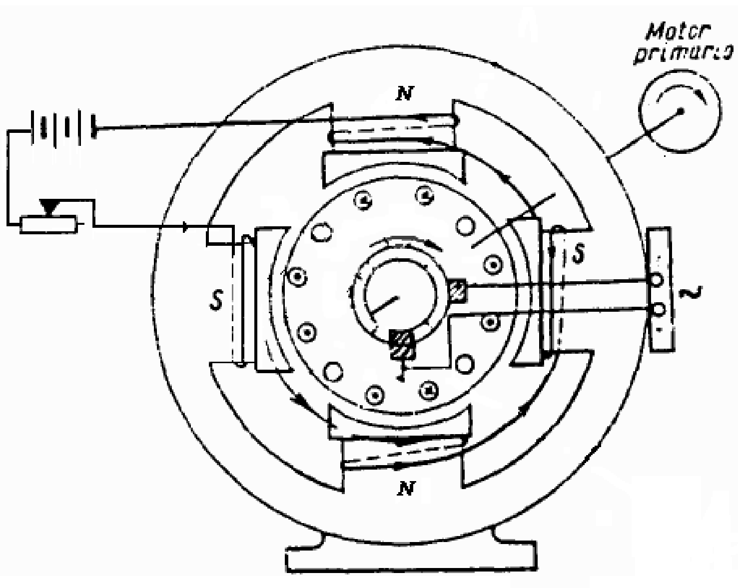
GENERADOR SÍNCRONO

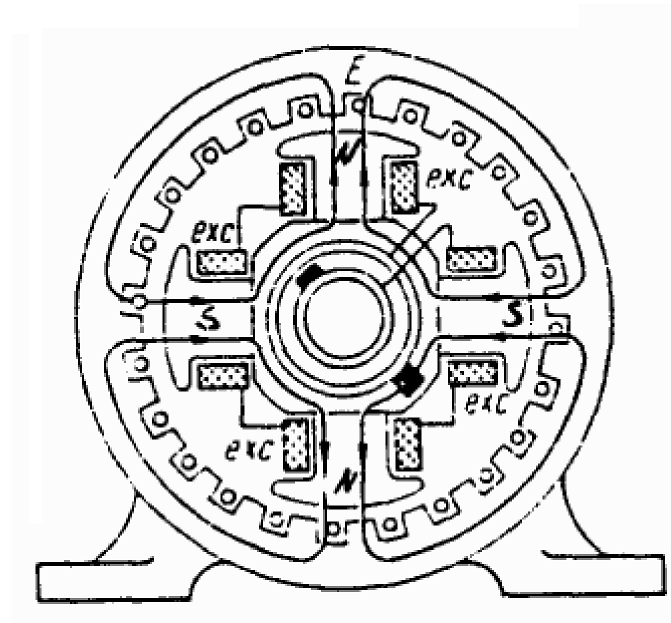
Electrotecnia y Máquinas Eléctricas

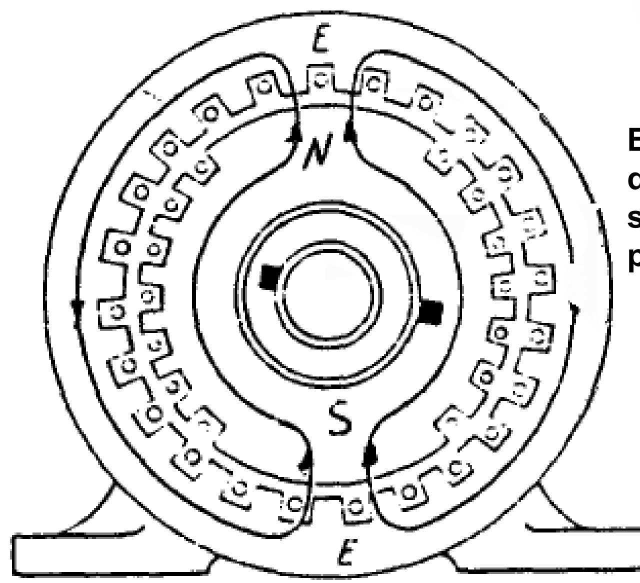
09/04/2021



Diseño de un generador de

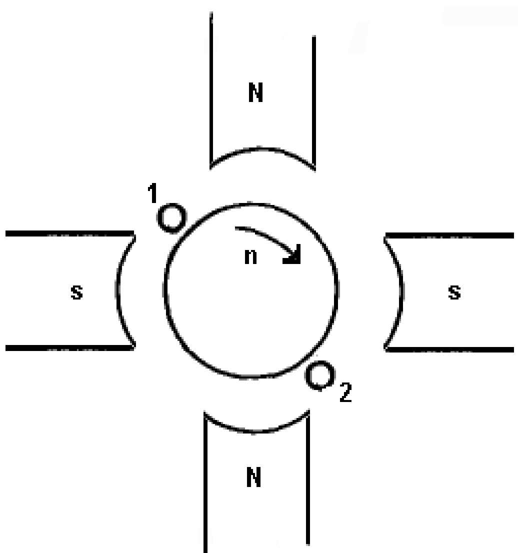
Inducido rotante





Esquema de construcción de alternadores sincrónicos con rotores de polos salientes y lisos

Frecuencia



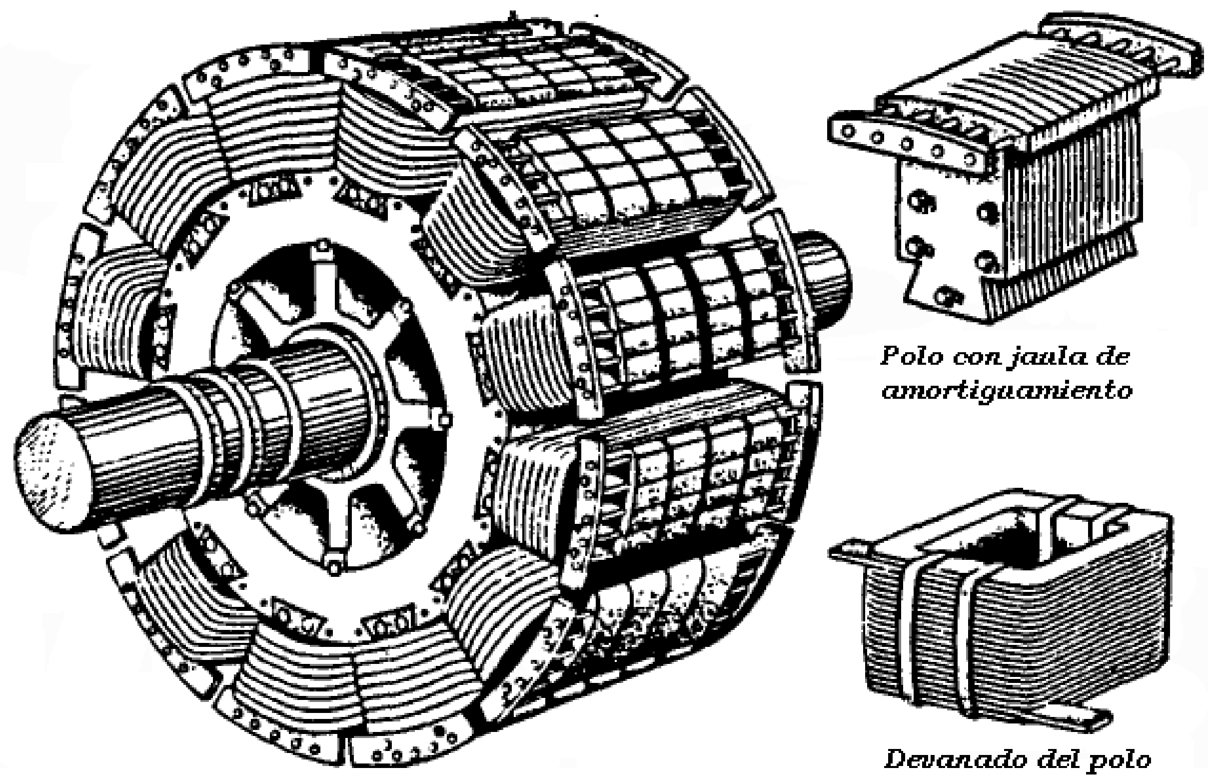


Fig. 4 Aspecto exterior de un rotor con polos salientes

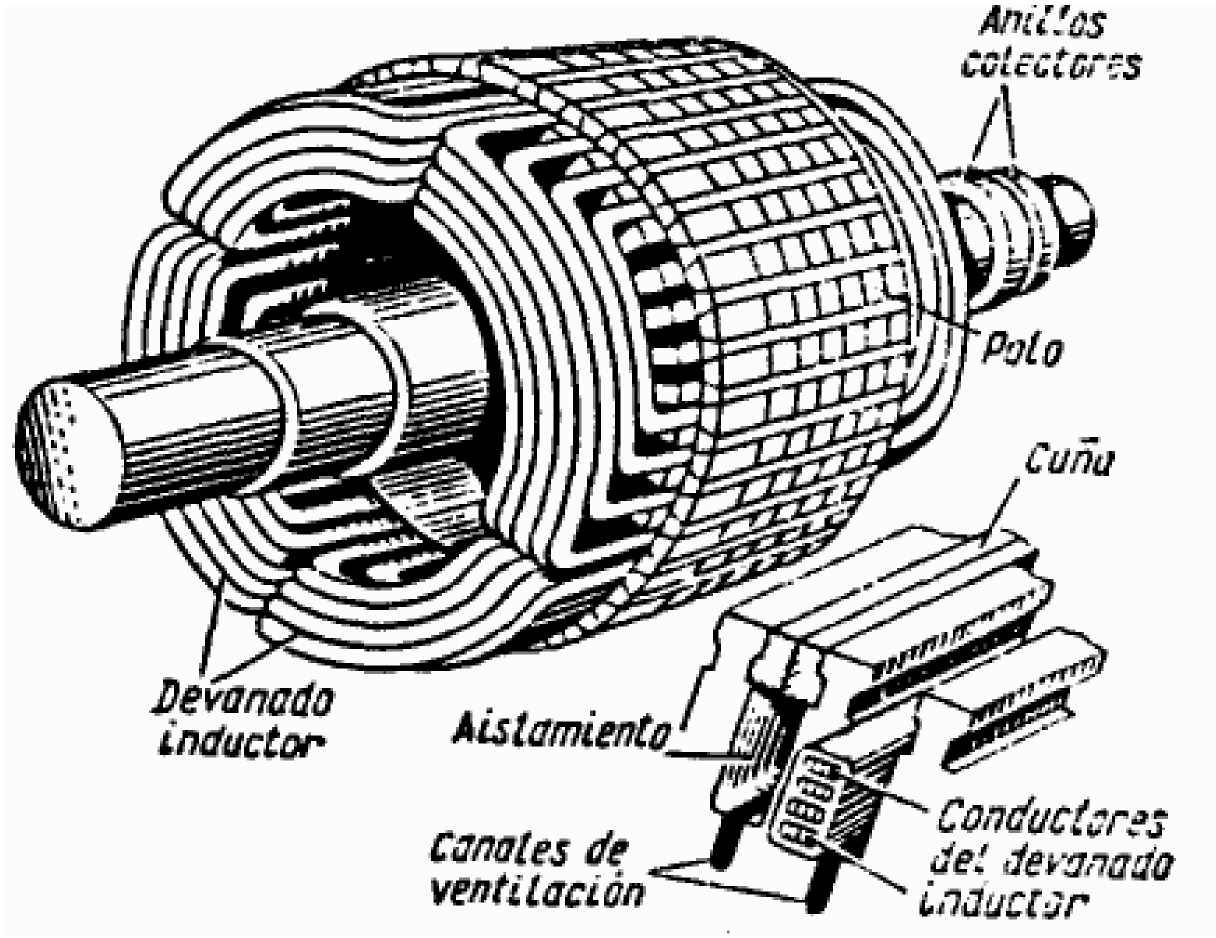


Fig. 5 Aspecto general de un rotor liso montado tetrapolar

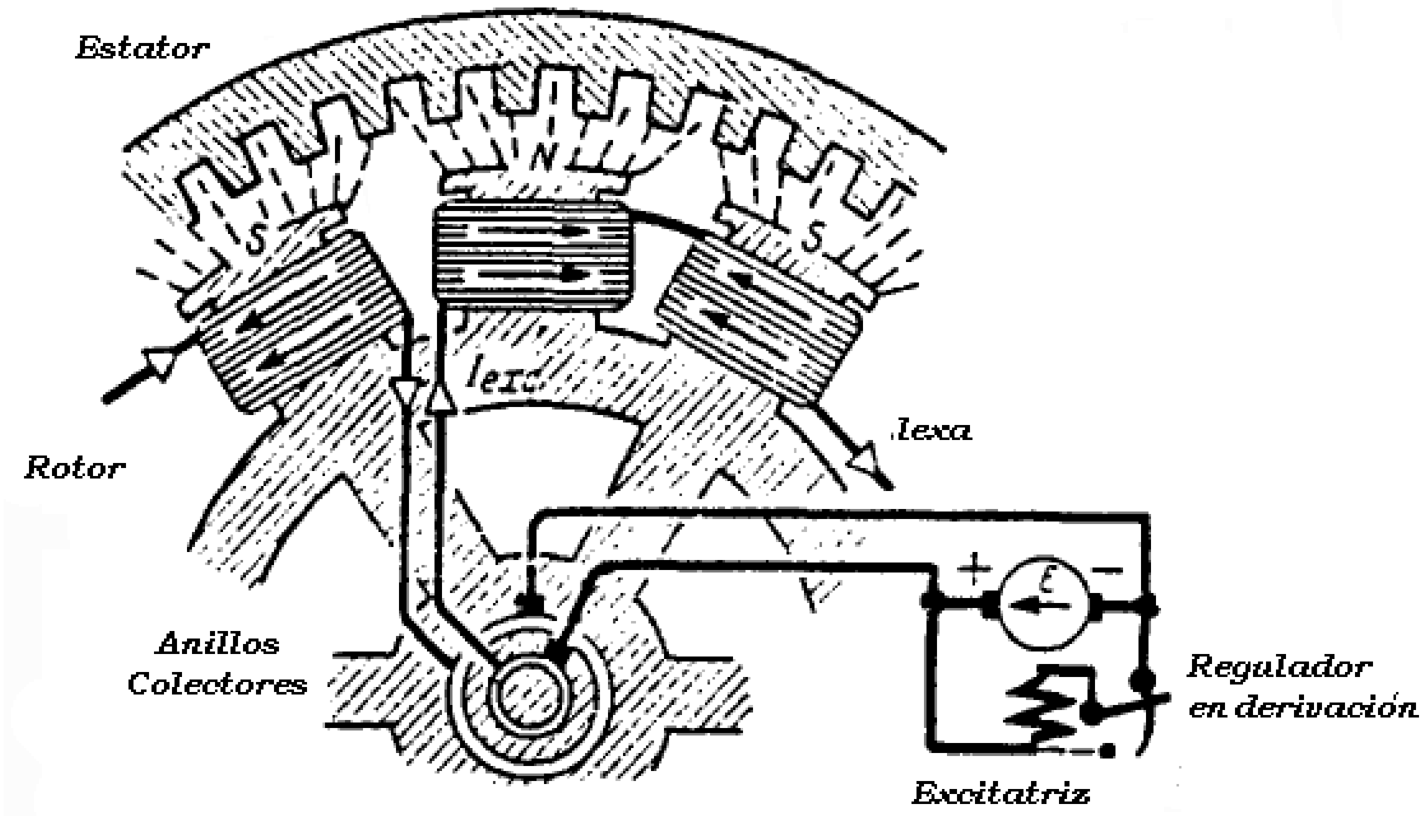


Fig. 6 Esquema de excitación de una máquina sincrónica

Expresión de la F.E.M.

