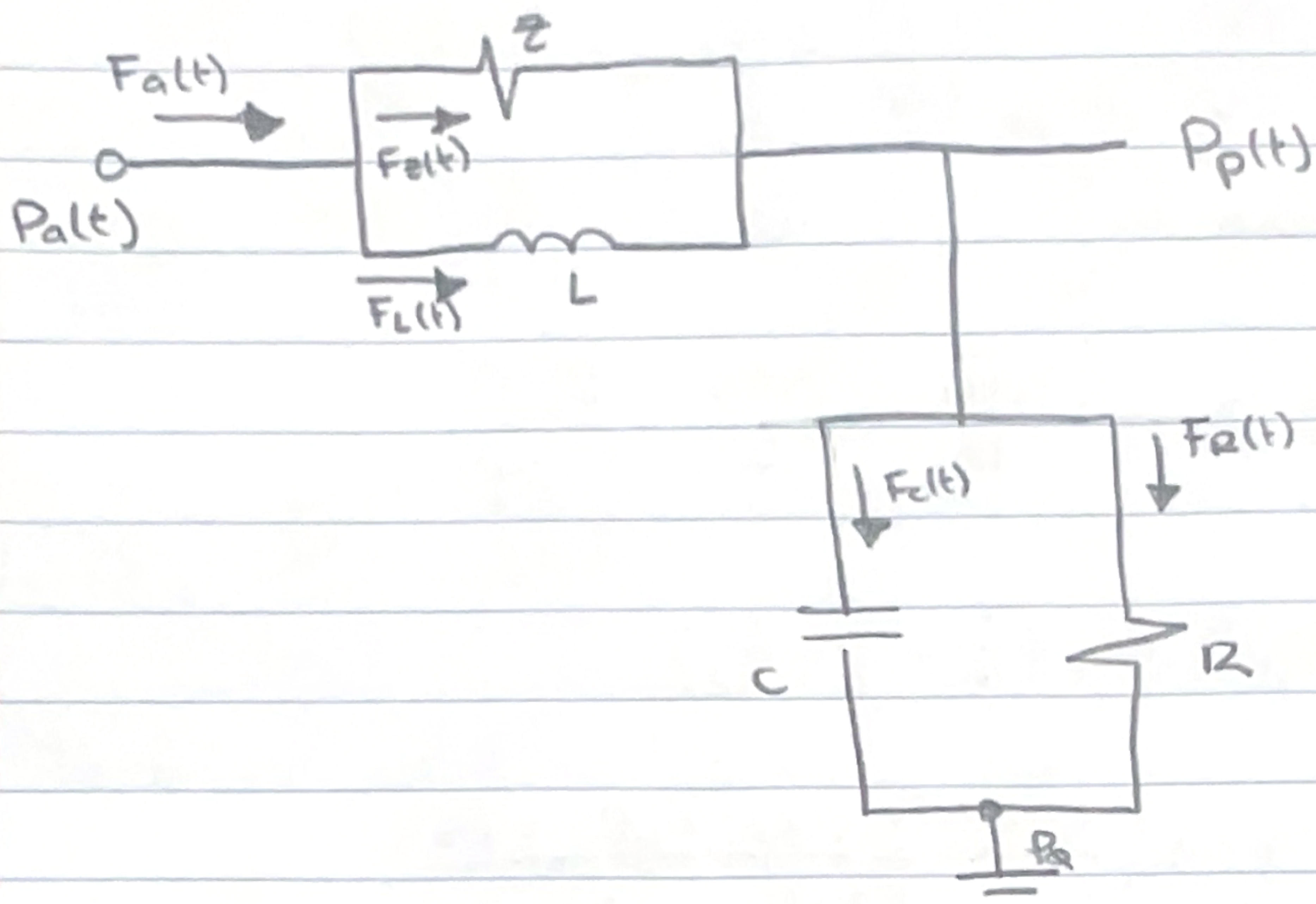
Mallas
Nodos → derivada

Sistema cardiovascular

08/Octubre/2025



Ecuación principal

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

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

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

$$F_c(t) = C \frac{dP_p(t)}{dt}$$

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

Transformada de Laplace

$$F_z(s) + F_L(s) = F_c(s) + F_R(s)$$

$$F_z(s) = \frac{P_a(s) - P_p(s)}{Z} \qquad F_R(s) = \frac{P_p(s)}{R}$$

$$F_L(s) = \frac{P_a(s) - P_p(s)}{Ls}$$

$$F_c(s) = Cs\, P_p(s)$$

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

Procedimiento algebraico

$$\frac{P_a(s)}{Z} + \frac{P_a(s)}{LS} = CsP_p(s) + \frac{P_p(s)}{R} + \frac{P_p(s)}{Z} + \frac{P_p(s)}{LS}$$

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

$$P_a(s)\left(\frac{Z+LS}{LZS}\right) = P_p(s)\left(\frac{CLRZs^2 + LRS + LRZ + RZ}{LRZS}\right)$$

