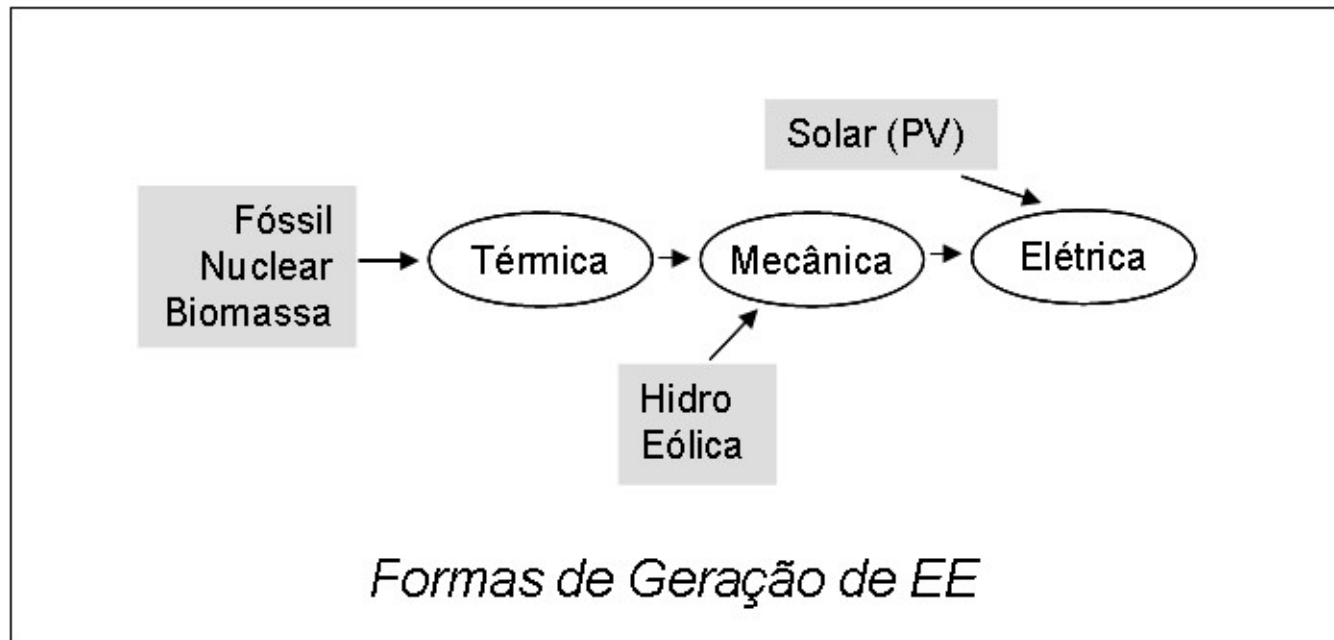
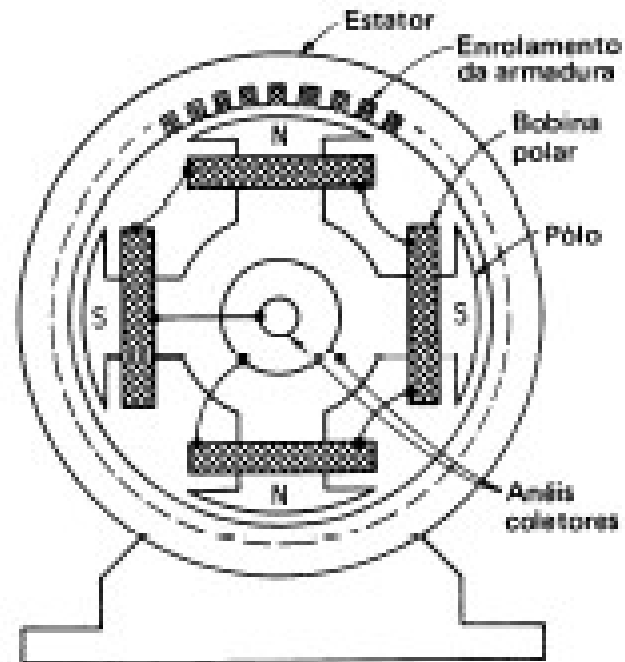
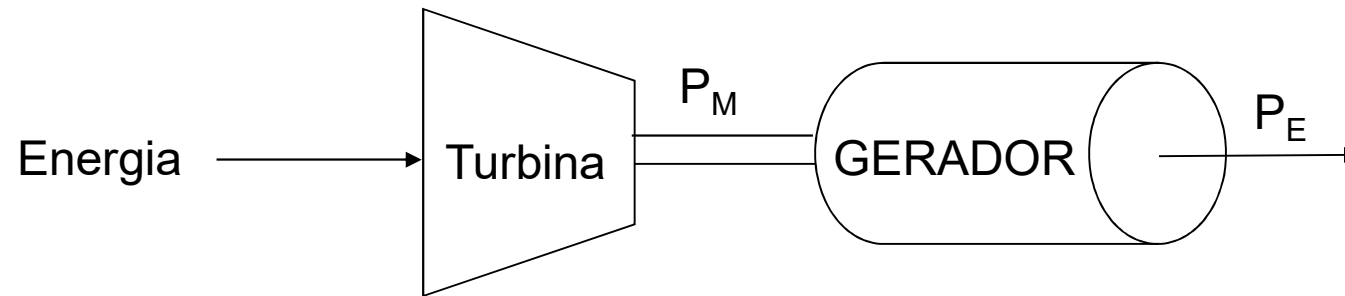