$$E = 4{,}44 . f . \phi . N . K$$

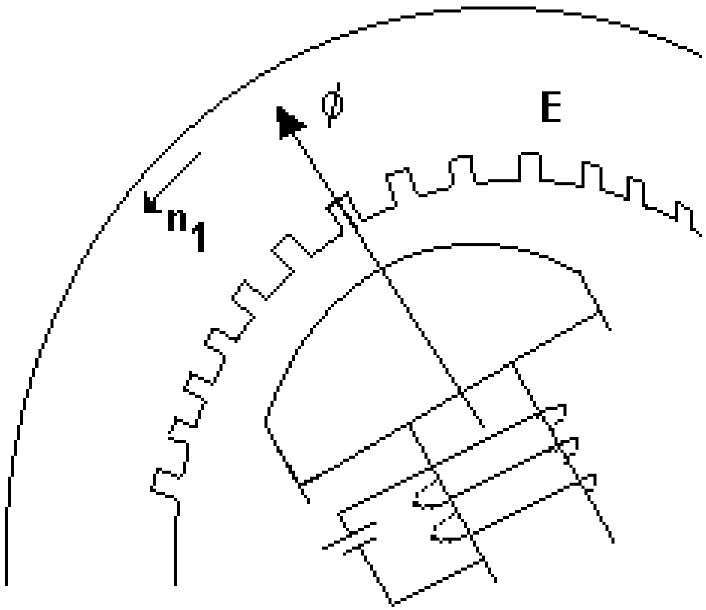


fig. 7

Campo rodante trifásico..\..\campo rodante.dwg

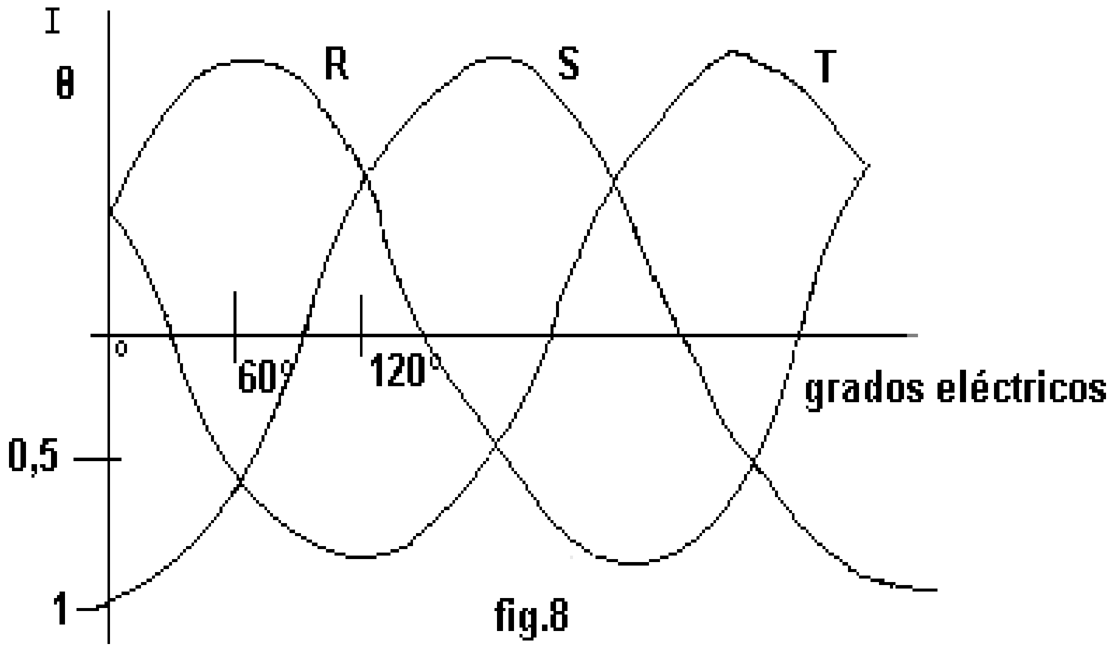


fig.8

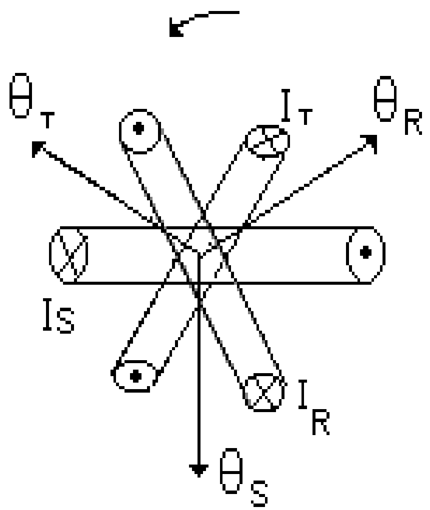


fig. 9

Campo rodante trifásico

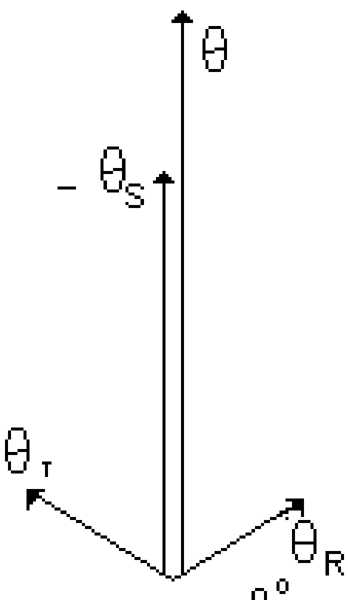


fig.10

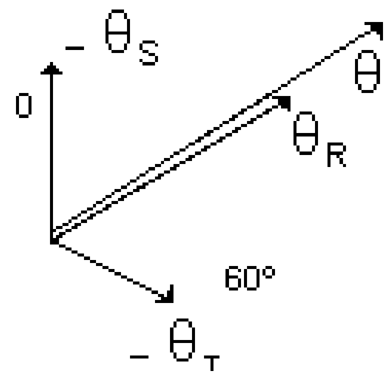


fig.11

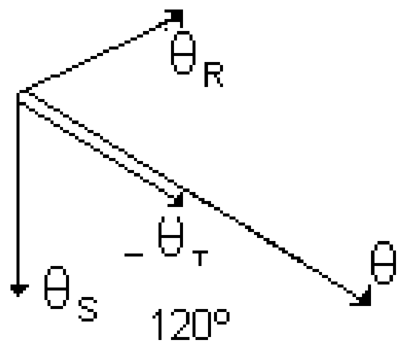
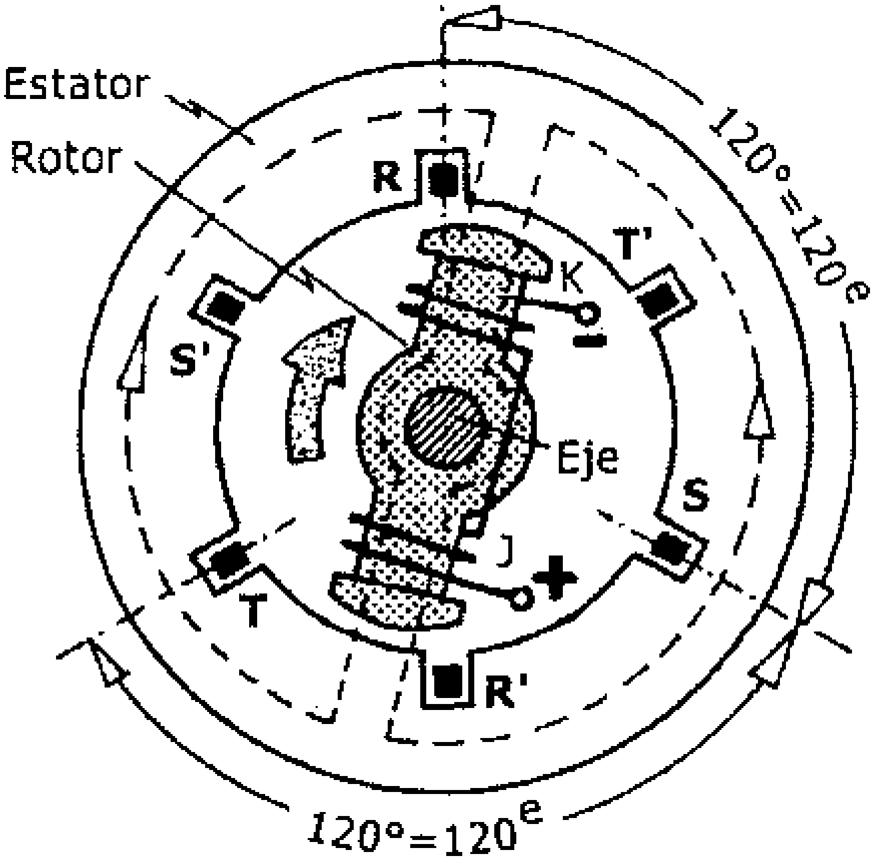
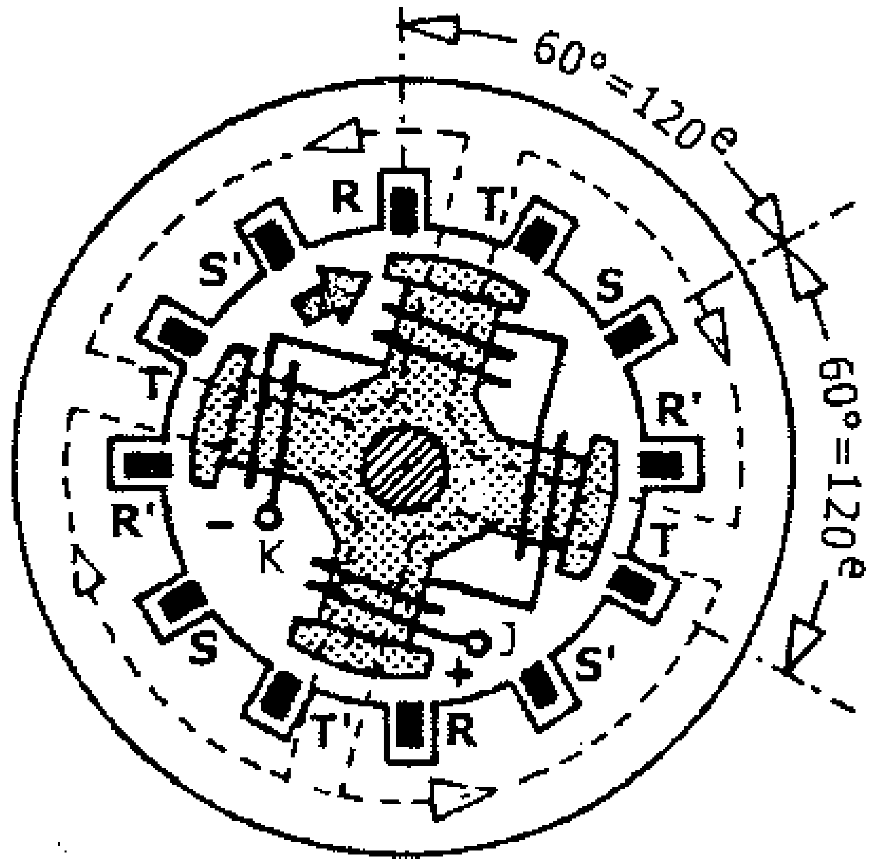


fig. 12



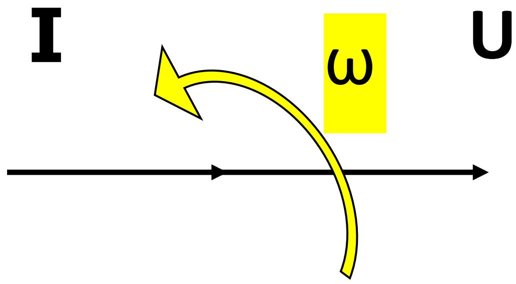
Alternador elemental de dos polos

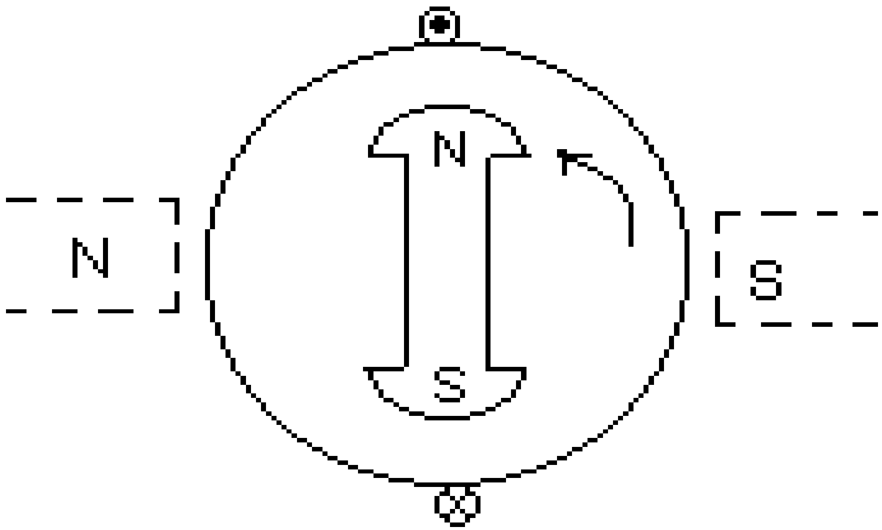


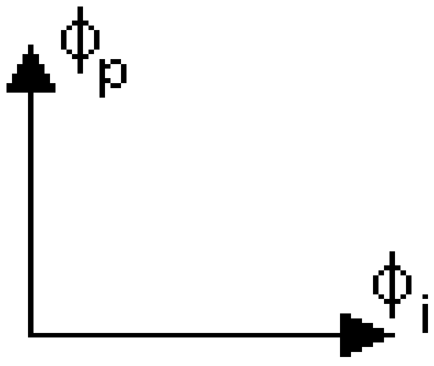
Alternador elemental de cuatro polos

Reacción de Inducido

- CARGA RESISTIVA PURA



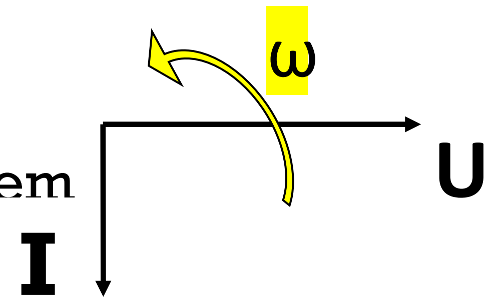


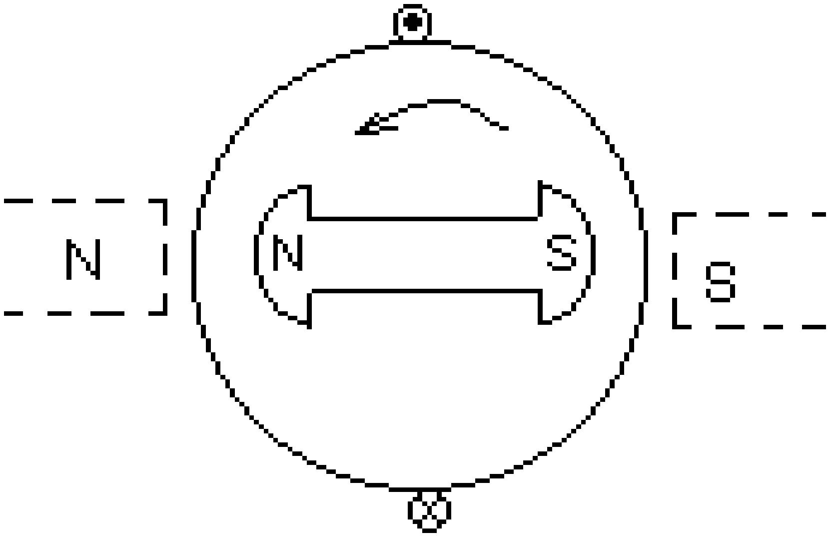


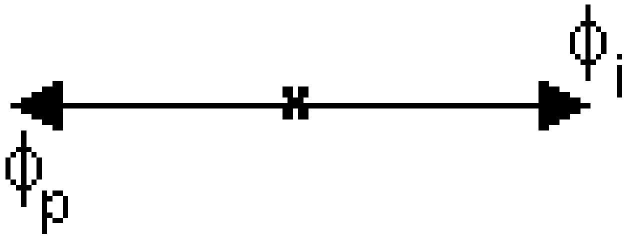
Reacción de Inducido

- CARGA INDUCTIVA PURA

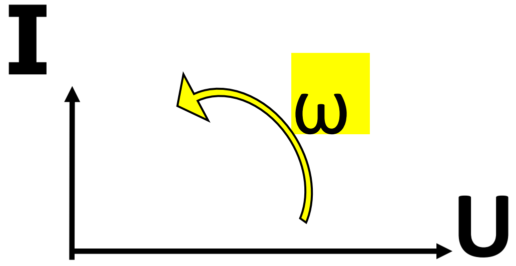
  Efecto Desmagnetizante – Menor fem



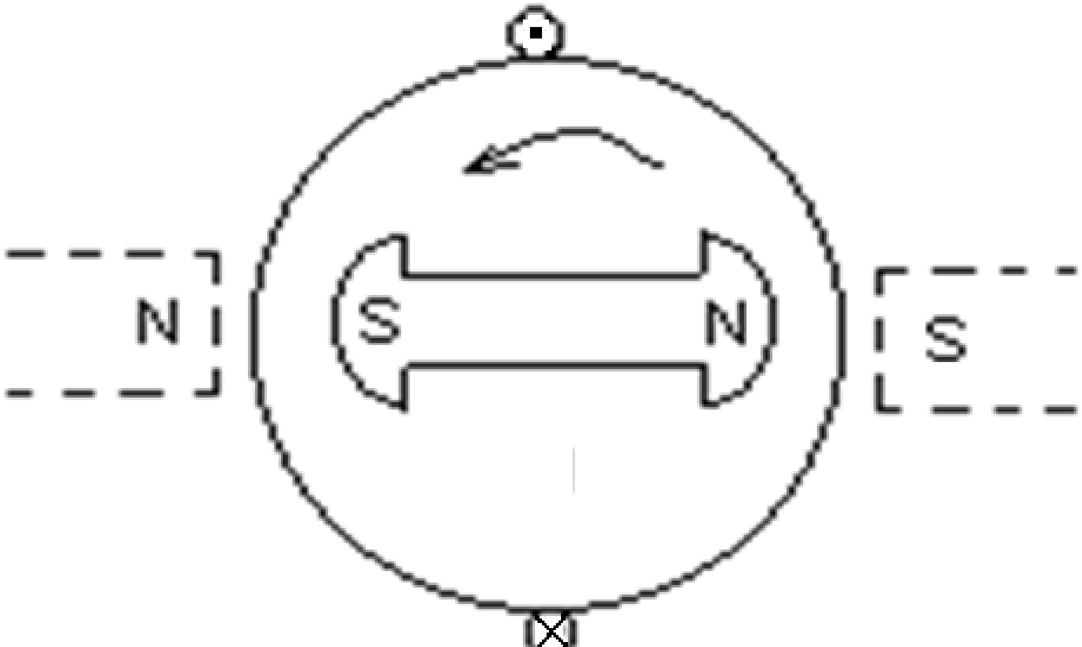




Reacción de Inducido

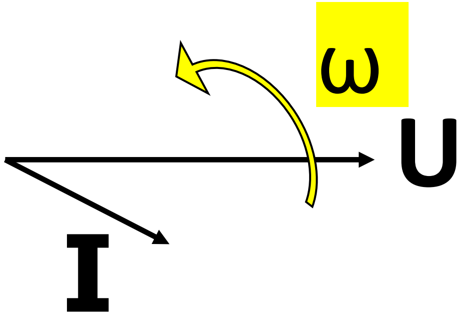


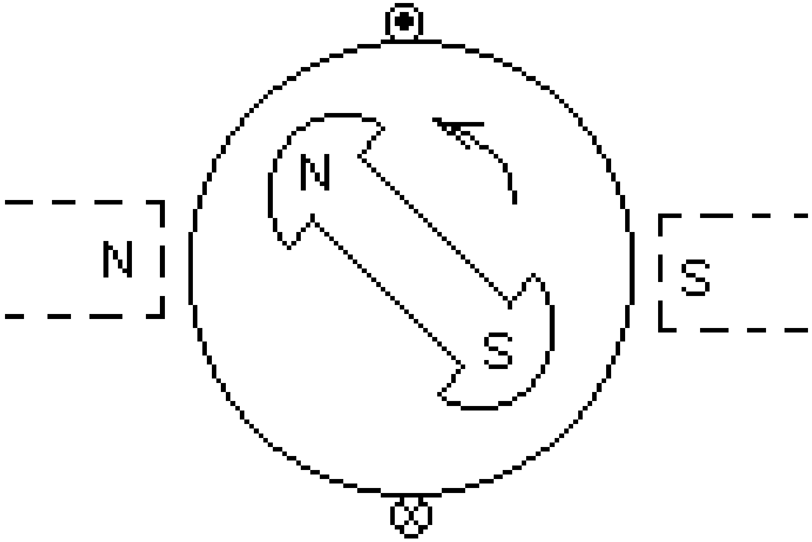
- CARGA CAPACITIVA PURA
- Efecto Magnetizante – Mayor fem

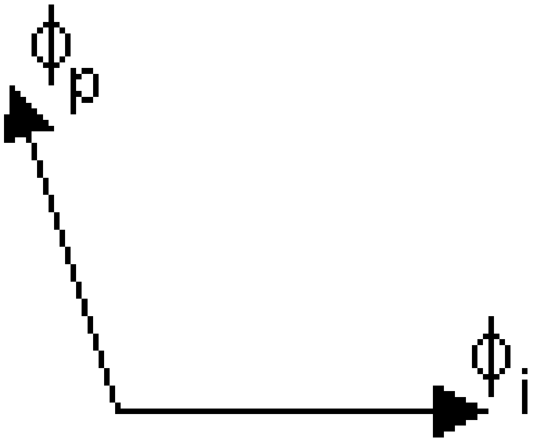


Reacción de Inducido

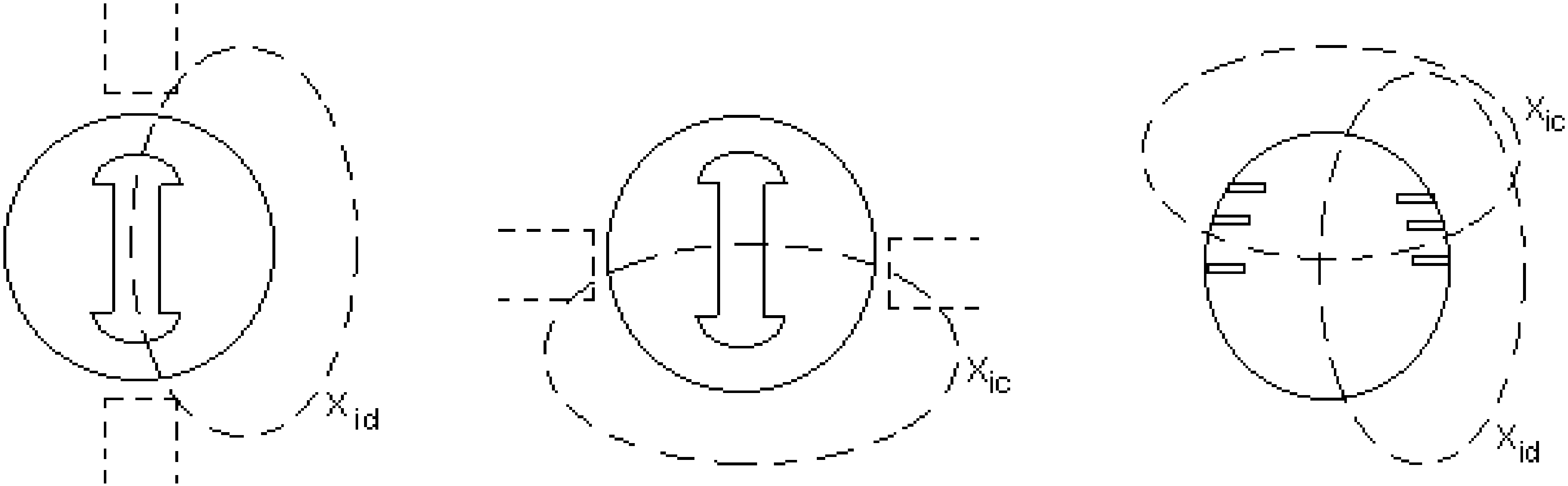
- CARGA R-L CUALQUIERA
- Conclusión: Es necesario un Regulador de tensión







