Dinâmica Eletromecânica dos Geradores Síncronos

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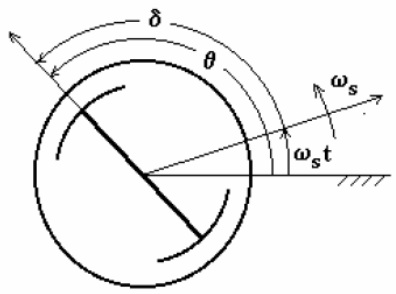
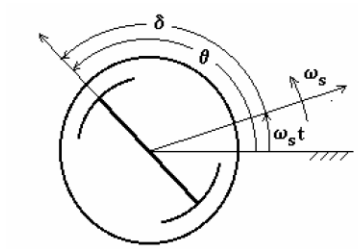
Equação de Balanço de Torques (I)



$$J\frac{d^2\theta}{dt^2} = T_m - T_e$$

Equação de Balanço de Torques (II)

$$\delta = \theta - w_s t$$



$$\frac{d\delta}{dt} = \frac{d\theta}{dt} - w_s$$

$$\frac{d^2\delta}{dt^2} = \frac{d^2\theta}{dt^2} = \gamma$$

$$\boxed{J\frac{d^2\delta}{dt^2} = T_m - T_e}$$

Equação de Balanço de Torques (III)

- Multiplicando pela velocidade:

$$\mathcal{M}\frac{d^2\delta}{dt^2} = P_m - P_e$$

- Constante de Inércia *H:*

$$H = \frac{\text{En. Cinética à veloc. nominal, } W}{\text{MVA nominal, } S_N}$$

- $$W = \frac{1}{2}Jw_0^2 = \frac{1}{2}\mathcal{M}w_0 \quad \Rightarrow \mathcal{M} = \frac{2W}{\omega_0} = \frac{2S_N H}{\omega_0}$$

Equação de Balanço de Torques (IV)

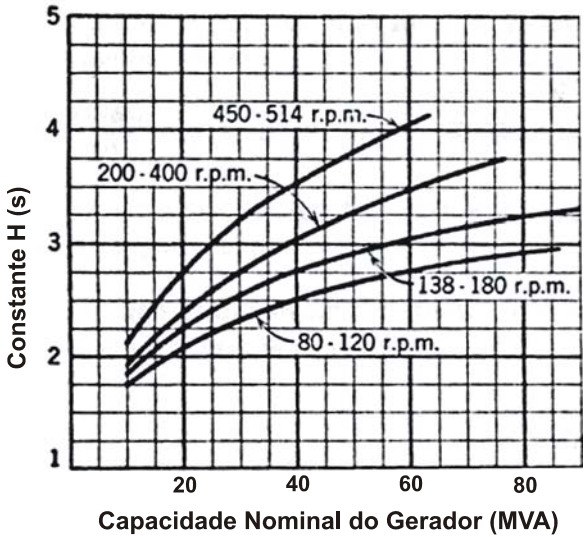
- Em termos da velocidade:

$$\mathcal{M}\frac{dw}{dt} = P_m - P_e$$

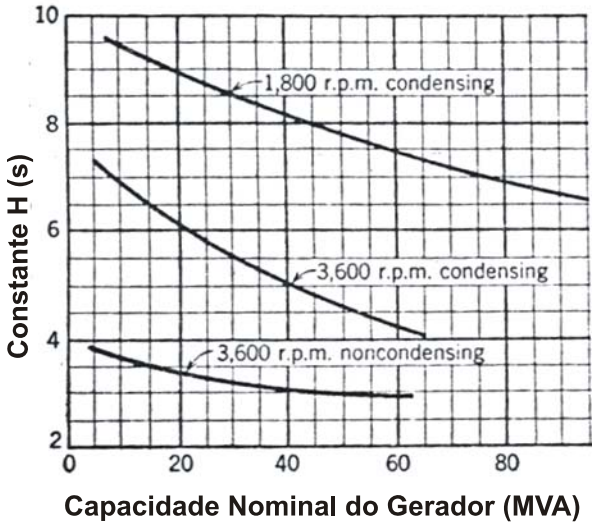
$$\mathcal{M} \times w_0 \frac{d}{dt}(\frac{w}{w_0}) = S_N(\frac{P_m}{S_N} - \frac{P_e}{S_N})$$