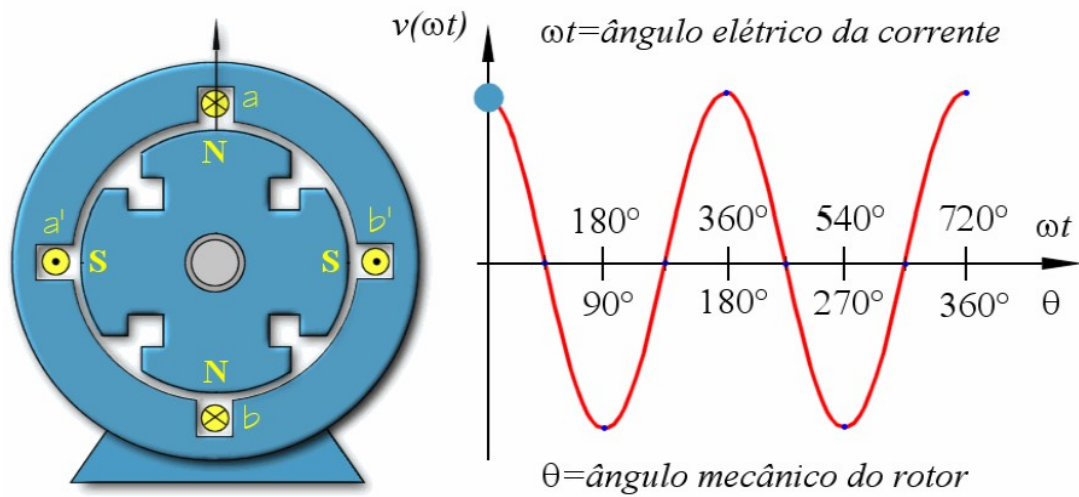
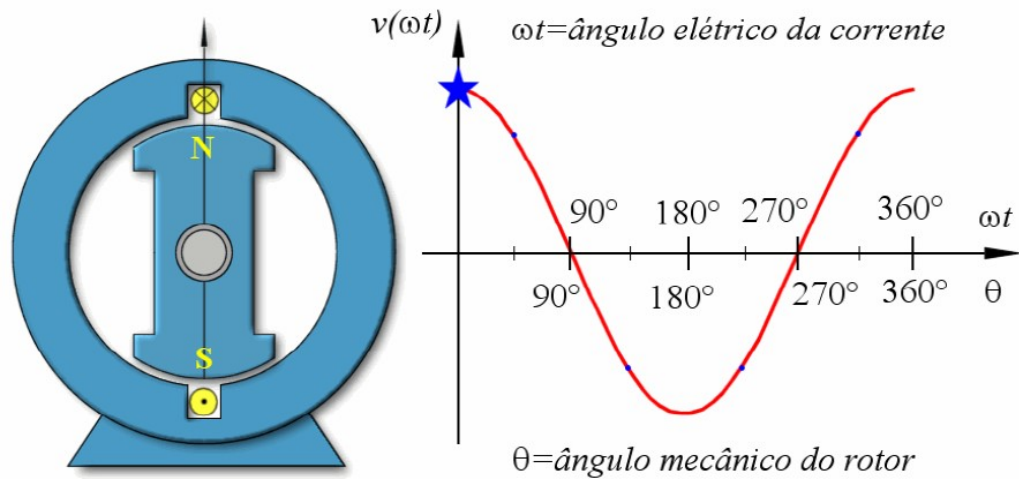


