



$$v = iR + L \frac{di}{dt} + K_b \dot{x}_1$$

$$M_1 \ddot{x}_1 = K_i i - b_1 \dot{x}_1 - b_2 (\dot{x}_1 - \dot{x}_2) - k_1 (x_1 - x_2)$$

$$M_2 \ddot{x}_2 = F - b_3 \dot{x}_2 - b_2 (\dot{x}_2 - \dot{x}_1) - k_1 (x_2 - x_1)$$

V.E:

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \end{bmatrix} = \begin{bmatrix} x_1 \\ \dot{x}_1 \\ x_2 \\ \dot{x}_2 \\ i \end{bmatrix}$$

$$\begin{bmatrix} u_1 \\ u_2 \end{bmatrix} = \begin{bmatrix} v \\ F \end{bmatrix}$$

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} x_2 \\ x_1 \\ i \end{bmatrix} = \begin{bmatrix} X_3 \\ X_1 \\ X_5 \end{bmatrix}$$

Derivamos los estados:

$$\dot{X}_1 = X_2$$

$$\dot{X}_3 = X_4$$

$$\dot{X}_5 = \frac{di}{dt} = ?$$

$$\frac{v - iR - K_b \dot{x}_1}{L} = \frac{di}{dt}$$

$$\dot{X}_5 = \frac{u_1 - X_5 R - K_b X_2}{L}$$

$$\dot{X}_2 = \ddot{x}_1 = ?$$

$$\ddot{x}_1 = \frac{K_i i - b_1 \dot{x}_1 - b_2 (\dot{x}_1 - \dot{x}_2) - k_1 (x_1 - x_2)}{M_1}$$

$$\dot{X}_2 = \frac{K_i X_5 - b_1 X_2 - b_2 (X_2 - X_4) - k_1 (X_1 - X_3)}{M_1}$$

$$\dot{X}_4 = \ddot{x}_2 = ?$$

$$\ddot{x}_2 = \frac{F - b_3 \dot{x}_2 - b_2 (\dot{x}_2 - \dot{x}_1) - k_1 (x_2 - x_1)}{M_2}$$

$$\dot{X}_4 = \frac{u_2 - b_3 X_4 - b_2 (X_4 - X_2) - k_1 (X_3 - X_1)}{M_2}$$

$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_3 \\ \dot{X}_4 \\ \dot{X}_5 \end{bmatrix} = \begin{pmatrix} \mathbf{0} & \mathbf{1} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ -k_1/M_1 & -(b_1 + b_2)/M_1 & k_1/M_1 & b_2/M_1 & K_i/M_1 \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{1} & \mathbf{0} \\ k_1/M_2 & b_2/M_2 & -k_1/M_2 & -(b_2 + b_3)/M_2 & \mathbf{0} \\ \mathbf{0} & -K_b/L & \mathbf{0} & \mathbf{0} & -R/L \end{pmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \end{bmatrix} + \begin{pmatrix} \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} \\ \mathbf{0} & 1/M_2 \\ 1/L & \mathbf{0} \end{pmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{pmatrix} \mathbf{0} & \mathbf{0} & \mathbf{1} & \mathbf{0} & \mathbf{0} \\ \mathbf{1} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{1} \end{pmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \end{bmatrix}$$