Reacción de Inducido

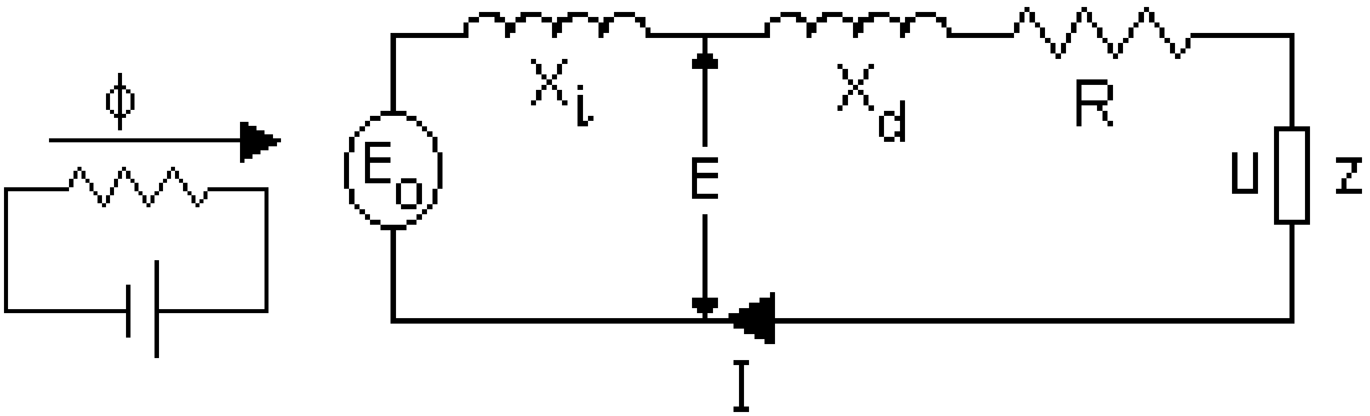


REACTANCIAS POR REACCIÓN DE INDUCIDO

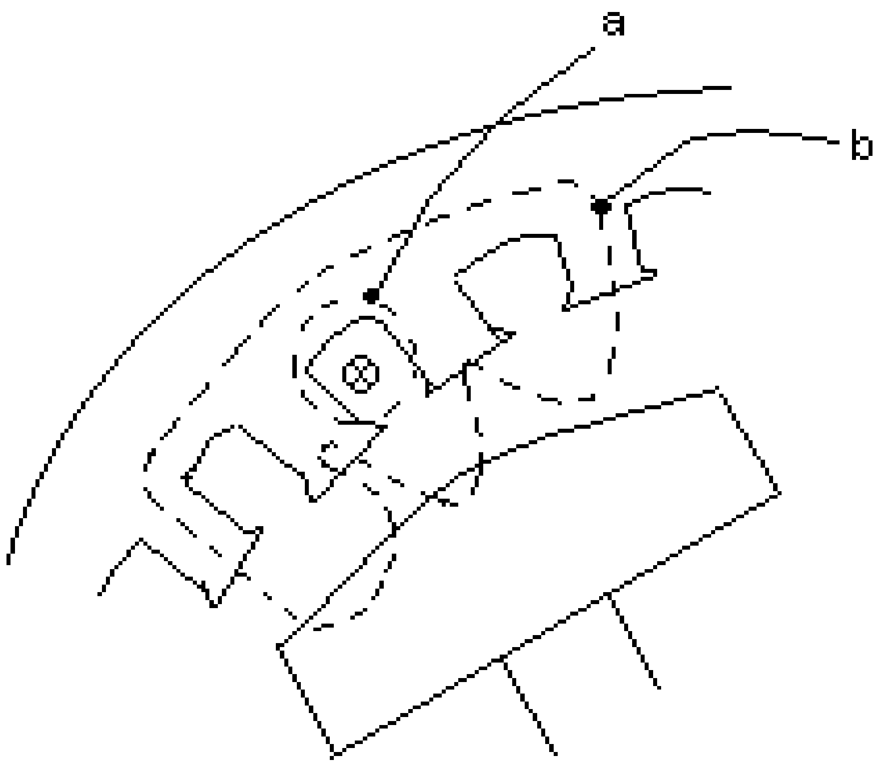
Circuito Equivalente

- Rotor cilíndrico

$$\overrightarrow{E_0} = \overrightarrow{U} + R.\overrightarrow{I} + jX_i.\overrightarrow{I} + jX_d.\overrightarrow{I}$$



Flujos Dispersos: (a) De ranura; (b) de cabezas de bobinas; (c) Zig zag



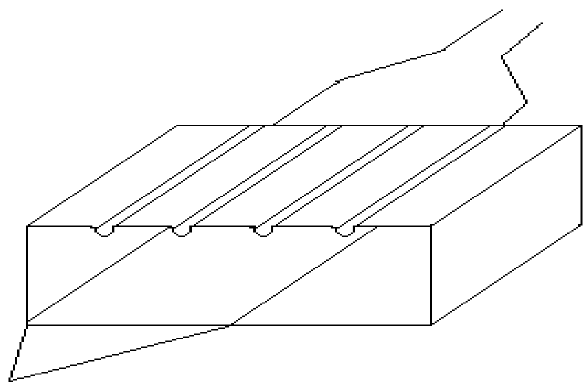
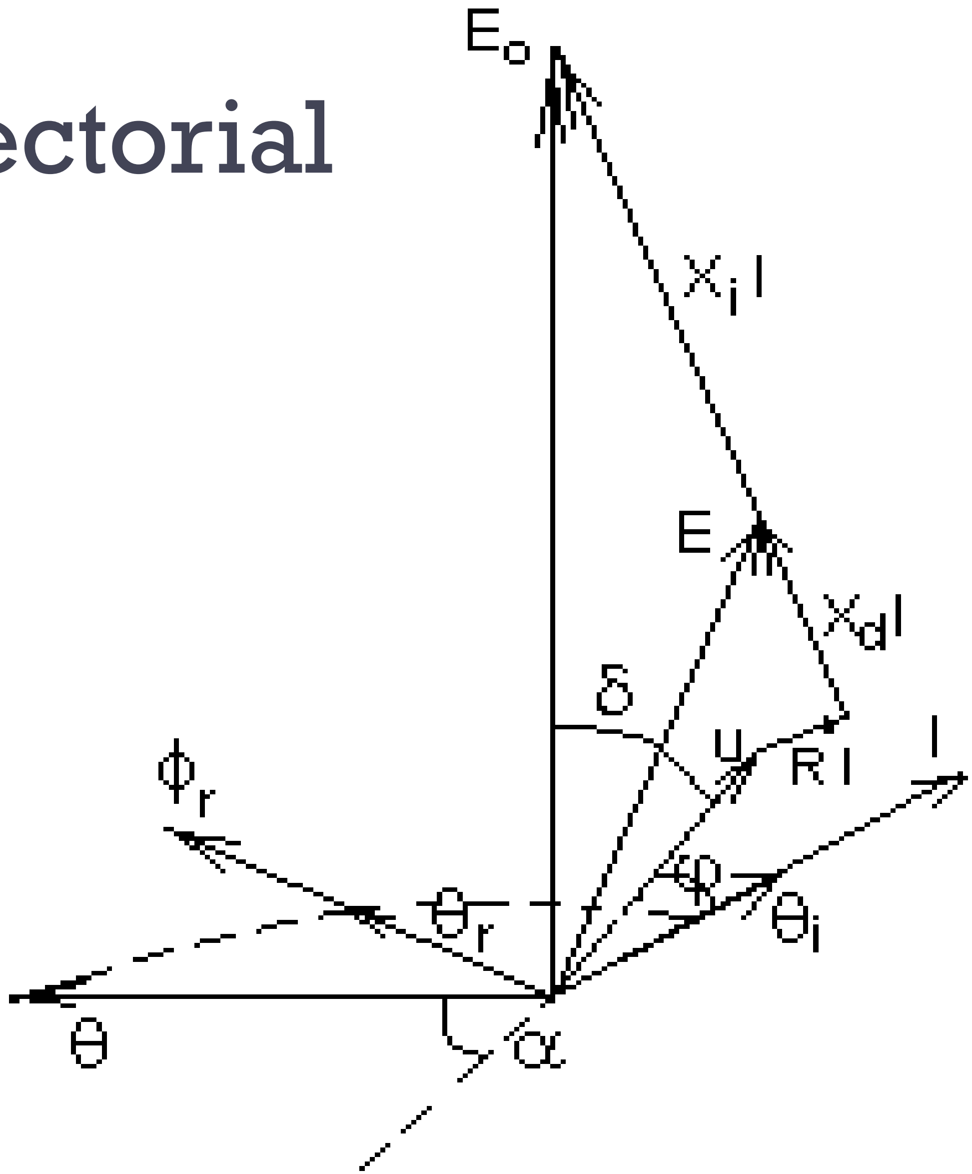


Diagrama Vectorial

- De rotor liso



Diagramas Vectoriales

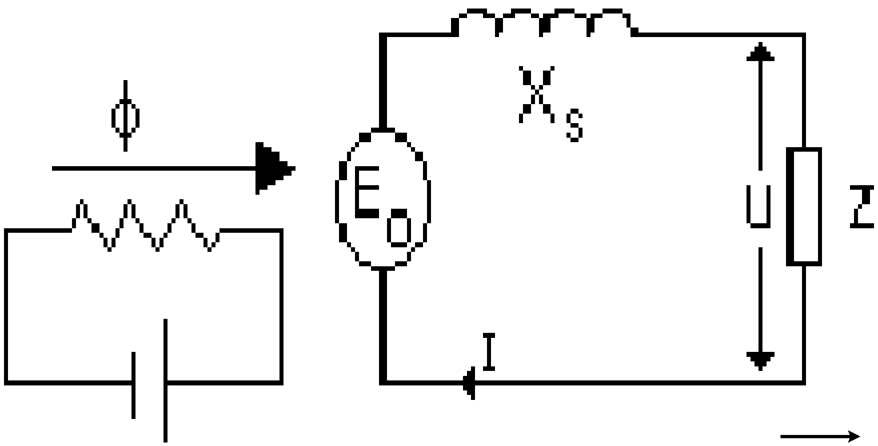
- Componentes del diagrama vectorial

	fmm.	Flujos	Fem.
campo rotórico	θ	ϕ	E_0
por reacción de inducido	θ_i	ϕ_i	$- j X_i I$
campo resultante	$\theta_r = \theta - \theta_i$	ϕ_r	E
flujo disperso	-----	ϕ_d	$- j X_d I$
caída óhmica	-----		***RI***

Diagrama Vectorial Simplificado

- Surge del Circuito Equivalente Simplificado

$$Xs = Xi + Xd$$



Circuito Simplificado

$$\overrightarrow{E_0} = \overrightarrow{U} + jX_s.\overrightarrow{I}$$

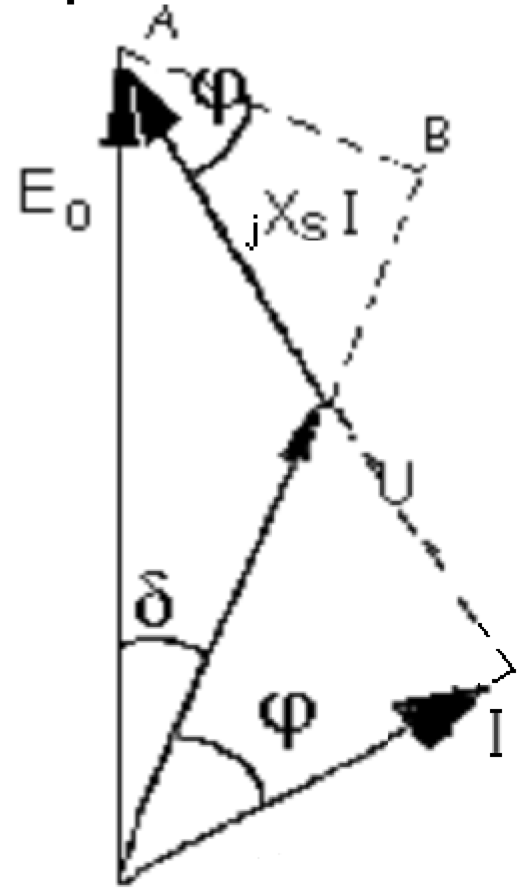
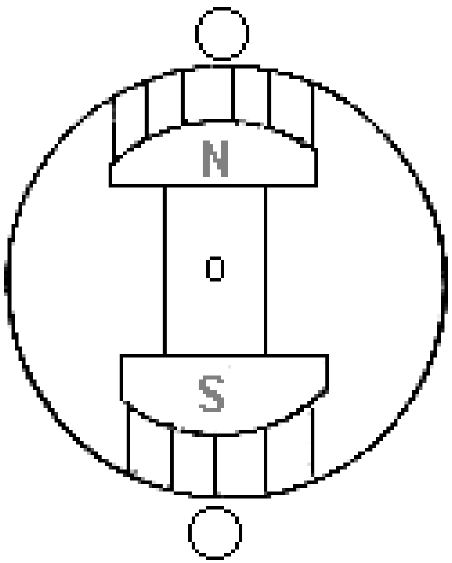


Diagrama Vectorial Simplificado

- Ángulo de carga



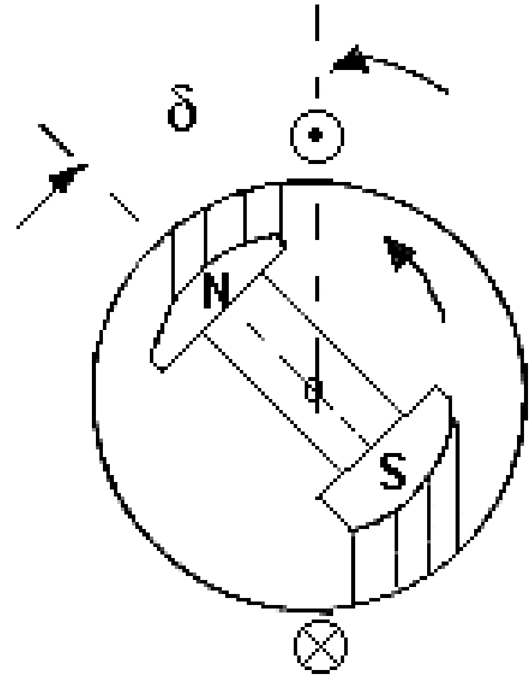


Diagrama Vectorial Simplificado

Análisis:

- 1) Si la U es cte. E_0 cambia con el tipo de carga

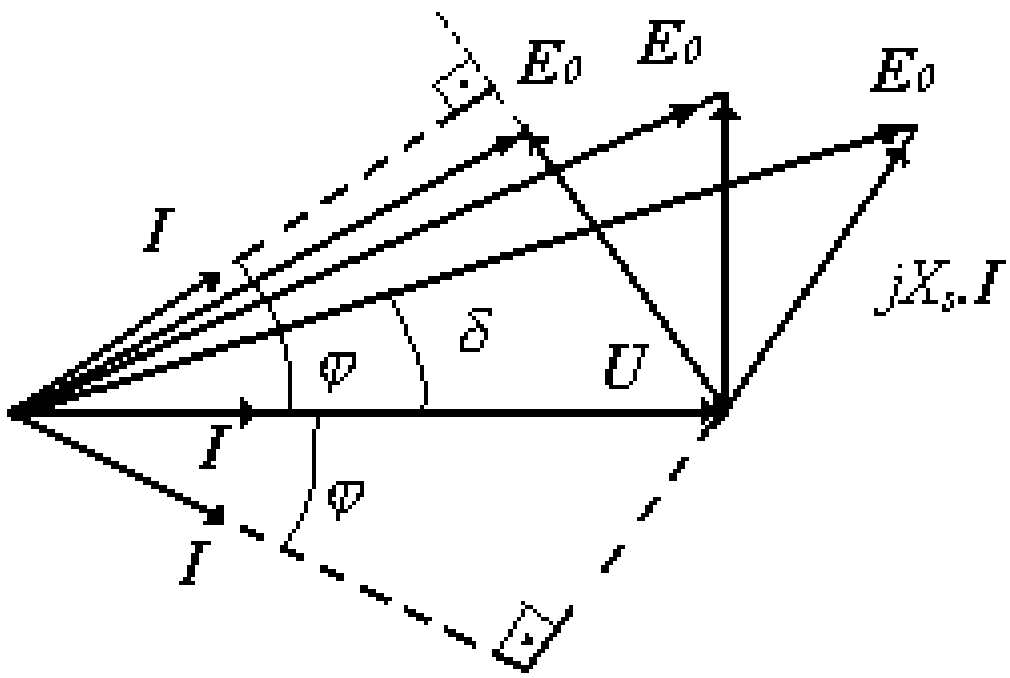


Diagrama Vectorial Simplificado

- 2) Si mantengo I_{ex} = cte. Varia la tensión U con el tipo de carga.

