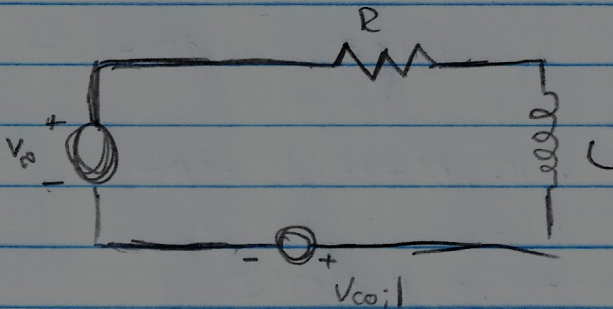


①



Circuito eléctrico



$$\lambda \rightarrow x$$

$$1/L \rightarrow k$$

$$1/R \rightarrow b$$

$$C \rightarrow m$$

$$L = T - V = \frac{M \dot{x}^2}{2} - \frac{1}{2L} \lambda^2$$

$$R = \frac{1}{2R} \dot{\lambda}^2 - \frac{b \dot{x}^2}{2}$$

x:

$$\frac{\partial L}{\partial \dot{x}} = M \dot{x} \Rightarrow \frac{d}{dt} \left(\frac{\partial L}{\partial \dot{x}} \right) = M \ddot{x}$$

$$\frac{\partial L}{\partial x} = 0$$

①

$$\frac{\partial R}{\partial \dot{x}} = b\dot{x}$$

$$\lambda: \frac{\partial L}{\partial \dot{\lambda}} = 0$$

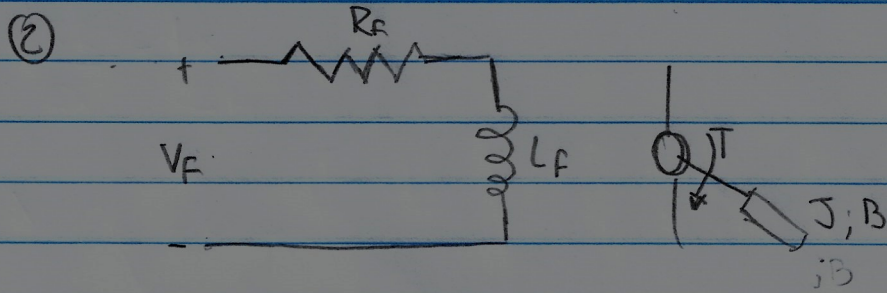
$$\frac{\partial L}{\partial \lambda} = -\frac{\lambda}{L}$$

$$\frac{\partial R}{\partial \dot{\lambda}} = \frac{\dot{\lambda}}{R}$$

$$M\ddot{x} + b\dot{x} = F = 9Bi$$

$$\frac{\lambda}{L} + \frac{\dot{\lambda}}{R} = \frac{V_a}{R} + \frac{V_{coil}}{LD}$$

(2)



$$L = T - V = \frac{J\dot{\theta}^2}{2} + \frac{L_F\dot{q}^2}{2}$$

$$R = \frac{R_F\dot{q}^2}{2} + \frac{B\dot{\theta}^2}{2}$$

$$\theta: \frac{\partial L}{\partial \theta} = J\dot{\theta} \Rightarrow \frac{d}{dt} \left(\frac{\partial L}{\partial \dot{\theta}} \right) = J\ddot{\theta} \quad | \quad q: \frac{\partial L}{\partial q} = L_F\dot{q} \Rightarrow \frac{d}{dt} \left(\frac{\partial L}{\partial \dot{q}} \right) = L_F\ddot{q}$$

$$\frac{\partial L}{\partial \theta} = 0$$

$$\frac{\partial L}{\partial q} = 0$$

$$\frac{\partial R}{\partial \theta} = B\dot{\theta}$$

$$\frac{\partial R}{\partial q} = R_F\dot{q}$$

$$J\ddot{\theta} + B\dot{\theta} = T = k\dot{q}$$

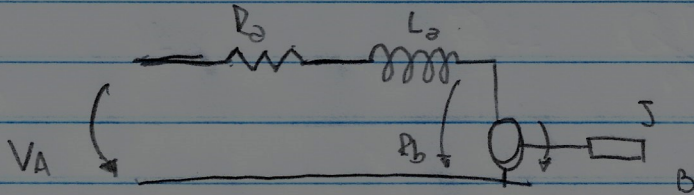
$$L_F\ddot{q} + R_F\dot{q} = V_F$$

$$L_F \approx 0 \Rightarrow \dot{q} = \frac{V_F}{R_F} \Rightarrow J\ddot{\theta} + B\dot{\theta} = \frac{V_F k}{R_F}$$

$$\zeta = \left(\frac{B}{J} \right)^{-2}; \quad k_m = \frac{k}{BR_F}$$

③

- I_m constante



$$L = T - V = \frac{J\dot{\theta}^2}{2} + \frac{L_a \dot{q}^2}{2}$$

$$R = \frac{B\dot{\theta}^2}{2} + \frac{R_a \dot{q}^2}{2}$$

$$J\ddot{\theta} + B\dot{\theta} = T = kq$$

$$L_a \ddot{q} + R_a \dot{q} = V_a - k_b \theta$$

$$L_a \approx 0 \Rightarrow \dot{q} = \frac{V_a - k_b \theta}{R_a}$$

$$J\ddot{\theta} + B\dot{\theta} = k \left(\frac{V_a - k_b \theta}{R_a} \right)$$

$$\ddot{\theta} + \left(\frac{B}{J} + \frac{k k_b}{J R_a} \right) \dot{\theta} = \frac{k}{J R_a} V_a$$

$$\zeta = \frac{R_a B + k k_b}{J R_a}$$

(4)