Salida / entrada

$$\frac{P_p(s)}{P_a(s)} = \frac{(LS+Z)\ LRZS}{(CLRZS^2 + L(Z+R)S + RZ)LZS}$$

$$= \frac{RLS+RZ}{CLRZs^2 + (LZ+LR)s + RZ} \Big\}$$ Función de transferencia

Modelo de ecuaciones integro-diferenciales

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

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

$$\frac{Z+R}{RZ}$$

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

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

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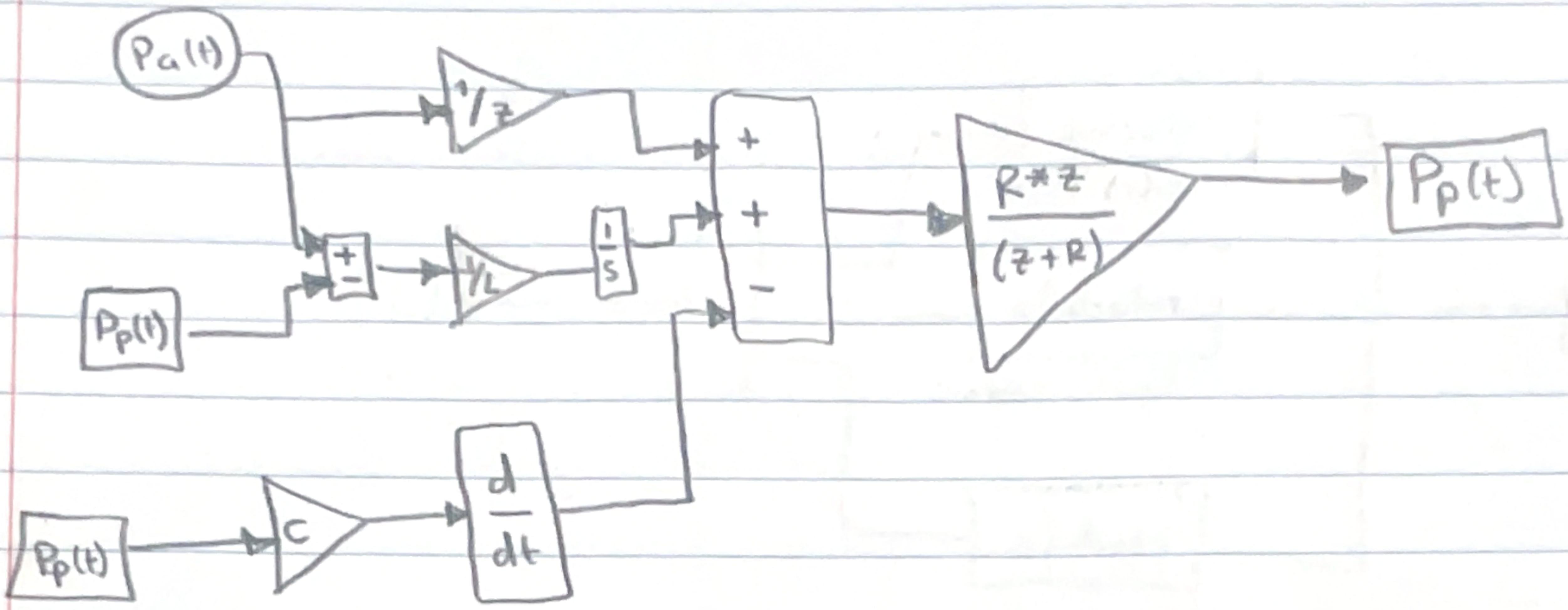
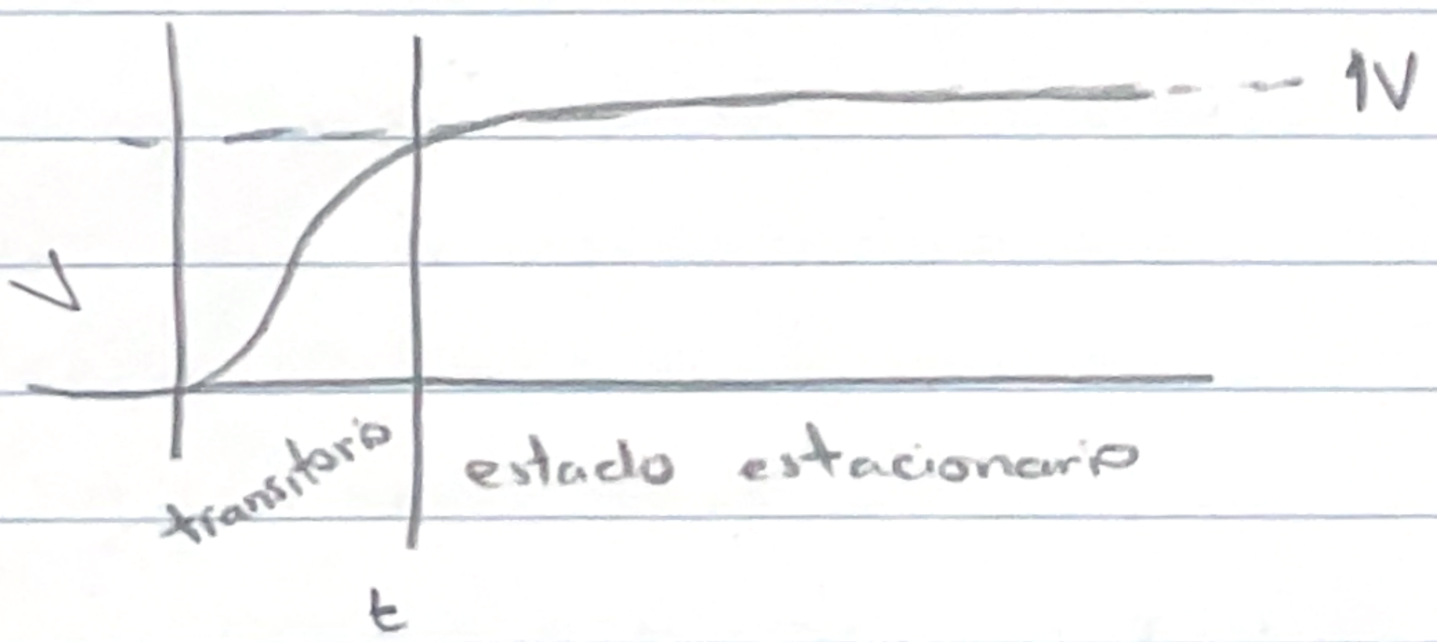


Error en estado estacionario (Límite cuando tiende a 0)