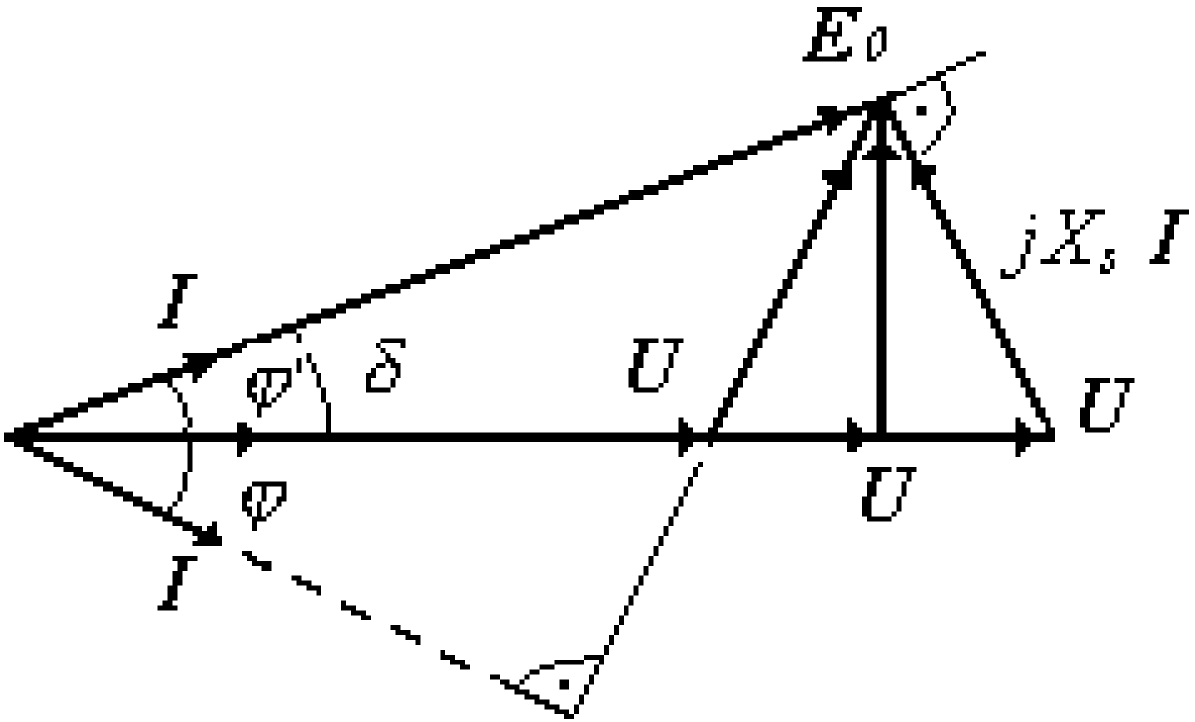


Diagrama Vectorial Simplificado

- 3) Diagrama de tensiones x cte . de escala = Diagrama de potencias.

$Cte. = 3U / Xs$

$Cte. = 3U / Xs$

$$Cte. = 3U / Xs$$

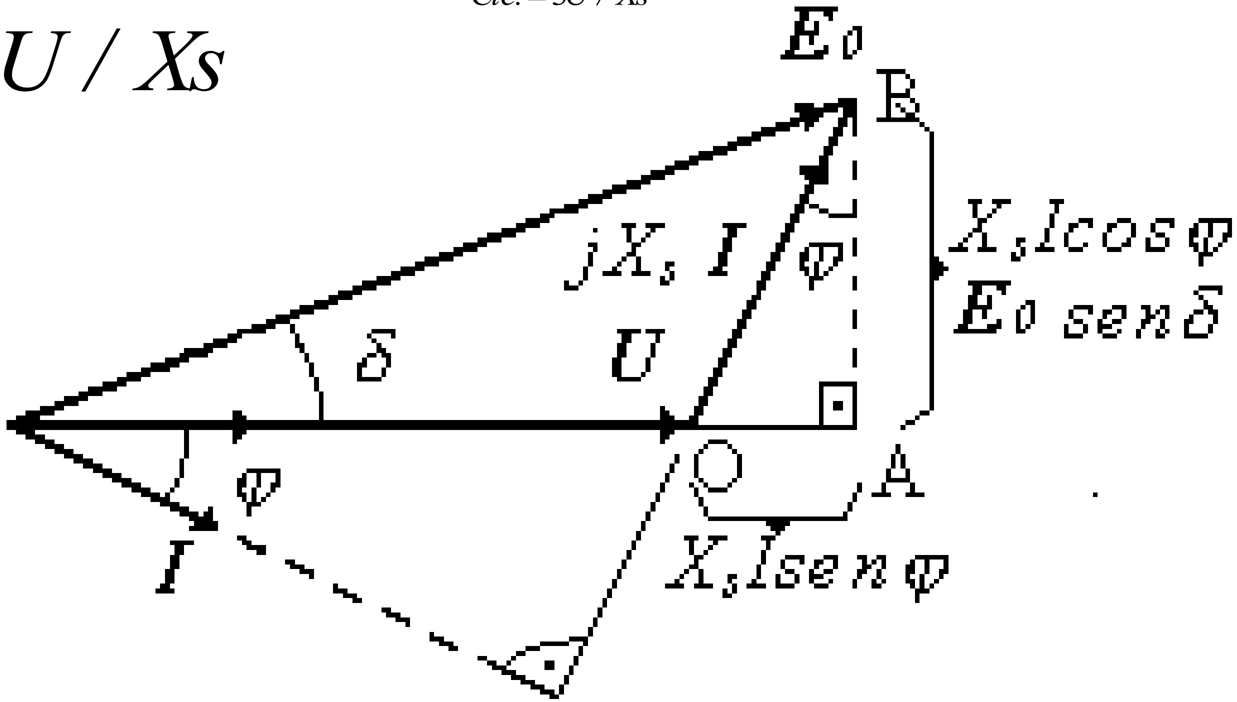


Diagrama Vectorial

- De polos salientes

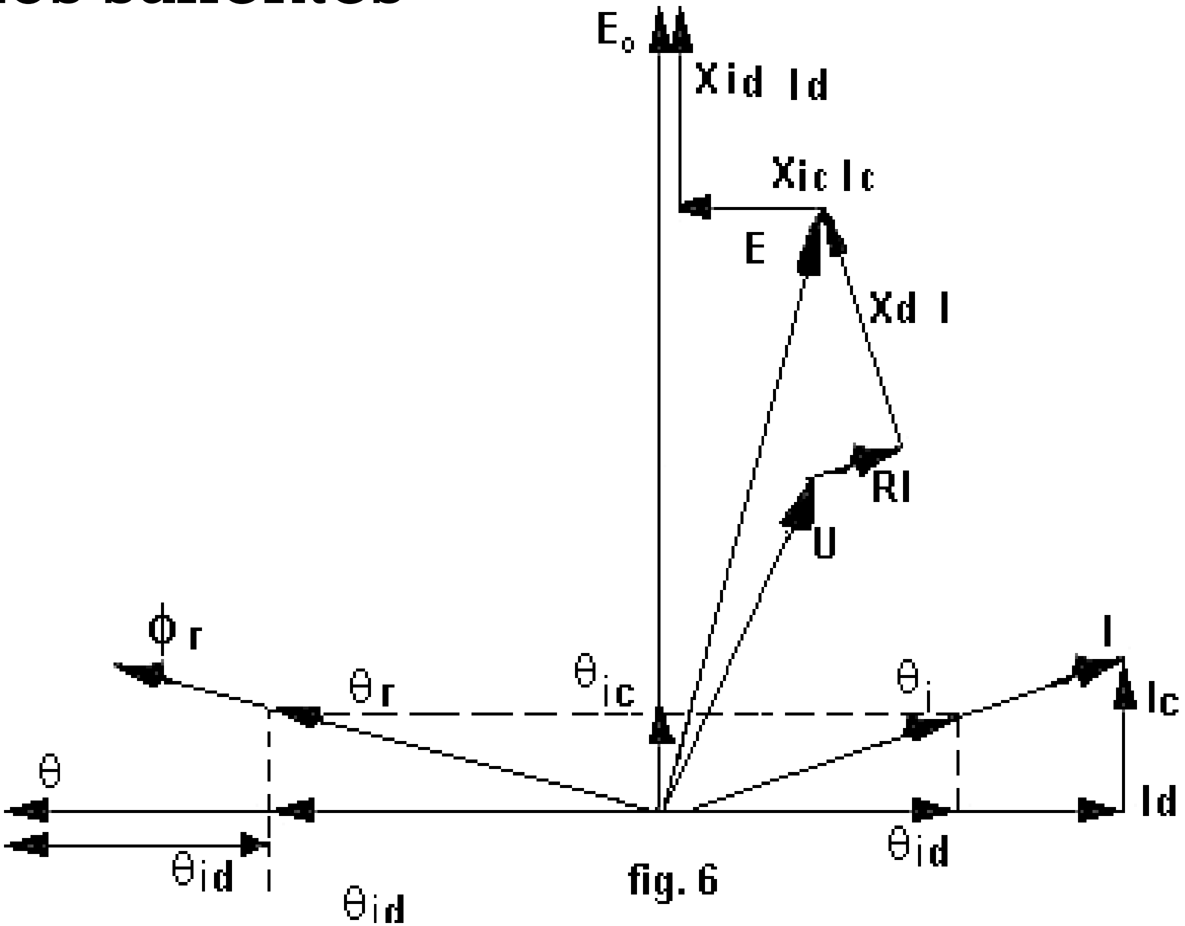
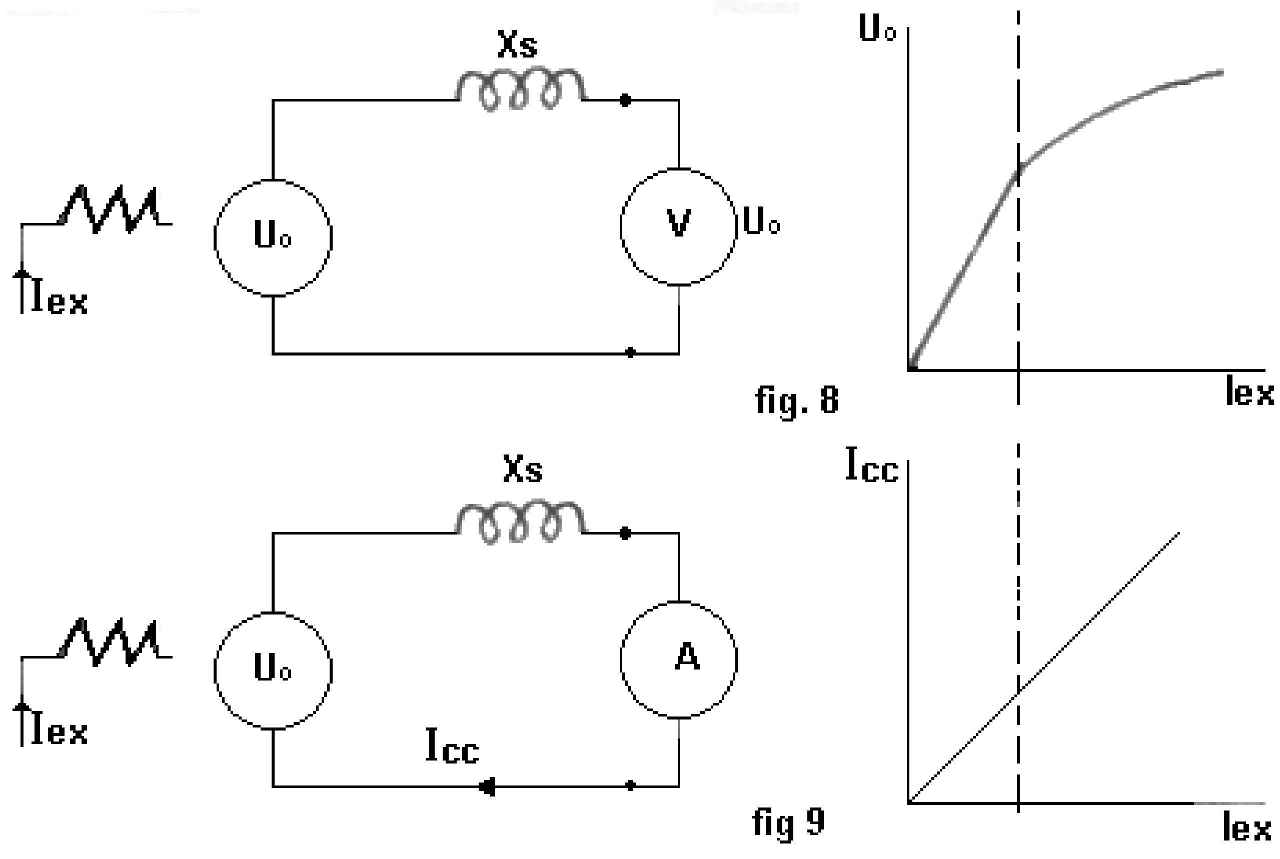
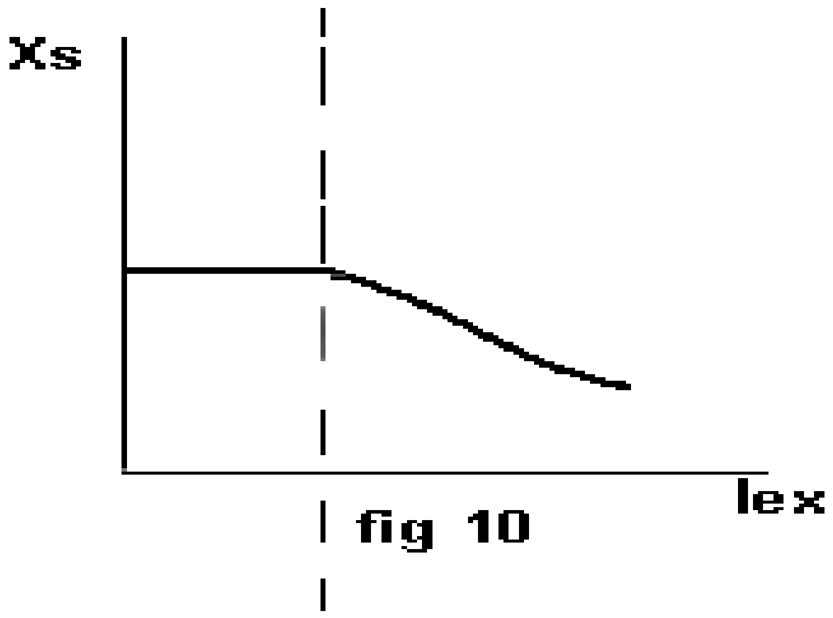


fig. 6

Reactancia Síncrona



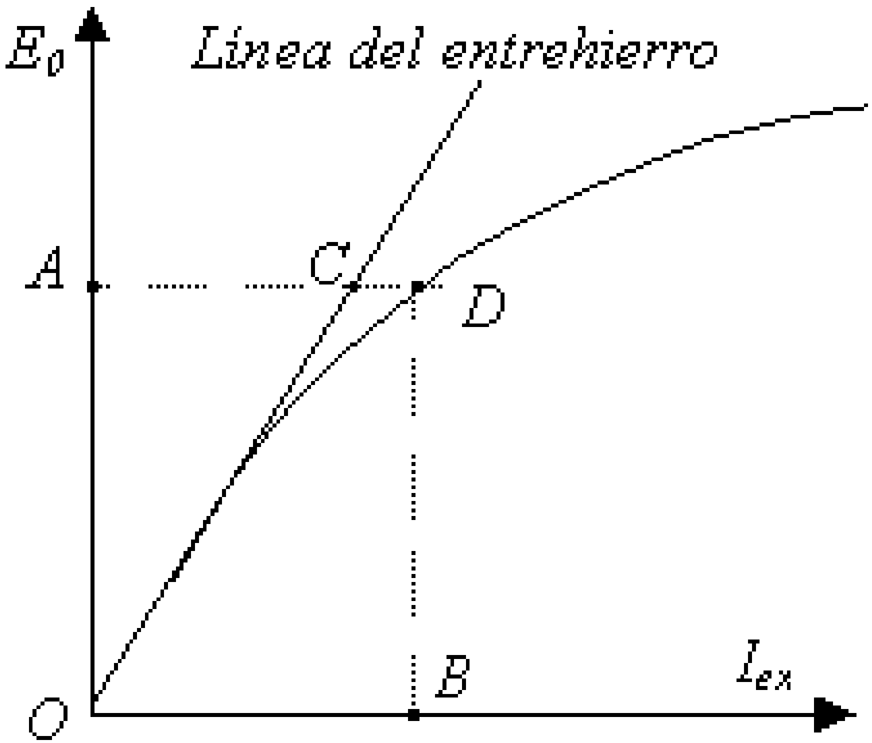
Reactancia Síncrona



CURVAS CARACTERÍSTICAS

1°) **Característica en vacío:**

n_{s} = cte. $E_0 = f\,(I_{ex})$



2°) C. de cortocircuito (c.c.): $I = f\,(I_{ex})$

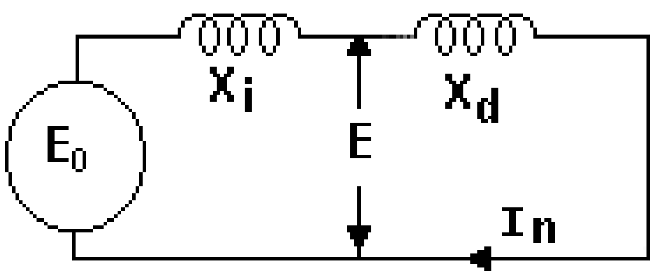


fig. 2

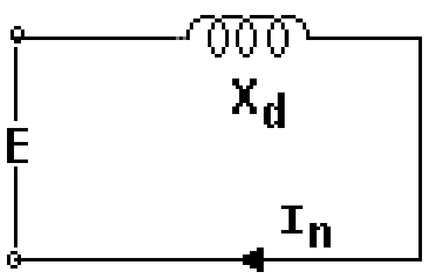


fig. 3

Circuito Equivalente

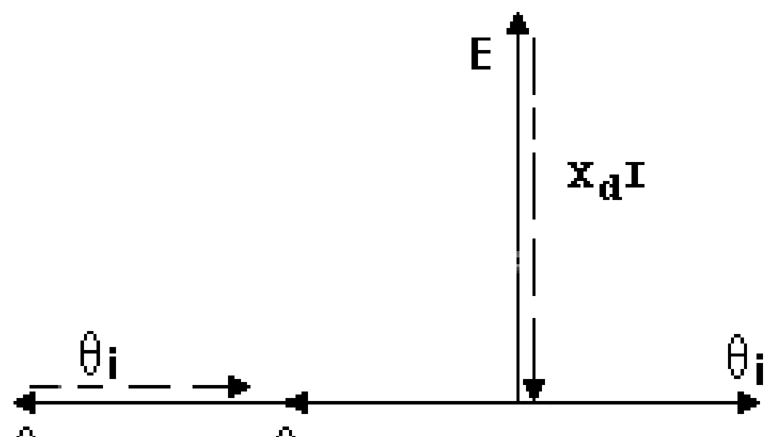
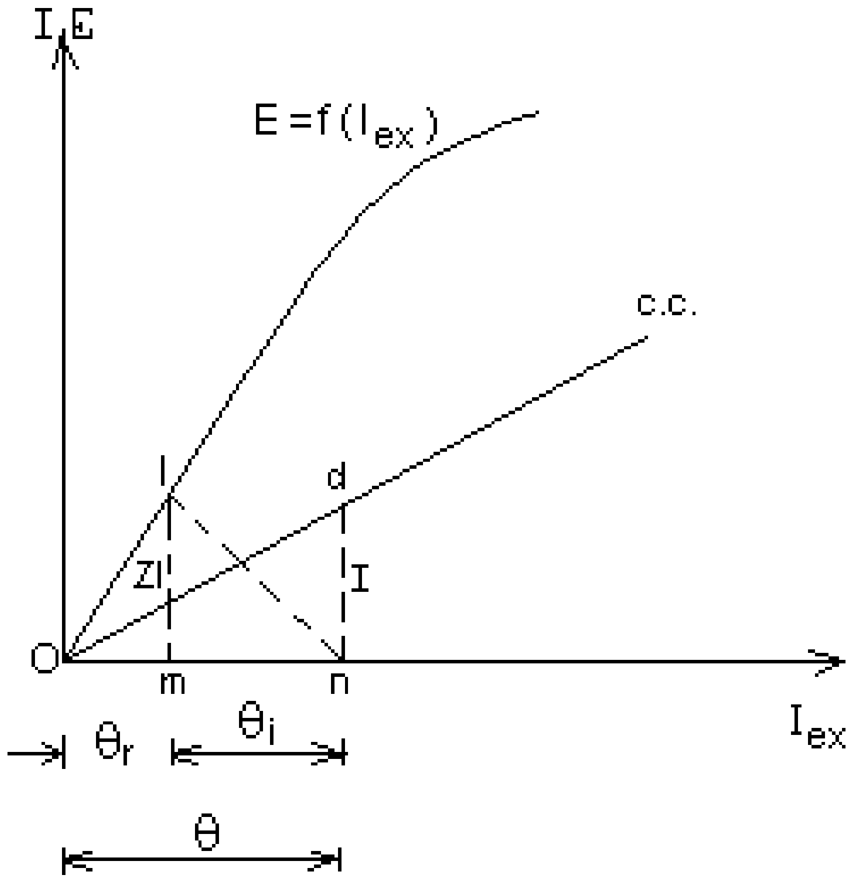