Geração de Energia Elétrica

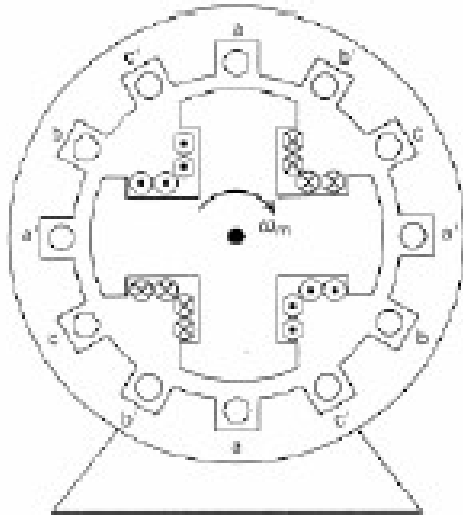


Gerador – Máquina Síncrona, Alternador





Rotor de pólos salientes:



Baixas rotações



HIDRELETRICAS

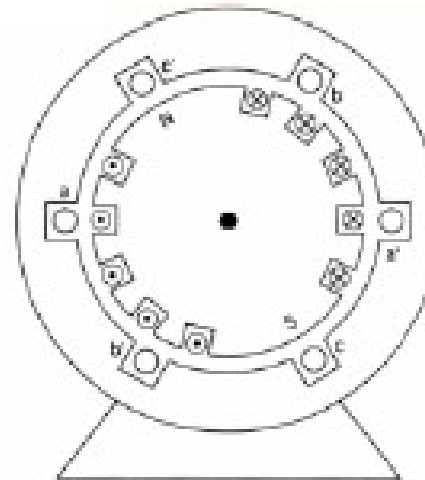
$$n_{rpm} = \frac{120 f}{p}$$

Ex.: Itaipu

60Hz – 78 pólos → $n = 92,3 \text{ rpm}$

50Hz – 66 pólos → $n = 90,9 \text{ rpm}$

Rotor de pólos lisos (cilíndrico):