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

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

$$= 0V$$



Estabilidad en lazo abierto

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

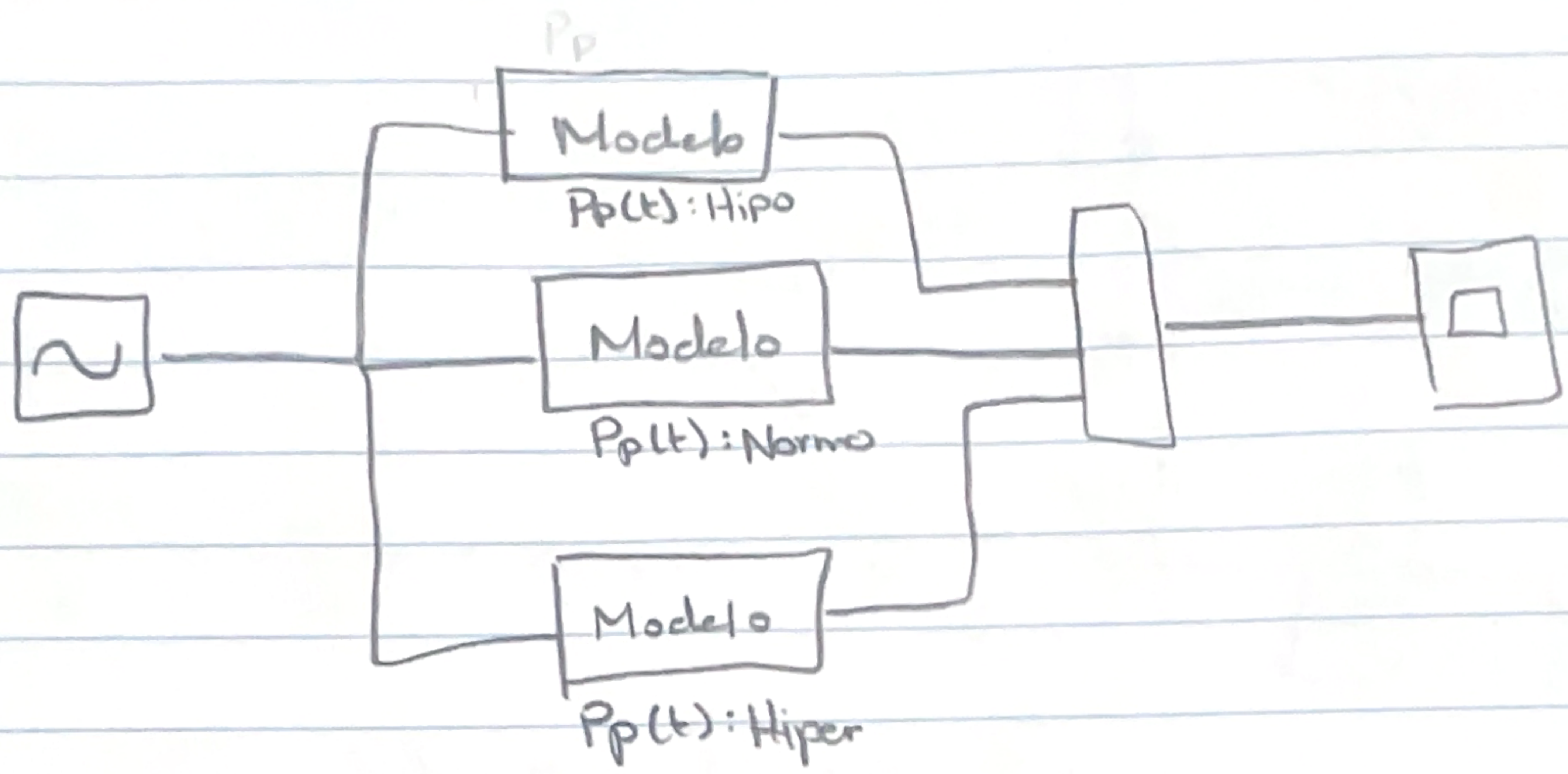
$a = CLRZ$

$b = (LZ + LR)$

$c = RZ$

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

$$\left.\begin{array}{l} \lambda_1 = Re < 0 \\ \lambda_2 = Re < 0 \end{array}\right\}$$ La respuesta del sistema es estable.


Pp
Modelo
Pp(t): Hipo
Modelo
Pp(t): Normo
Modelo
Pp(t): Hiper