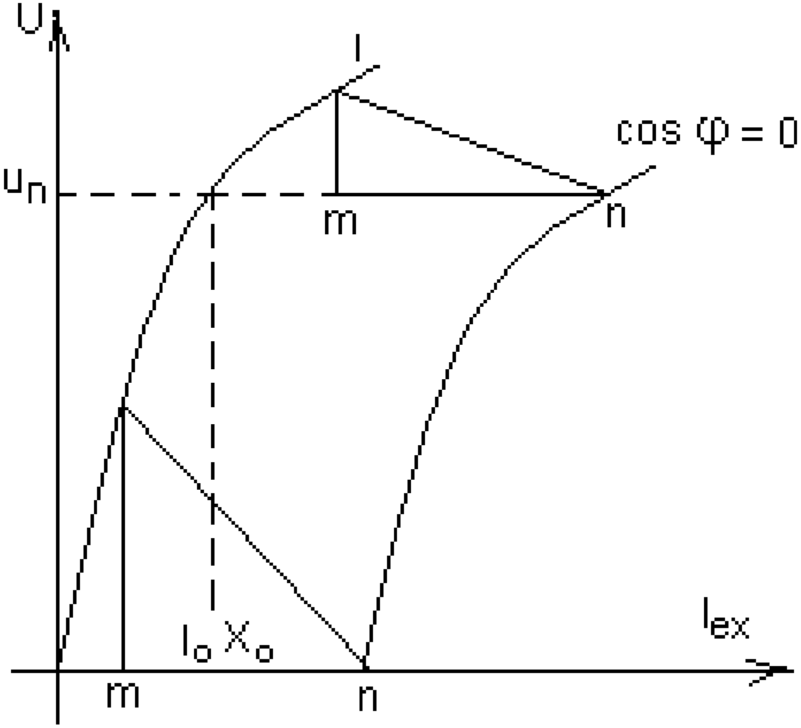
fig. 4

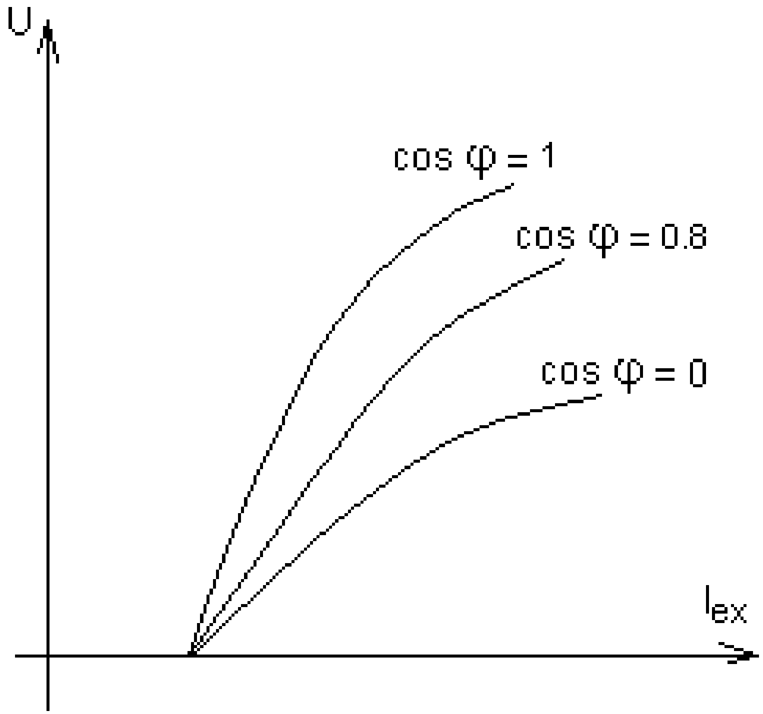
Diagrama Vectorial

2°) C. de cortocircuito (c.c.): $I = f\,(I_{ex})$

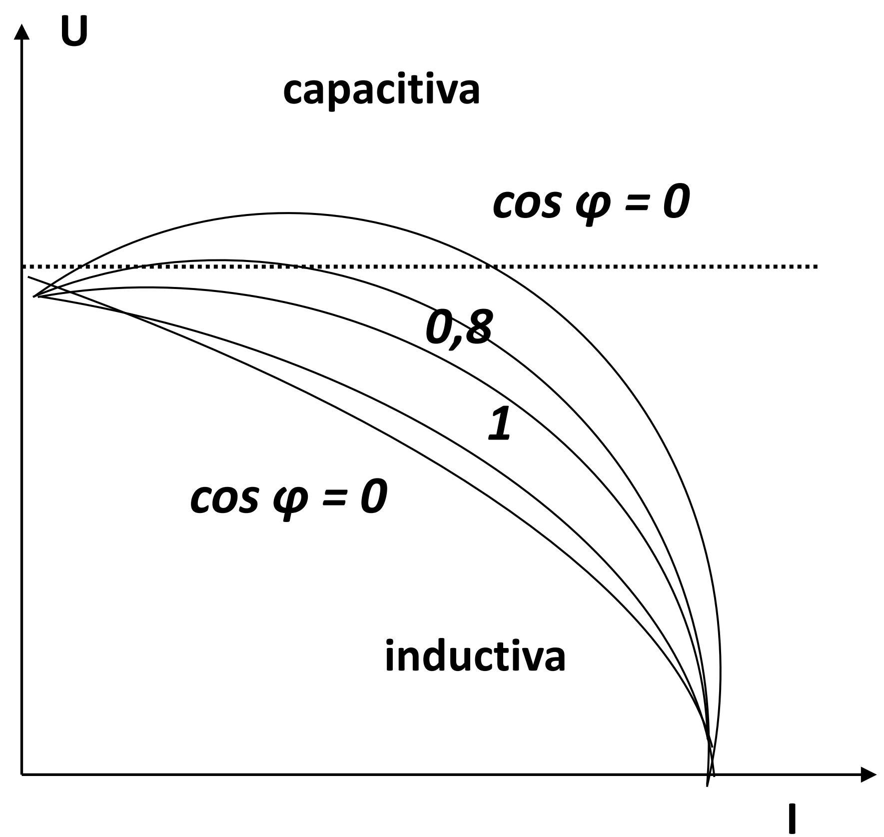


3°) Característica en carga: $U = f\,(\,I_{ex}\,)$

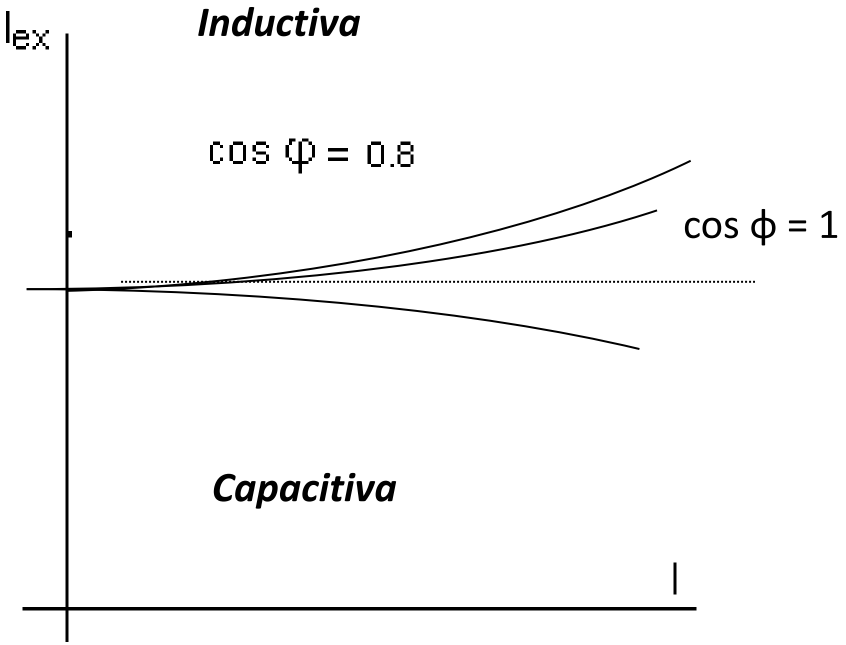




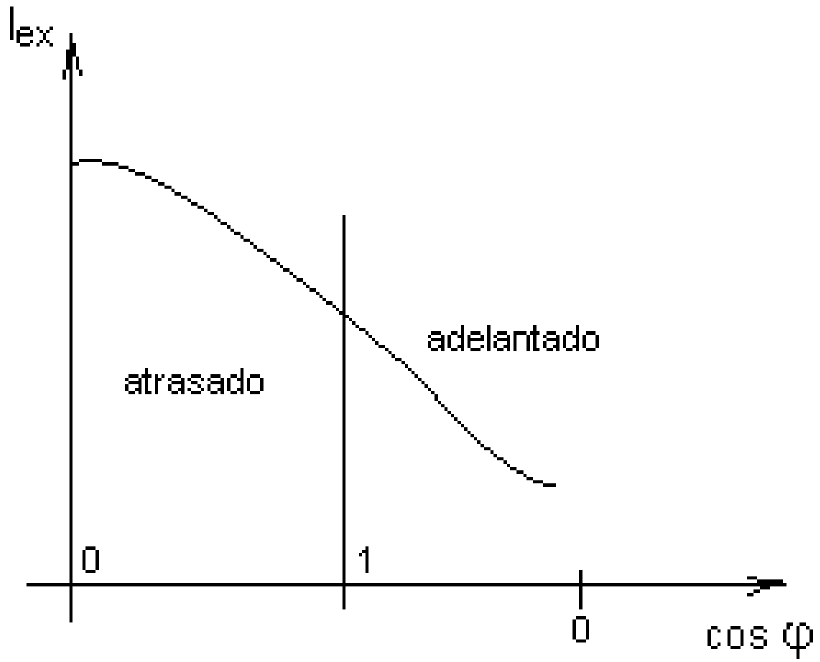
4°) C. Externa $U = f(I)$ $(I_{exc} = cte\ ;\ \cos\varphi = cte)$



5°) Curva de regulación:

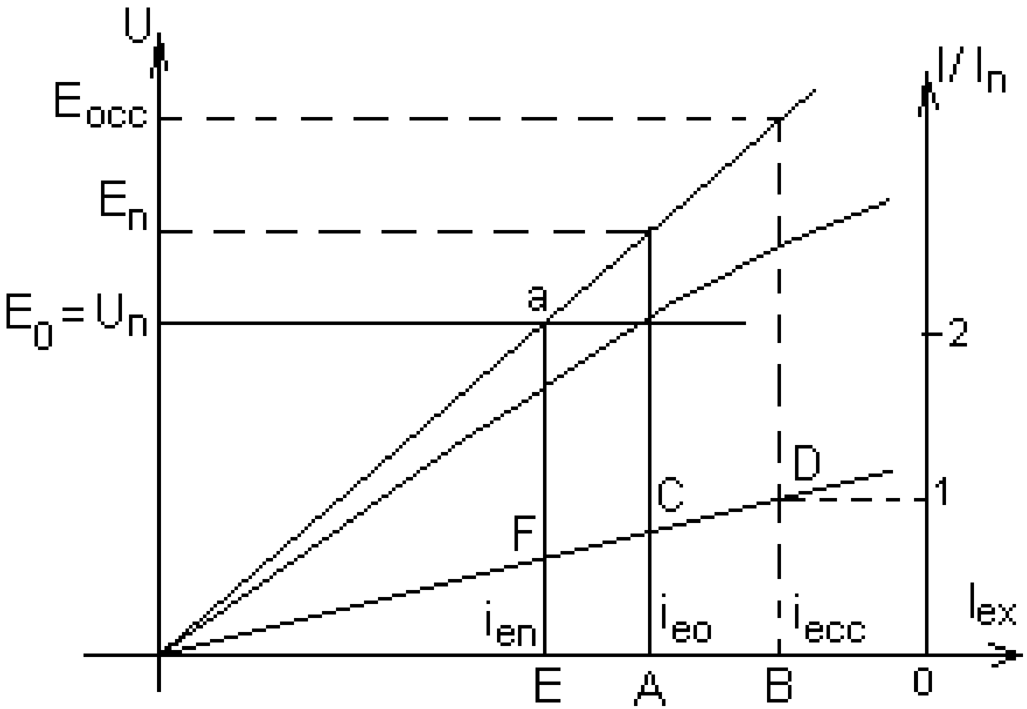


$I_{ex} = f\,(I)$ $(U = cte.\ ;\ \cos\varphi = cte.)$

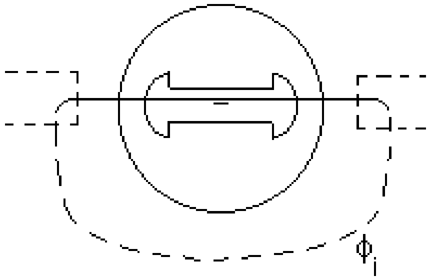


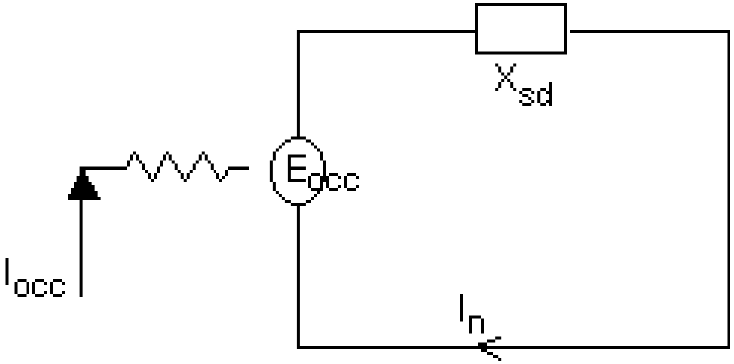
$I_{ex} = f\,(\cos\varphi)$ $(I = cte.\ ;\ U = cte.)$