Altas rotações

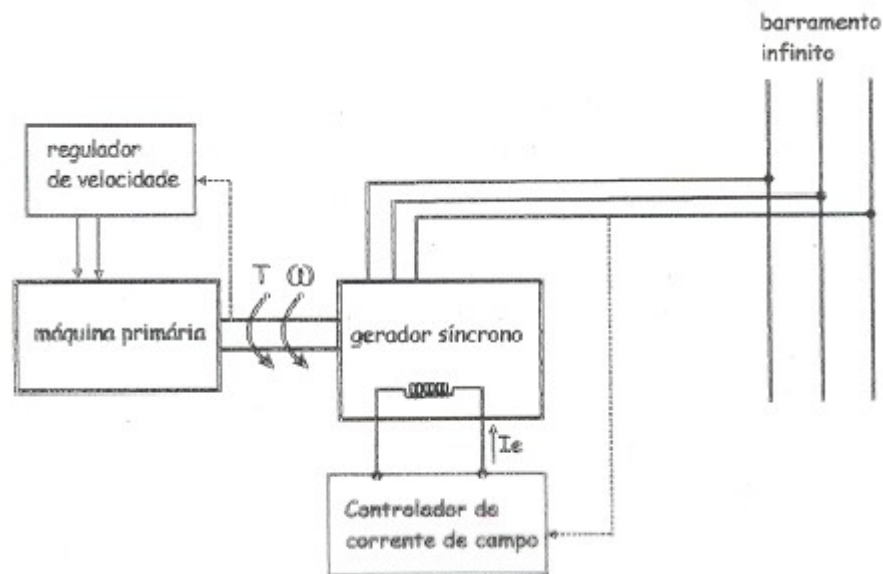


TERMELETRICAS

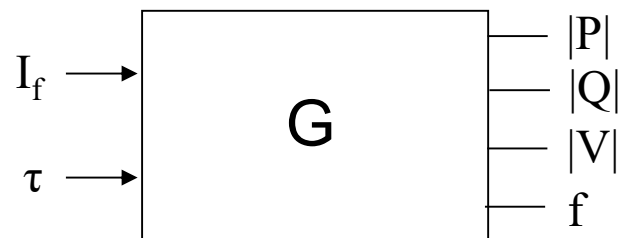
Ex.: Térmica a gás

60Hz – 4 pólos → $n = 1800 \text{ rpm}$

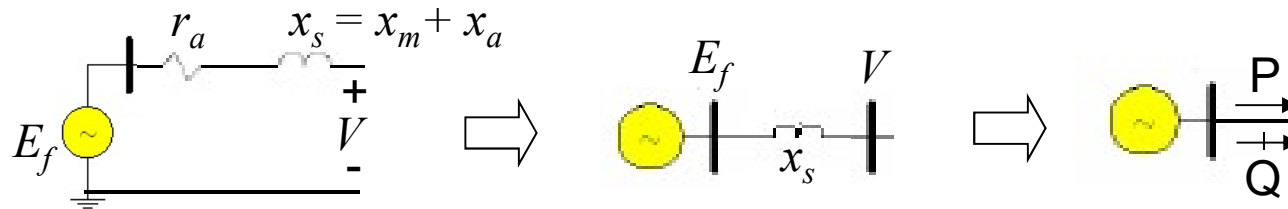
Arranjo esquemático de uma Máquina Síncrona



Controles da máquina



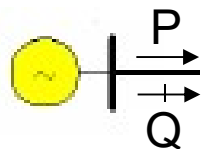
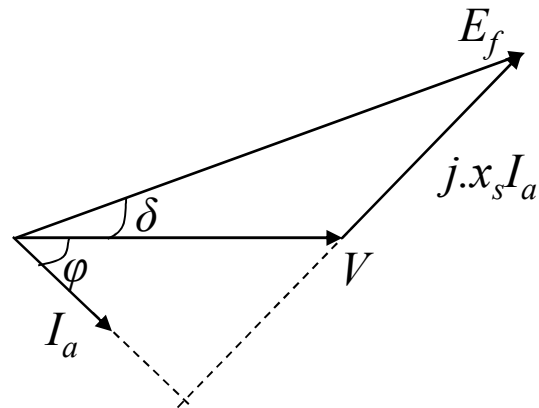
Modelos equivalentes



do circuito:

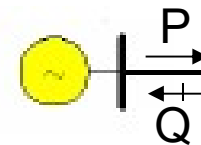
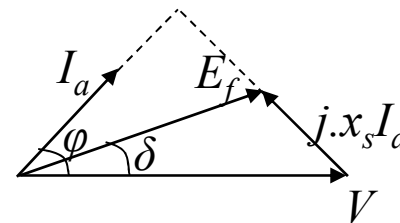
$$E_f = V + I_a (j \cdot x_s)$$

Operação sobre-excitada



(capacitiva)

Operação sub-excitada



(indutiva)

Do diagrama fasorial:

$$P = \operatorname{Re} \{ V \cdot I_a^* \} = \frac{E_f \cdot V}{x_s} \operatorname{sen} \delta$$

$$Q = \operatorname{Im} \{ V \cdot I_a^* \} = \frac{E_f \cdot V}{x_s} \cos \delta - \frac{V^2}{x_s}$$

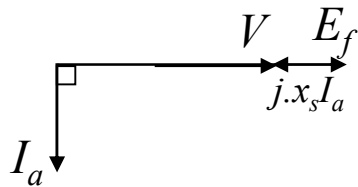
Como, na operação, $\delta \ll \pi/2$ $\left\{ \begin{array}{l} \operatorname{sen} \delta \approx \delta \\ \cos \delta \approx 1 \end{array} \right.$

Assim,

$$\left. \begin{array}{l} P \approx \frac{E_f \cdot V}{x_s} \delta \\ Q \approx \frac{V}{x_s} (E_f - V) \end{array} \right\} \begin{array}{l} \text{acoplamento P-}\delta \text{ e} \\ \text{desacoplamento Q-}\delta \end{array}$$

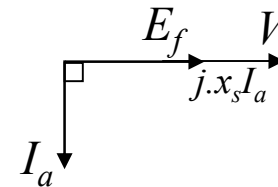
Compensador Síncrono

- Máquina síncrona que opera com $P=0$.
- Controle de Tensão: injeta ou absorve potência reativa.



(capacitiva)

Injeta reativo $\Rightarrow V \uparrow$



(indutiva)

Absorve reativo $\Rightarrow V \downarrow$

Cargas

Composição típica:

Motores	60-70%
Resistiva	25-30%
Eletrônica	~ 5%

$$P_L = \frac{V^2}{R^2 + (2\pi fL)^2} R$$

$$Q_L = \frac{V^2}{R^2 + (2\pi fL)^2} (2\pi fL)$$

Modelos Típicos (para análises em regime permanente):

- Potência constante (P_{cte})
- Impedância constante (Z_{cte})
- Corrente constante (I_{cte})
- Combinação ponderada das anteriores: modelo ZIP

$$S = V \cdot I^* = V^2 / Z$$