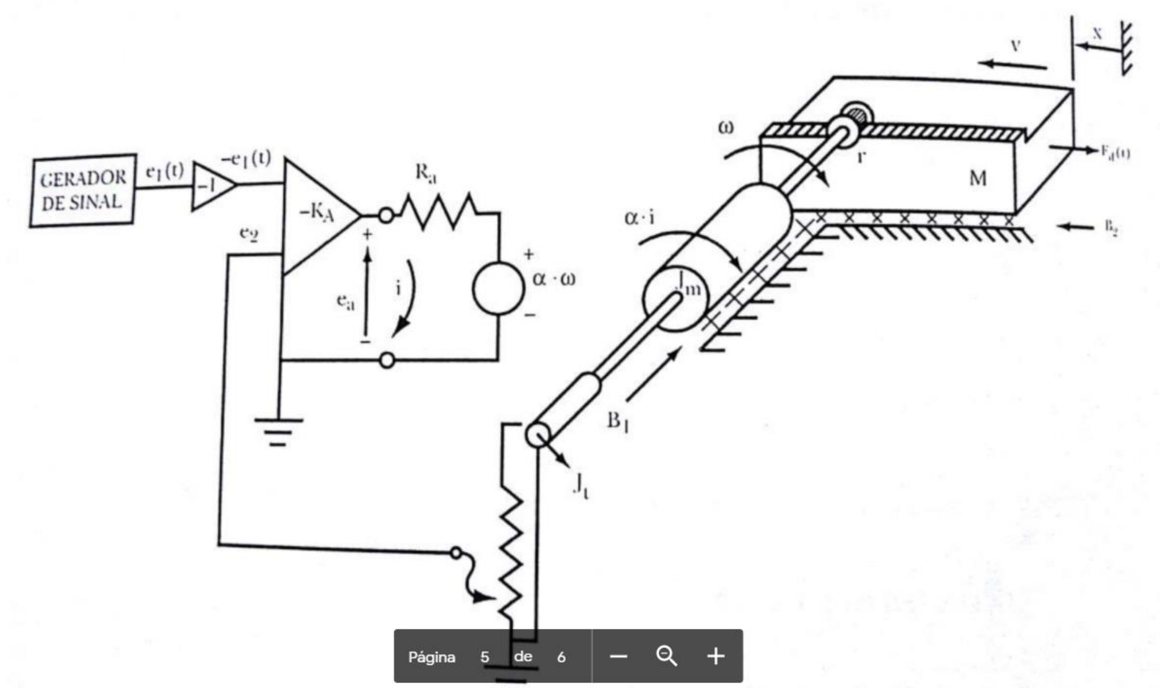


$$e_a = iR_a + \alpha\dot{\theta}$$

$$(J_m + J_t)\ddot{\theta} = \alpha i - B_1\dot{\theta} - Fr$$

$$M\ddot{x} = F - B_2\dot{x} - F_d$$

$$e_2 = K\dot{\theta}$$

$$e_a = -K_A(e_2 - e_1) = K_A(e_1 - e_2)$$

$$x = r\theta$$

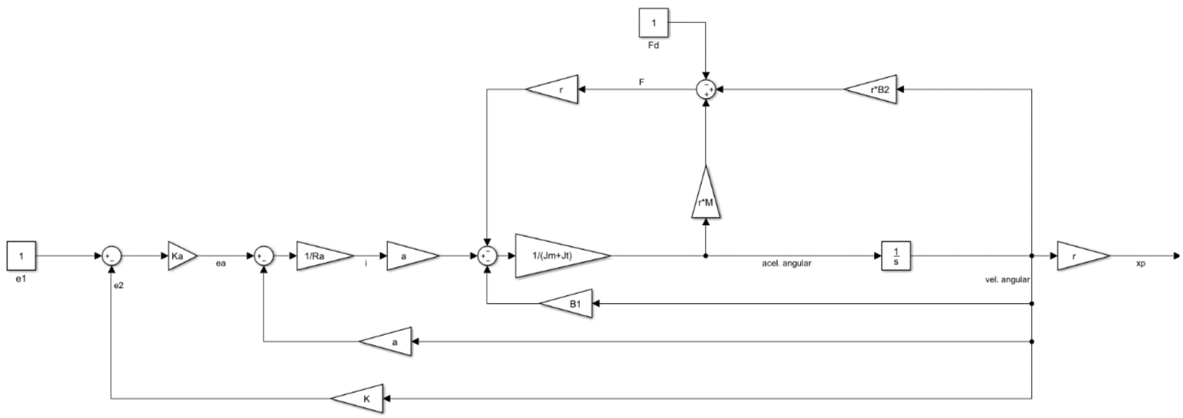
$$\dot{x} = r\dot{\theta}$$

$$\ddot{x} = r\ddot{\theta}$$

Diagrama de bloques:

$$\ddot{\theta} = \frac{\alpha i - B_1\dot{\theta} - Fr}{J_m + J_t}$$

$$F = M\ddot{x} + B_2\dot{x} + F_d$$



VE:

$$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} \theta \\ \dot{\theta} \end{bmatrix}$$

$$\begin{bmatrix} u_1 \\ u_2 \end{bmatrix} = \begin{bmatrix} e_1 \\ F_d \end{bmatrix}$$

$$y = \dot{x} = r\dot{\theta} = rx_2$$

Derivamos los estados

$$\boldsymbol{\dot{x}_1 = x_2}$$

$$\dot{x}_2 = \ddot{\theta} = \frac{\alpha i - B_1\dot{\theta} - Fr}{J_m + J_t}$$

$$F = M\ddot{x} + B_2\dot{x} + F_d = Mr\ddot{\theta} + B_2r\dot{\theta} + F_d$$

$$i = \frac{e_a - \alpha\dot{\theta}}{R_a}$$

$$e_a = K_A(e_1 - K\dot{\theta})$$

$$i = \frac{K_A(e_1 - K\dot{\theta}) - \alpha\dot{\theta}}{R_a}$$

$$\ddot{\theta} = \frac{\alpha\frac{K_A(e_1 - K\dot{\theta}) - \alpha\dot{\theta}}{R_a} - B_1\dot{\theta} - \left(Mr\ddot{\theta} + B_2r\dot{\theta} + F_d\right)r}{J_m + J_t}$$

$$(J_m + J_t + Mr^2)\ddot{\theta} = \alpha\frac{K_A(e_1 - K\dot{\theta}) - \alpha\dot{\theta}}{R_a} - B_1\dot{\theta} - B_2r^2\dot{\theta} - F_dr$$

$$\ddot{\theta} = \frac{\alpha\frac{K_A(e_1 - K\dot{\theta}) - \alpha\dot{\theta}}{R_a} - B_1\dot{\theta} - B_2r^2\dot{\theta} - F_dr}{J_m + J_t + Mr^2}$$

$$\dot{x}_2 = \frac{\alpha \dfrac{K_A(u_1 - Kx_2) - \alpha x_2}{R_a} - B_1 x_2 - B_2 r^2 x_2 - u_2 r}{J_m + J_t + Mr^2}$$

$$\boxed{\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{pmatrix} 0 & 1 \\ 0 & -\dfrac{\dfrac{\alpha K_A K + \alpha^2}{R_a} + B_1 + B_2 r^2}{J_m + J_t + Mr^2} \end{pmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{pmatrix} 0 & 0 \\ \dfrac{\dfrac{\alpha K_A}{R_a}}{J_m + J_t + Mr^2} & \dfrac{-r}{J_m + J_t + Mr^2} \end{pmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}}$$

$$\boxed{y = \begin{pmatrix} 0 & r \end{pmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}}$$