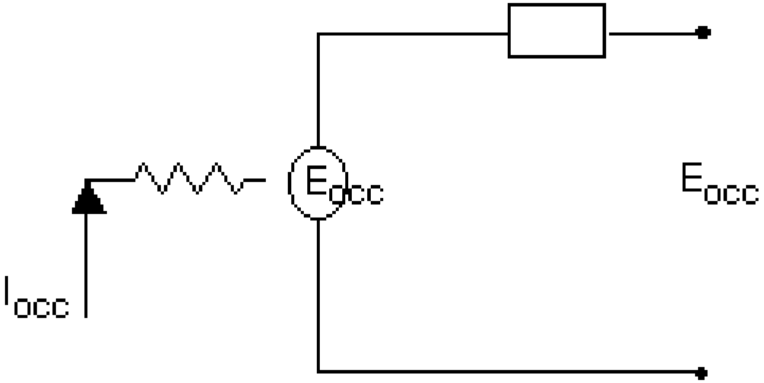
6°) Relación de cortocircuito



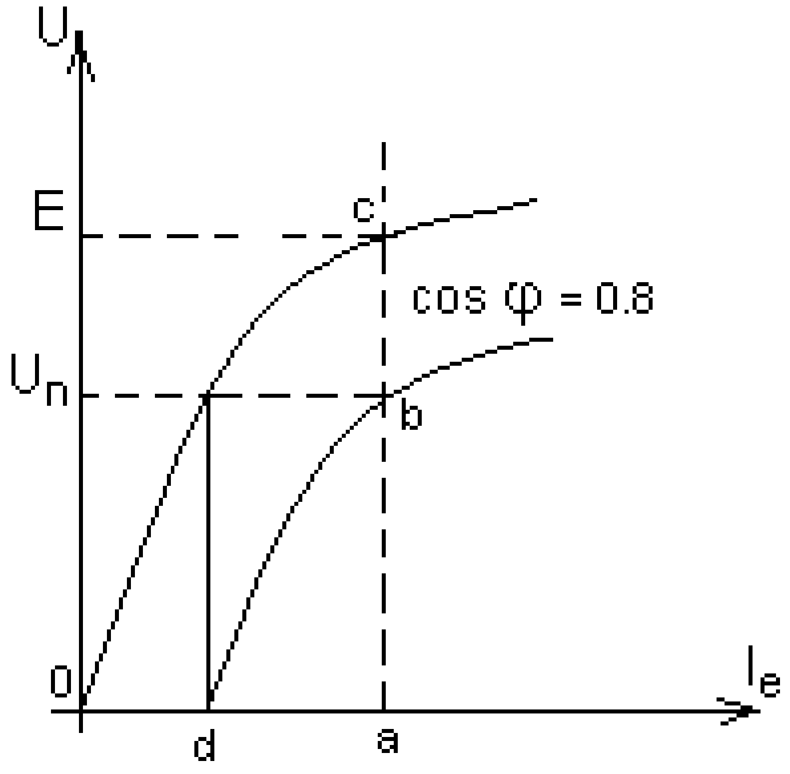
6°) **Relación de cortocircuito**



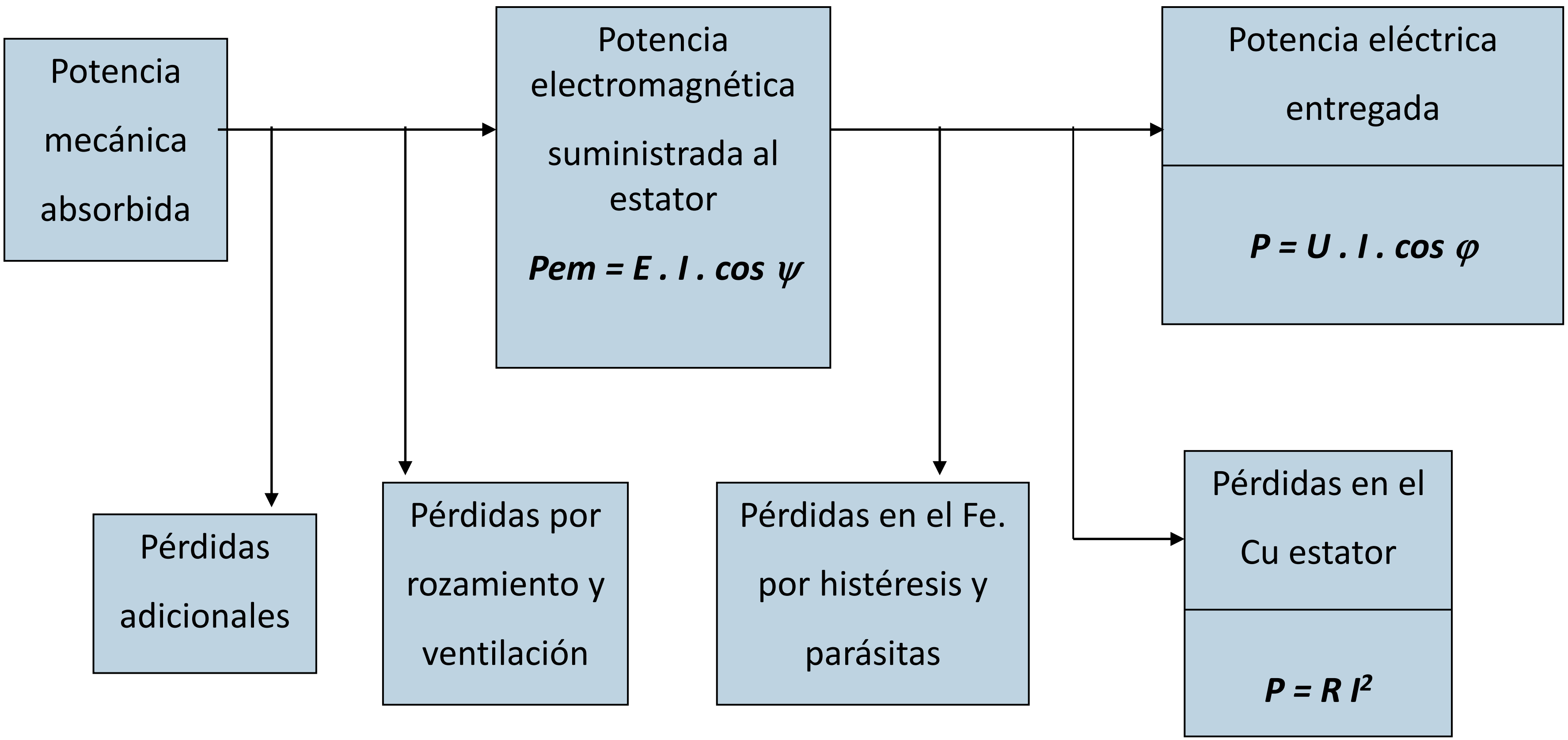




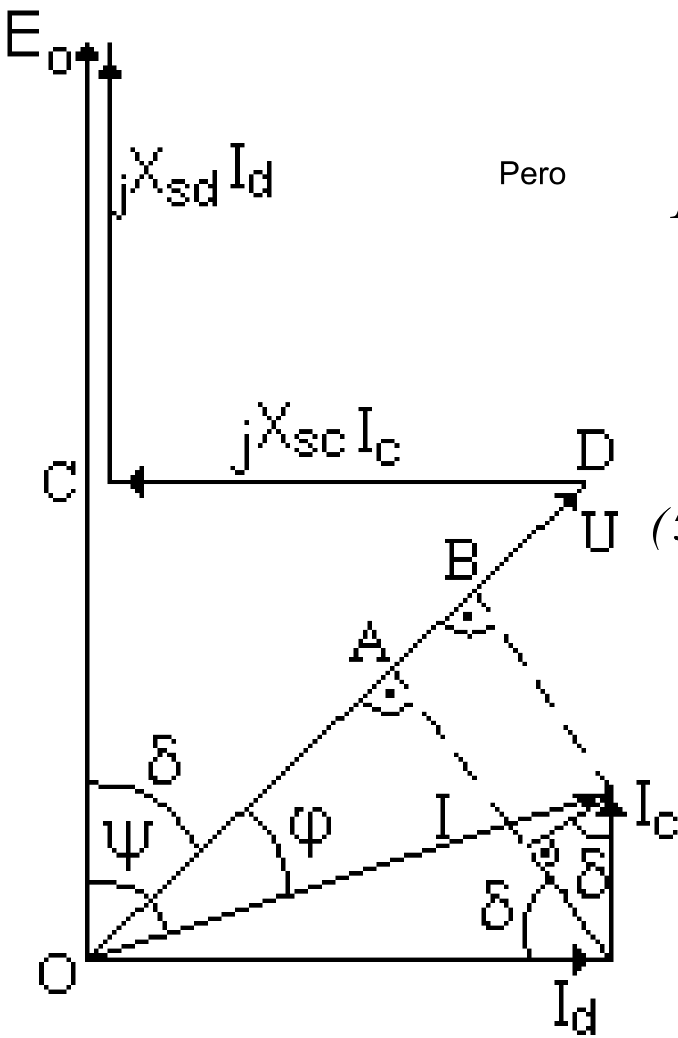
7°) Variación de tensión



Balance Energético



Potencia Electromagnética



$$P_{em} = E.I.\cos\psi = U.I.\cos\varphi \quad (1)$$

Pero

$$I\cos\varphi = \overline{OA} + \overline{AB} = I_d sen\delta + I_c\cos\delta \quad (2)$$

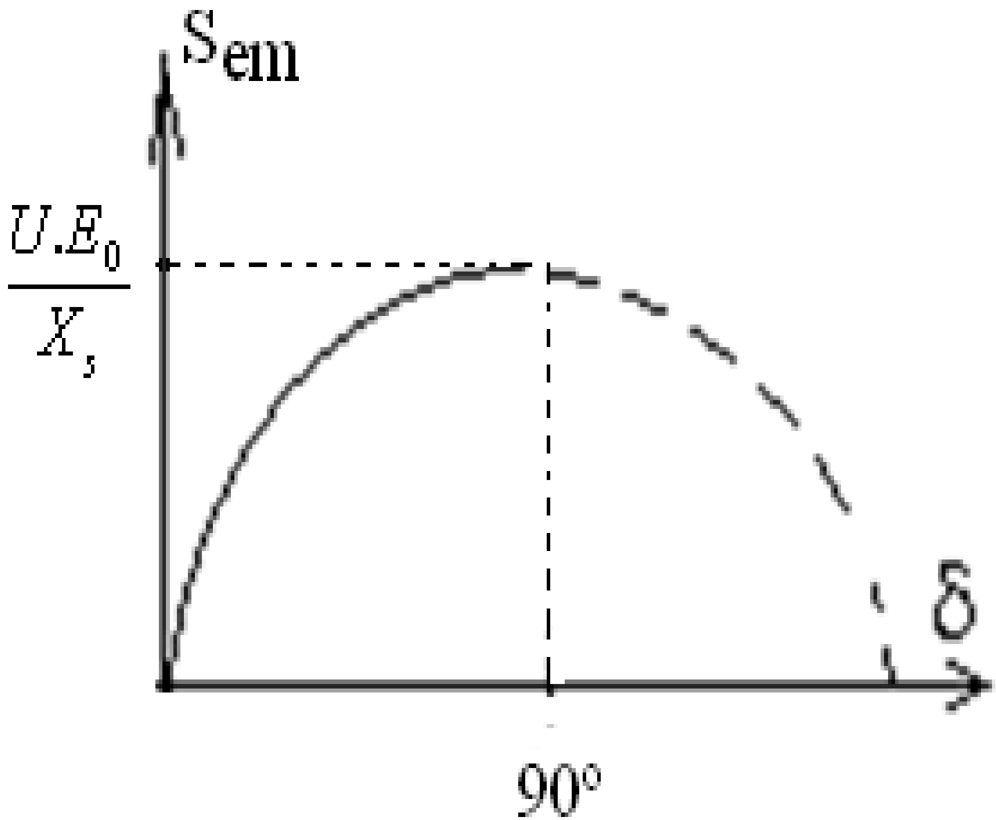
$$(3) \quad \overline{CD} = Usen\delta = X_{sc}.I_c \Rightarrow I_c = \frac{U}{X_{sc}}.sen\delta \; (4)$$

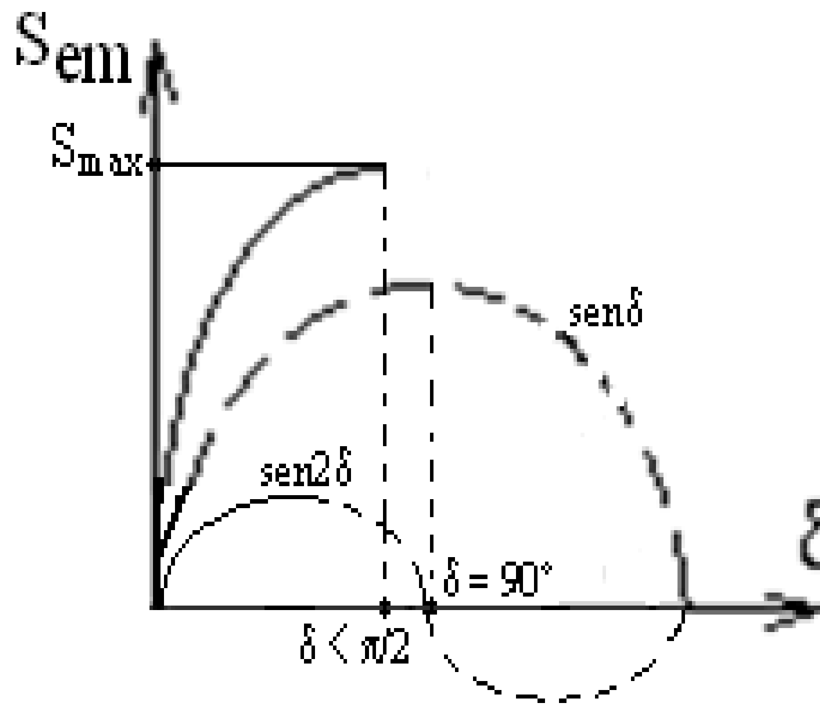
$$(5) \quad \overline{OC = U\cos\delta} = E_0 - X_{sd}.I_d \Rightarrow I_d = \frac{E_0 - U.\cos\delta}{X_{sd}} \; (6)$$

Sustituyendo (4) y (6) en (2) y luego en (1)

$$P_{em} = \frac{U.E_0}{X_{sd}}.sen\delta + \tfrac{1}{2}U^2.\frac{X_{sd} - X_{sc}}{X_{sd}.X_{sc}}.sen2\delta$$

Característica angular

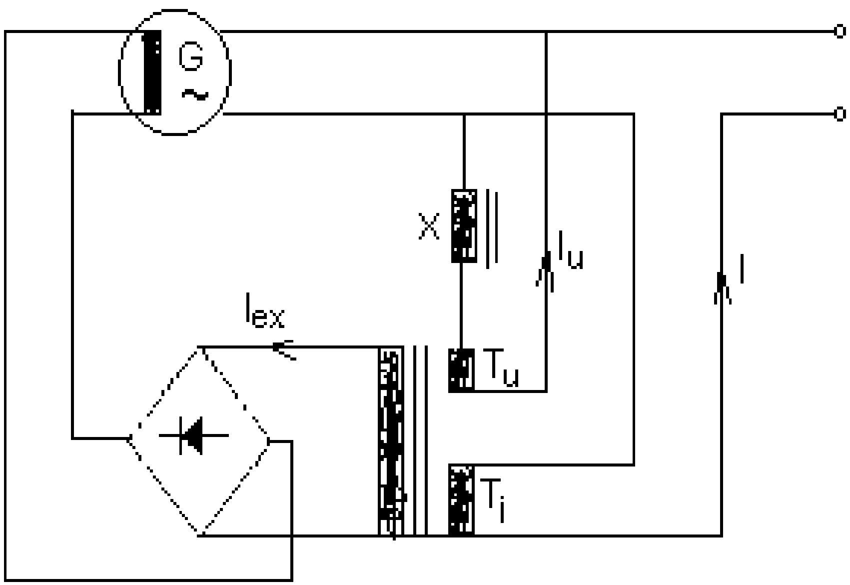


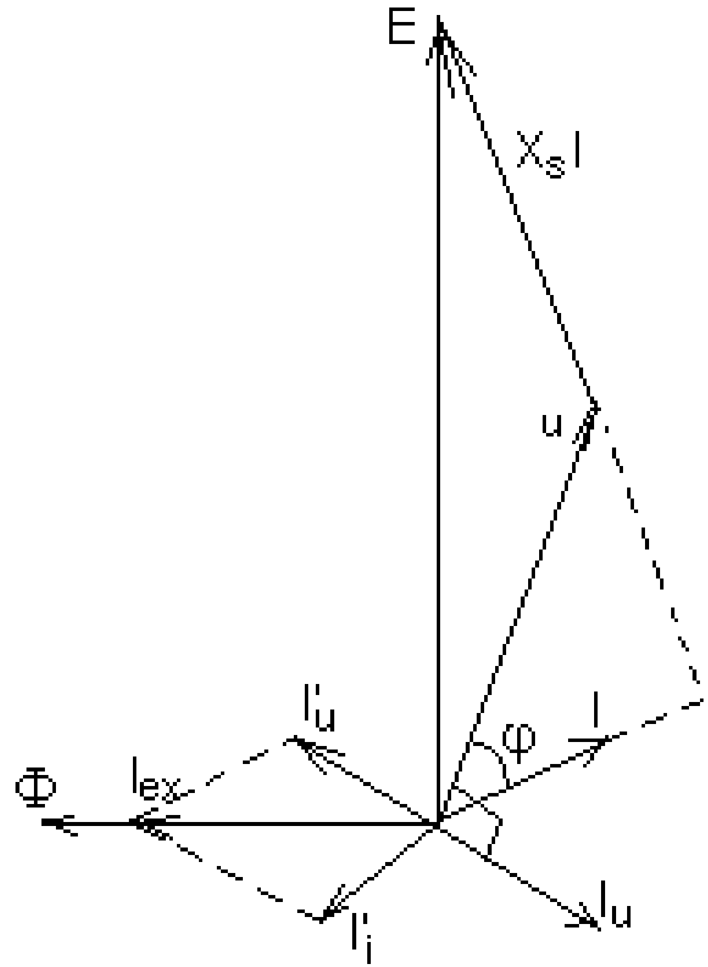


Característica angular
Rotor cilíndrico $\delta = 90^o \rightarrow S_{em} = S_{max}$

Característica angular
Rotor polos salientes $\delta < 90$

Generadores autoexcitados

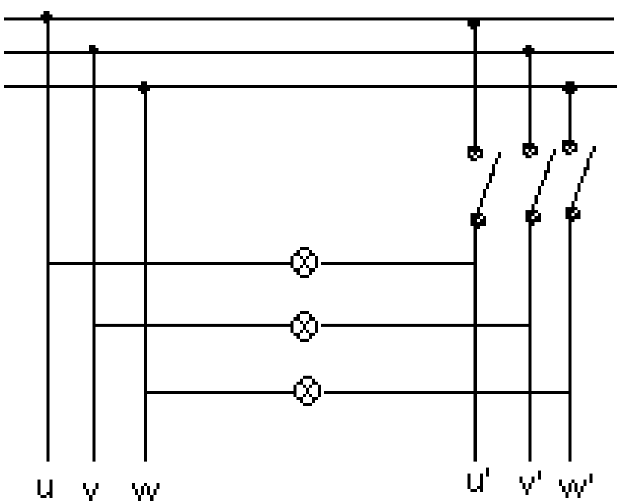


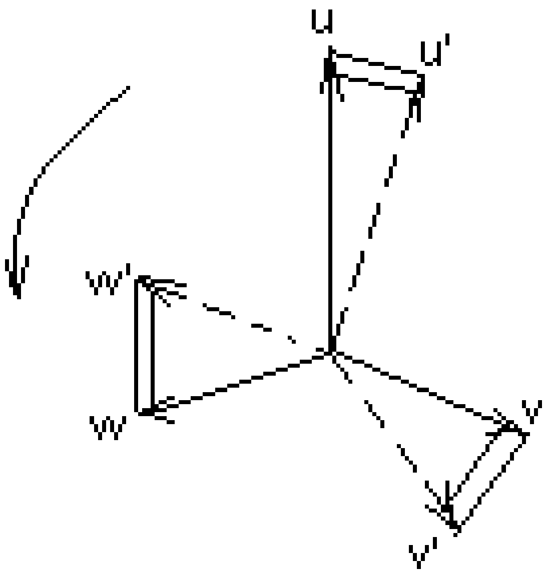


PARALELO DE GENERADORES SÍCRONOS

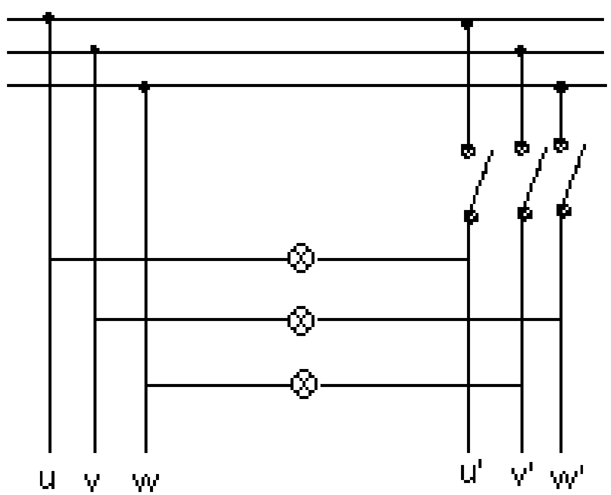
1) Acoplamiento:

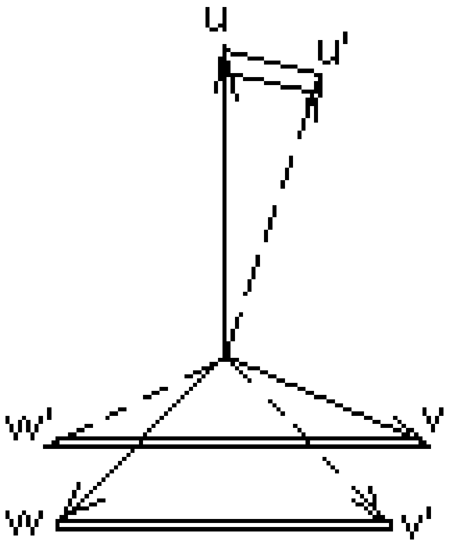
- El método de las "lámparas de fase apagadas"





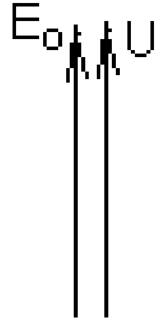
- El método de las "luces rotantes"



