones Integro-diferenciales

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

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

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

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



Error en estado estacionario

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

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

$$=0V$$

Estabilidad en lazo abierto

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

$a = CLRZ$

$b = (LZ + LR)$

$c = RZ$

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

$\lambda_1 = Re < 0$

$\lambda_2 = Re < 0$

La respuesta del sistema es estable