$$\boxed{2H\frac{d}{dt}(w_{pu}) = P_{m,pu} - P_{e,pu}}$$

Hidrogeradores



Turbogeradores



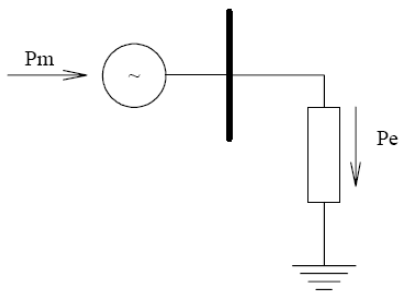
Modelo para Pequenas Perturbações

$$2H \times \frac{d\omega}{dt} = P_m - P_e$$

$$2H\frac{d}{dt}(w_0 + \Delta w) = P_m^0 + \Delta P_m - (P_e^0 + \Delta P_e)$$

$$\boxed{2H\frac{d}{dt}(\Delta w) = \Delta P_m - \Delta P_e}$$

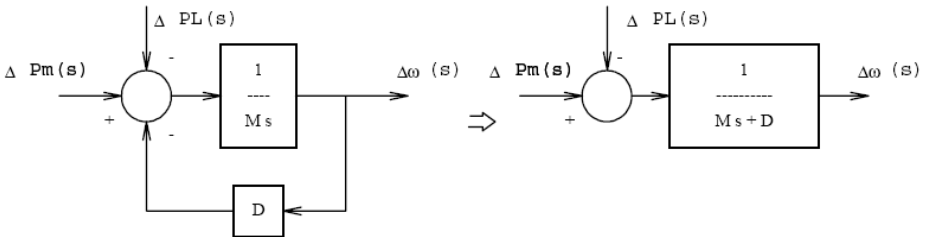
Caso de Sistema Isolado



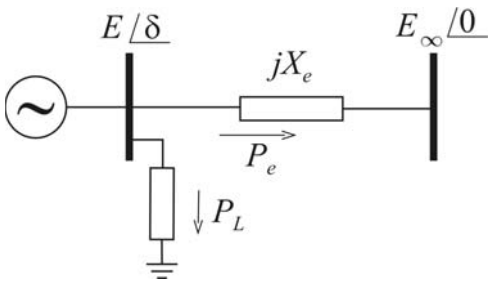
$$\Delta P_e = \Delta P_L + D \times \Delta w$$

$$\boxed{2H\frac{d}{dt}(\Delta w) = \Delta P_m - \Delta P_L - D\Delta w}$$

Sistema Isolado: Diagrama de Blocos



Sistema Máquina-Barra Infinita (I)



$$P_e = \frac{E\ E_\infty}{X_e}\,\text{sen}\,\delta$$

$$\Delta P_e = \left(\frac{E\ E_\infty}{X_e}\cos\delta_0\right)\Delta\delta = K_s\ \Delta\delta$$

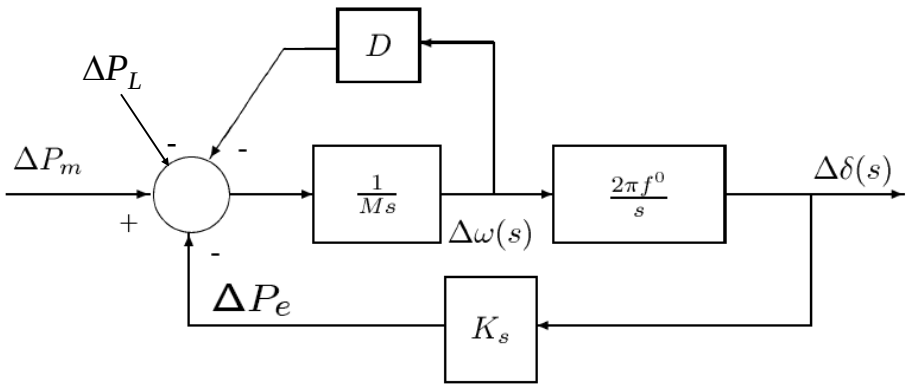
Sistema Máquina-Barra Infinita (II)

$$M\ \frac{d(\Delta\omega)}{dt} = \Delta P_m - \Delta P_L - D\ \Delta\omega - K_s\Delta\delta$$

$$\Delta\delta = 2\pi f_0 \int_o^t \Delta\omega\ dt$$

Aplicando a Transformada de Laplace:

$$\Delta\omega(s) = \frac{1}{Ms}[\Delta P_m(s) - \Delta P_L(s) - D\ \Delta\omega(s) - K_s\ \Delta\delta(s)]$$

$$\Delta\delta(s) = \frac{2\pi f_0}{s}\ \Delta\omega(s)$$

Sistema Máquina-Barra Infinita (III)