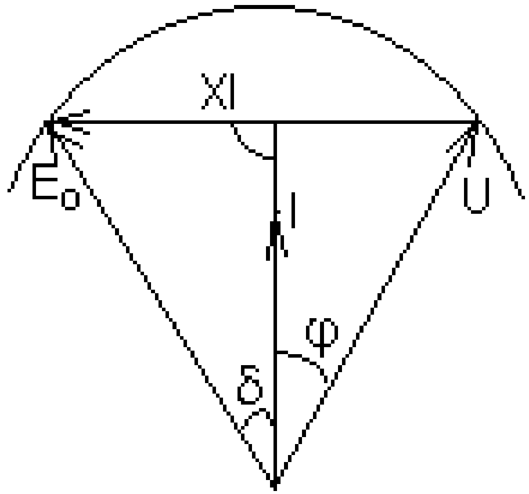


2) Análisis sobre barras infinitas

2.1 Proceso para tomar carga:

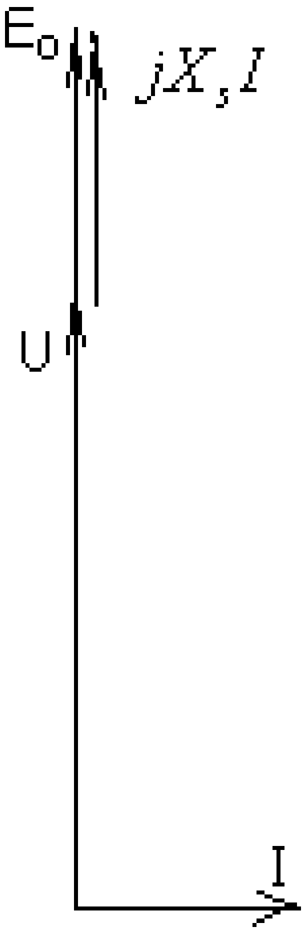


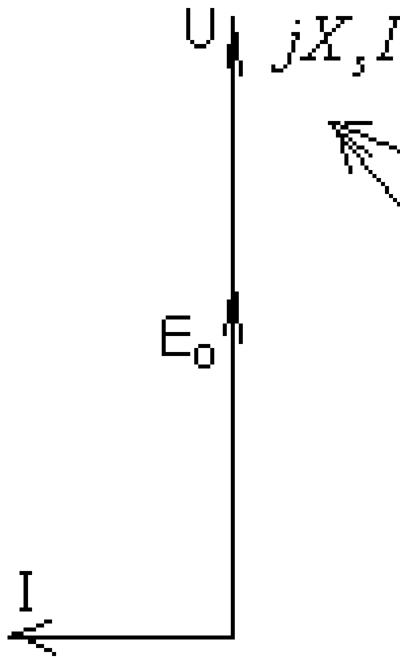
1° Caso

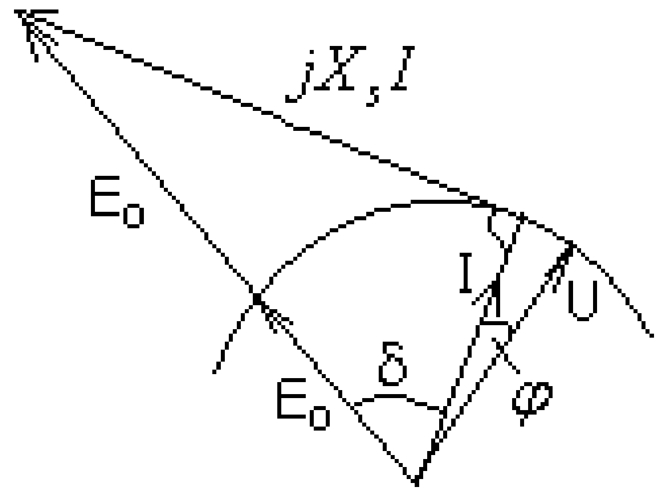


2° Caso

Como tomar carga







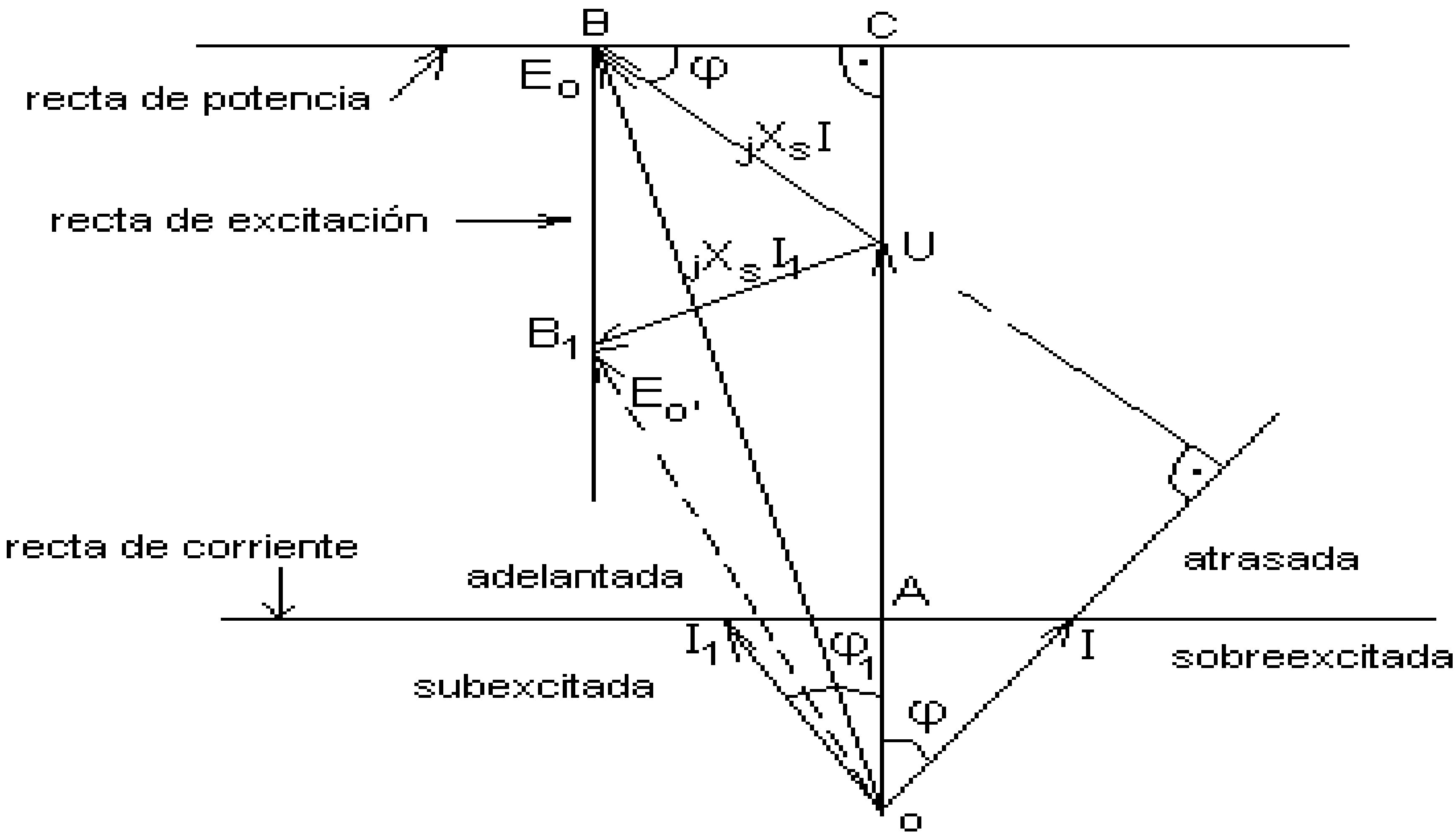
Sobreexcitado

Subexcitado

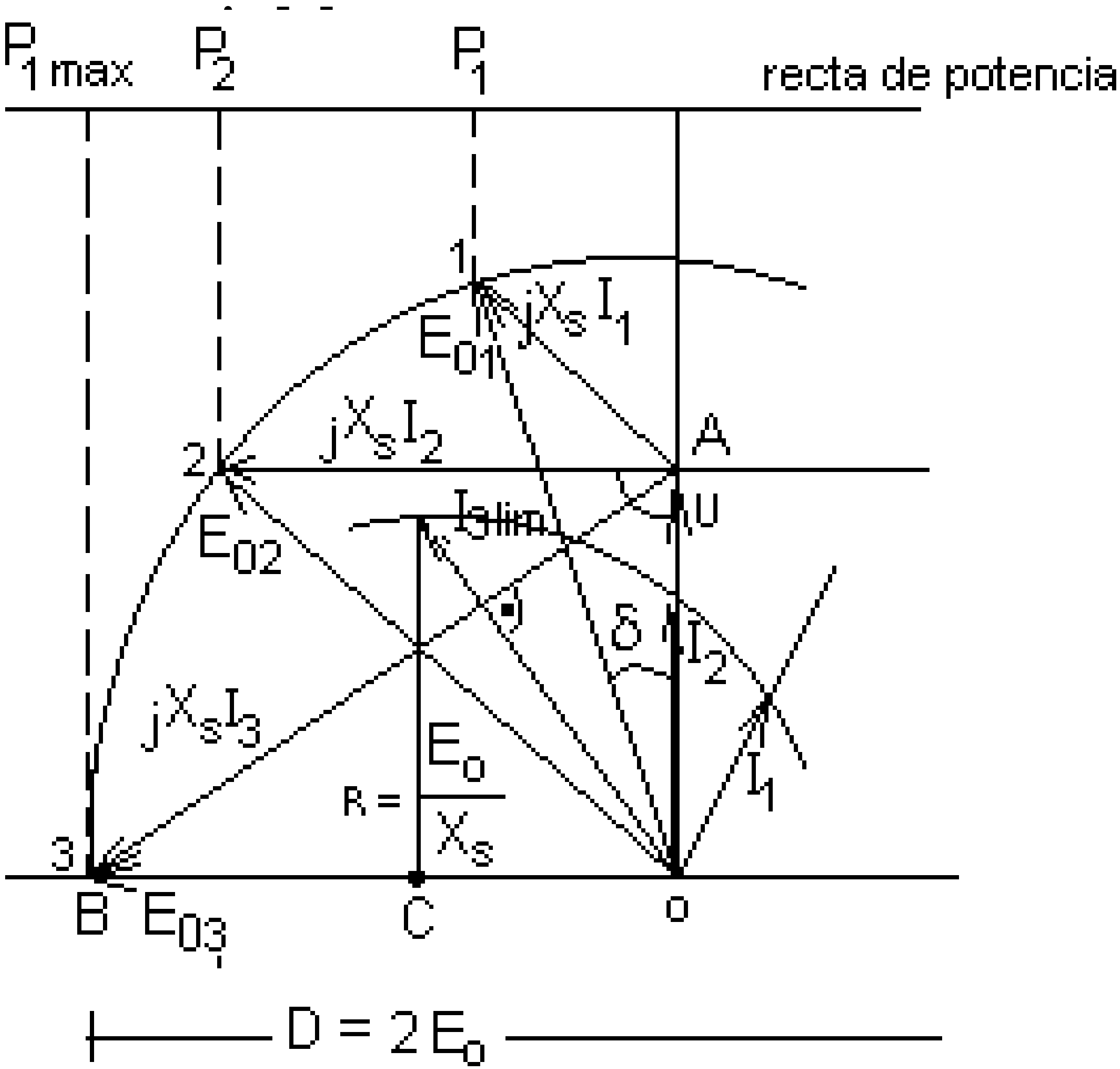
3° Caso

4° Caso

Diagrama a Pot. cte y Excitación variable

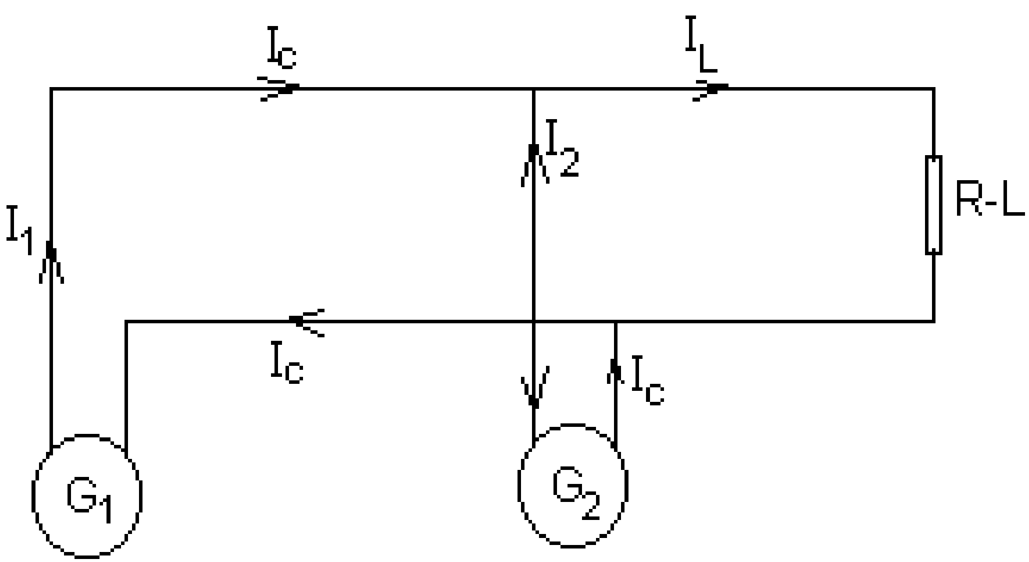


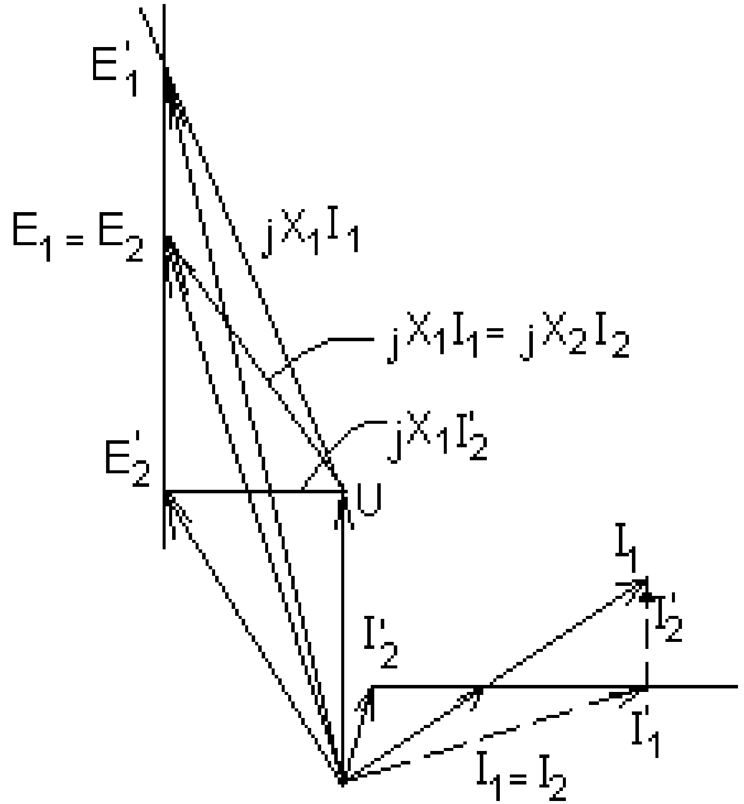
2.3 Diagrama a Excitación cte y Potencia



