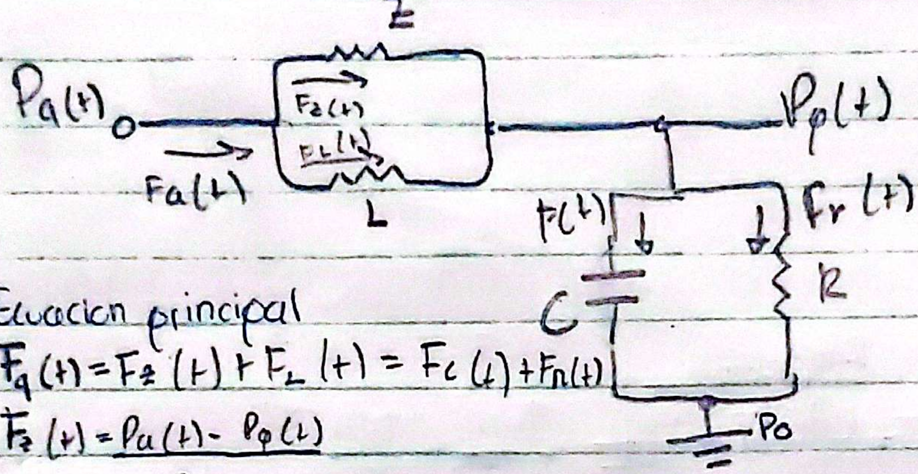
Modelo - Sistema CardioVascular



Ecuacion principal

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

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

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

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

- Trans de Laplace

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

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

- $F_L(s) = \dfrac{P_a(s) - P_p(s)}{L \cdot S}$

- $F_C(s) = CS\, P_p(s)$

- $F_R(s) = \dfrac{P_p(s)}{R} + \dfrac{P_a(s)}{L \cdot S} - \dfrac{P_p(s)}{LS} = CS\, P_p(s) + \dfrac{P_p(s)}{R}$

→ Procedimiento Algebraico

$$\frac{P_a(s)}{Z} + \frac{P_a(s)}{L \cdot C} = CSP_p(s) + \frac{P_p(s)}{R} + \frac{P_p(s)}{Z} + \frac{P_p(s)}{Ls}$$

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

$$P_a(s)\,\frac{Ls+Z}{LZs} = P_p(s)\,\frac{CLRZs^2 + \overbrace{LZs + LRs}^{L(Z+R)s} + RZ}{LRZs}$$

Funcion de trans

$$\frac{P_p(s)}{P_a(s)} = \frac{(Ls+Z)\cancel{L}R\cancel{Z}\cancel{s}}{(CLRZs^2 + L(Z+R)s + RZ)LZs}$$

$$= \frac{RLs + RZ}{CLRZs^2 + (LZ+LR)s + RZ}$$

Modelo de ecuacion integro - diferencial

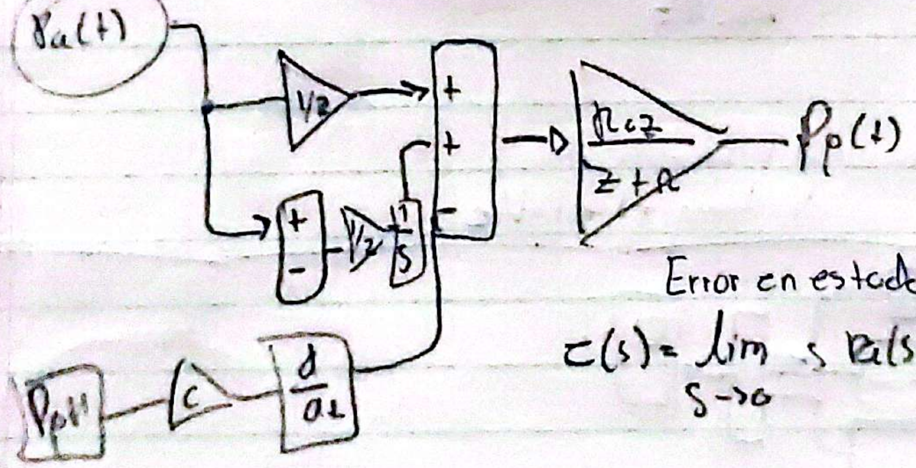
$$F_Z(t) + F_L(t) = F_C(t) + F_R(t)$$

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

$$\overbrace{\left(\frac{1}{R} + \frac{1}{Z}\right)}^{\frac{Z+R}{R\cdot Z}}$$

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

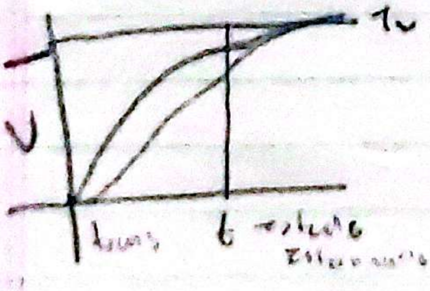
$$P_\varphi(t) = \left[\frac{P_a(t)}{Z} + \frac{1}{L}\int [P_a(t) - P_\varphi(t)]\,dt - C\frac{dP_\varphi(t)}{dt}\right]\frac{RZ}{Z+R}$$



Error en estado Estacionario

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

$$= \lim_{s\to 0} s\cdot\frac{1}{s}\left[1 - \frac{RLs + RZ}{CLRZs^2 + (LZ + LR)s + RZ}\right]$$



$$\frac{P_\varphi(s)}{P_a(s)} = \frac{RLs + RZ}{CLRZs^2 + (LZ + LR)s + RZ} = a$$

Estabilidad en lazo abierto

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

$a = CLRZ$

$b = (LZ + LR)$

$c = RZ$

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

$\lambda_1 = R_z \angle \phi$

$\lambda_2 = R_z \angle \phi$

La respuesta del sistema es estable