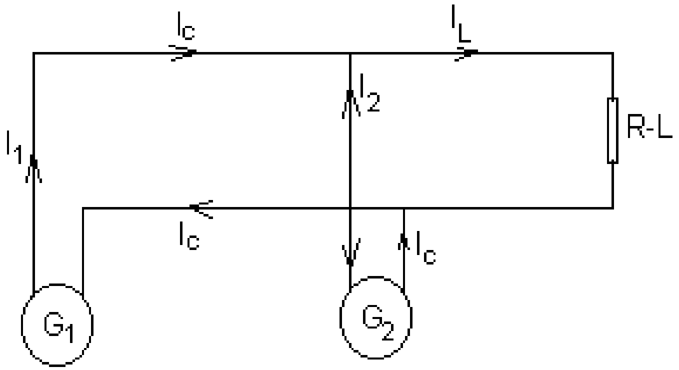
3. Análisis de dos máquinas en paralelo

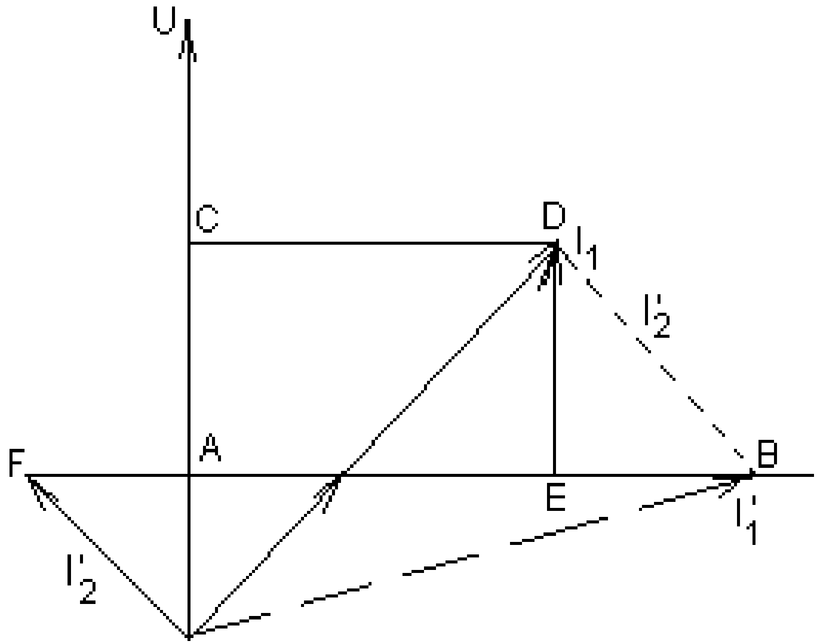
1° Caso: cambio de excitación



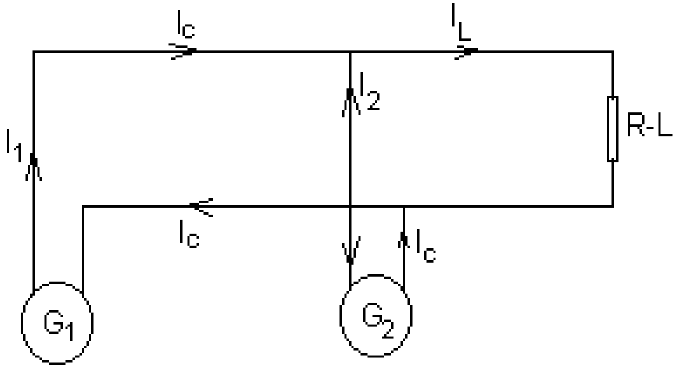


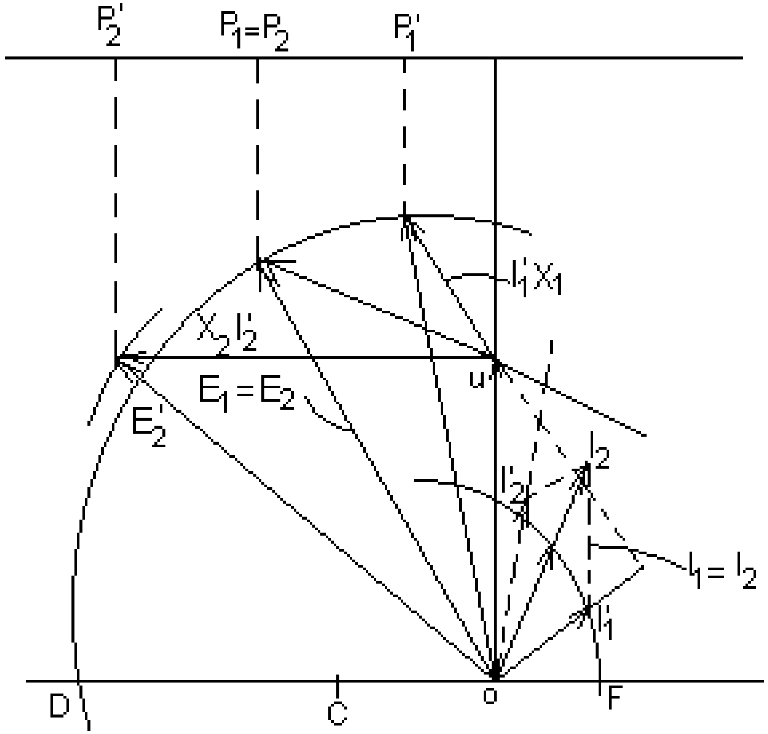
2° Caso





3° Caso: cambio de potencia



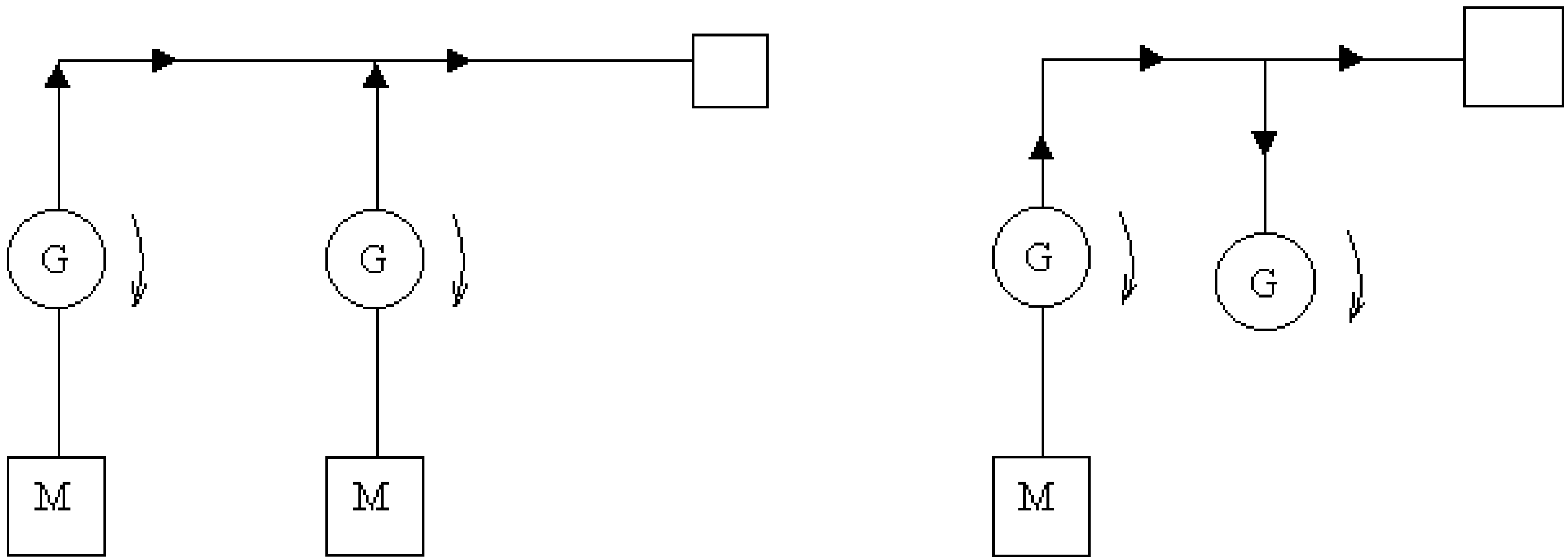


MOTOR SÍNCRONO

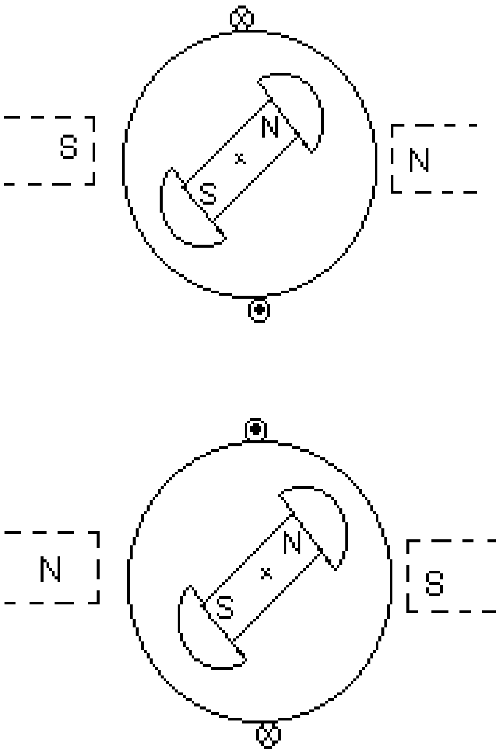
Electrotecnia y Máquinas Eléctricas

09/04/2021

Principio de funcionamiento



Principio de funcionamiento



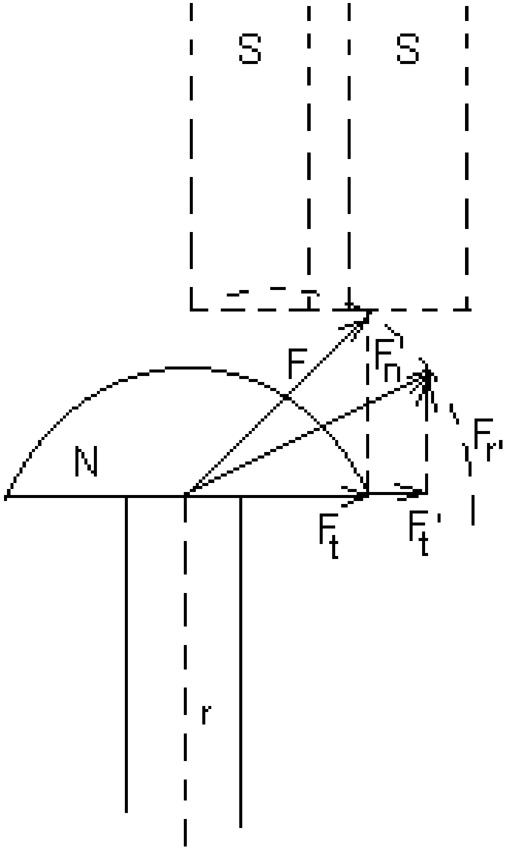
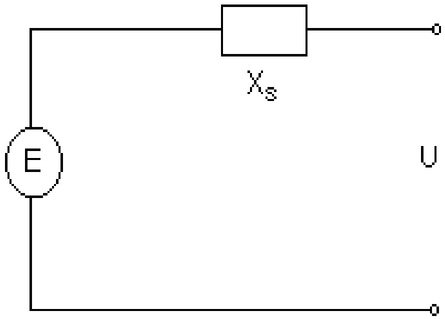


Diagrama Vectorial

Circuito equivalente
para generador y motor



- Generador:

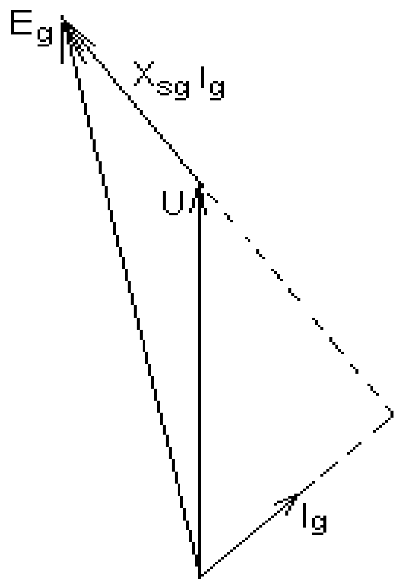
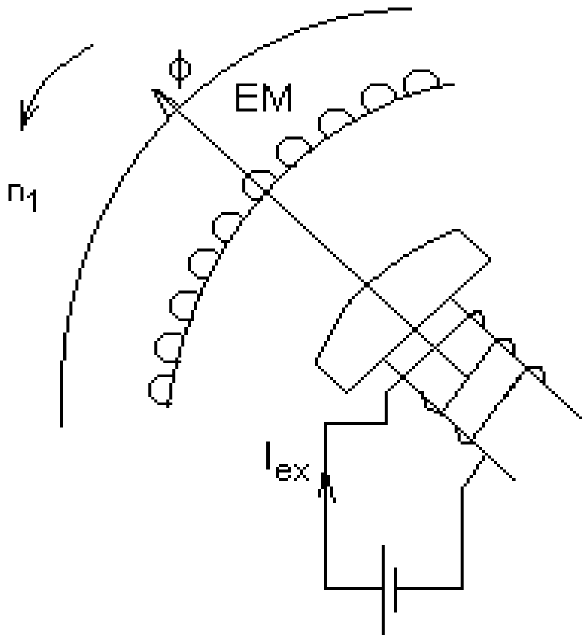
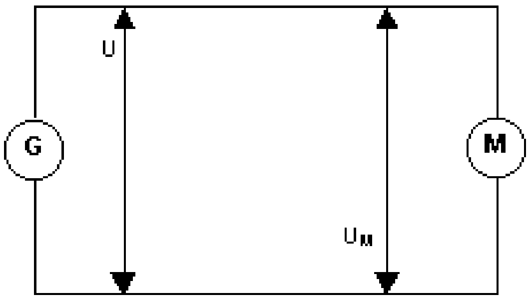
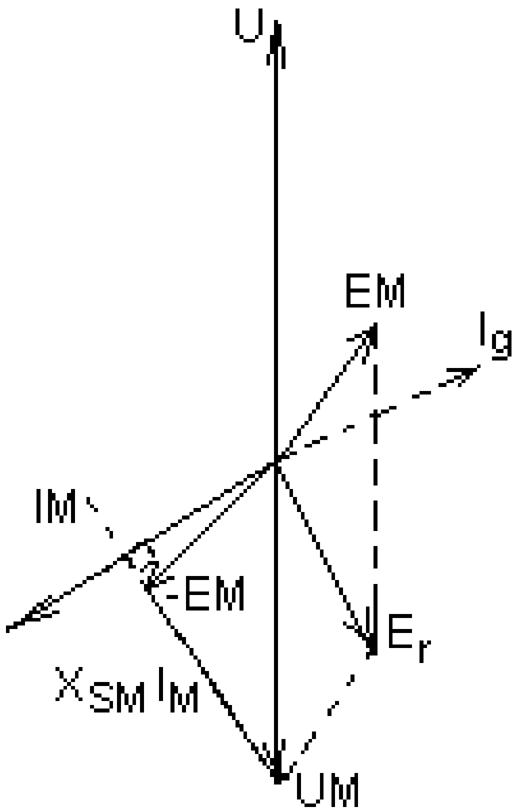


Diagrama Vectorial

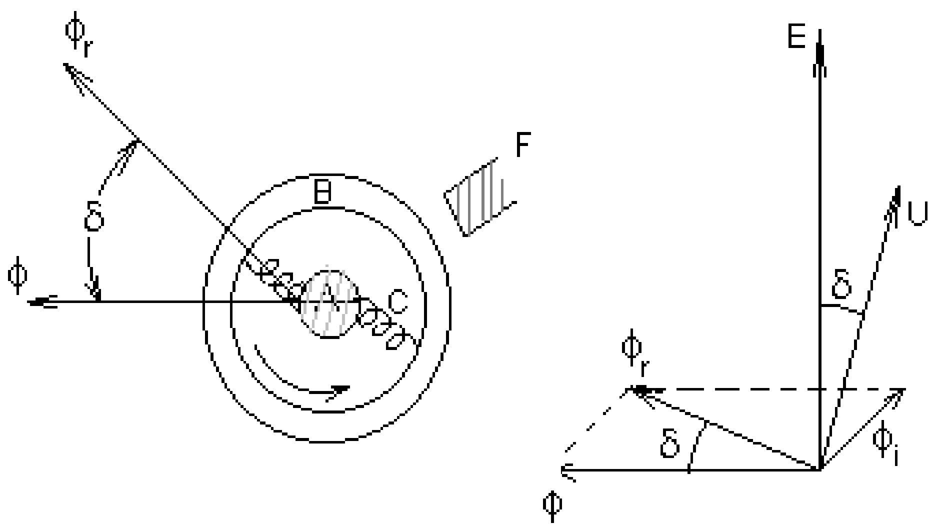
- Motor

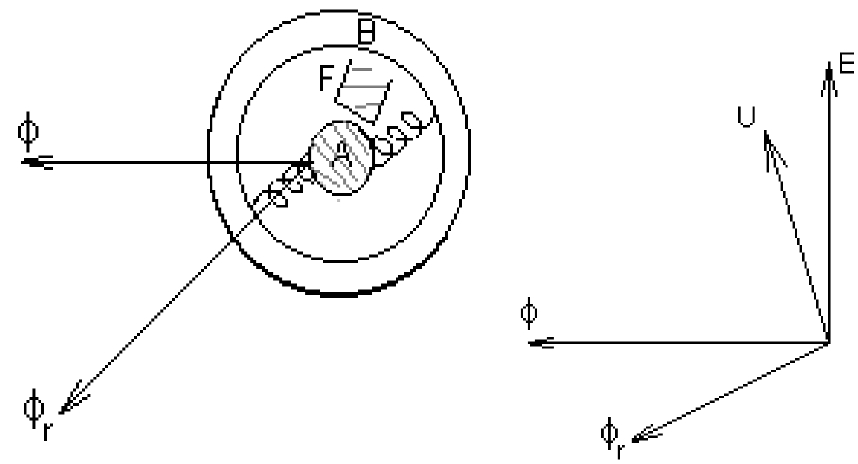






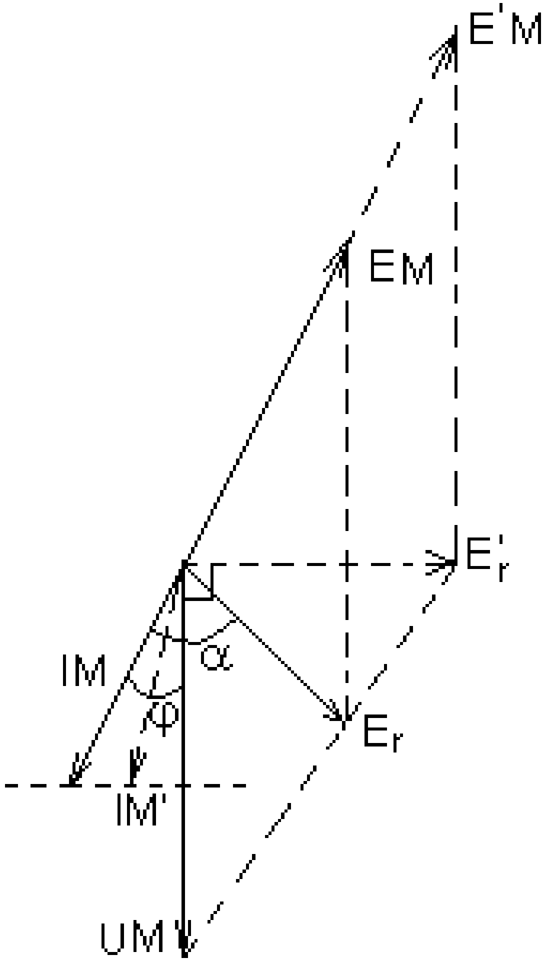
- Generador
- Motor



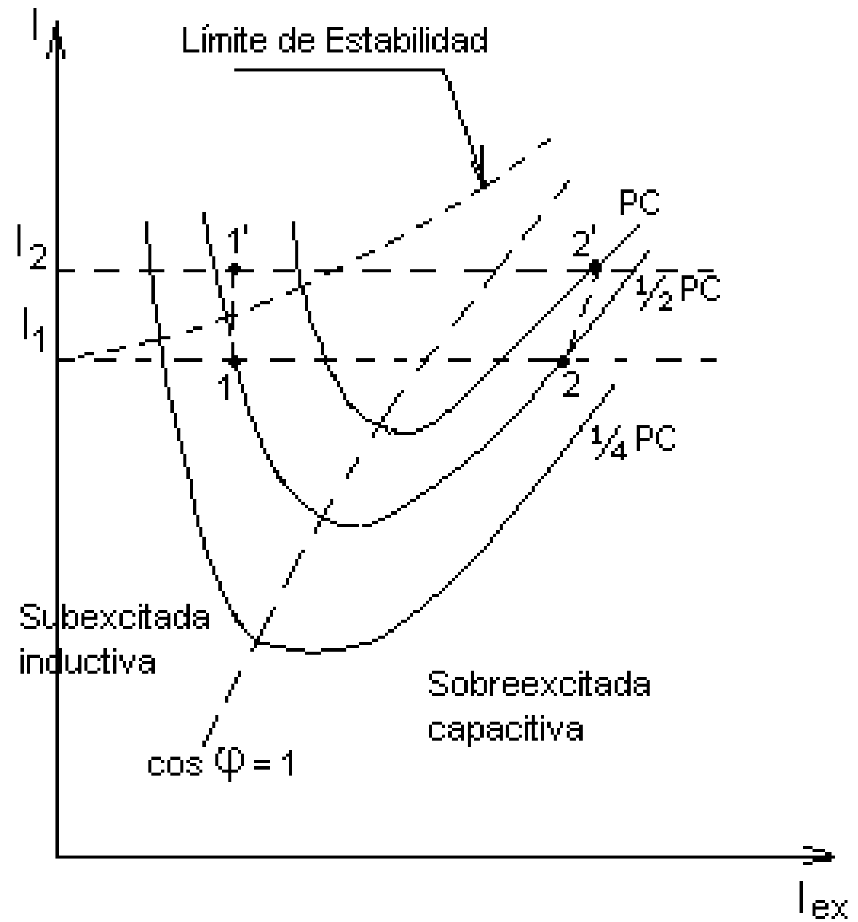


Un símil mecánico de la máquina síncrona como generador - fig. 10 – Podría representarse como un eje A (rueda polar) que gira accionado por un motor y esta ligado a una corona B (inducido) por resortes C (flujo resultante). Al hacer girar el eje, aplicando un freno F a la corona (carga de la máquina) el resorte se estira (los polos se desplazan) formando un cierto ángulo (ángulo de carga) proporcional al frenado (potencia entregada).
Como motor – fig.11 - giraría la corona (campo rodante del inducido) y los resortes (flujo) arrastrarían al eje (rotor) en el que se encuentra ahora el freno (momento resistente).-

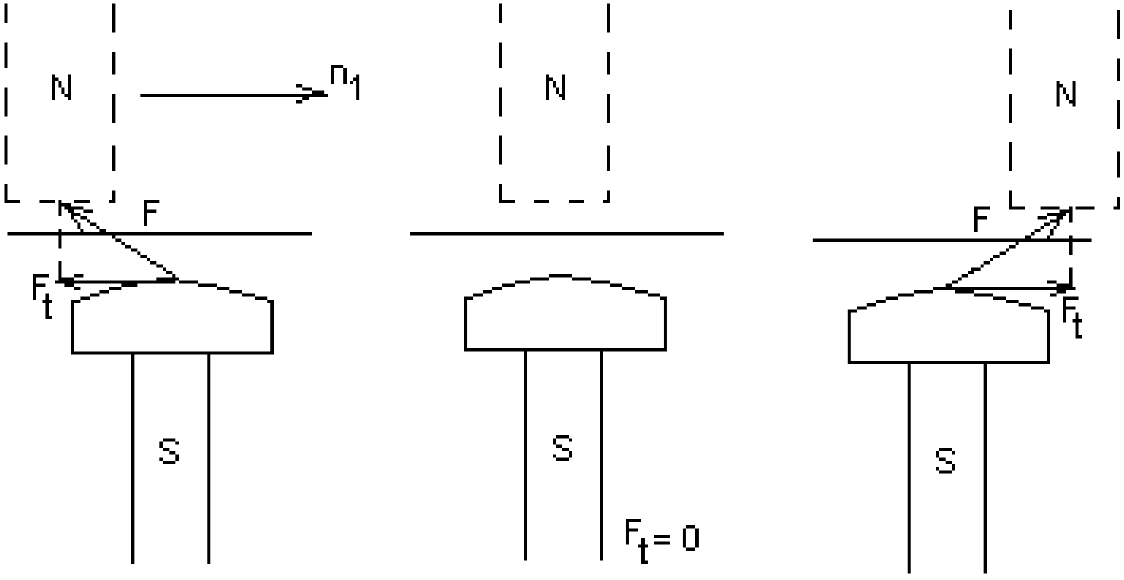
Medición del cosφ



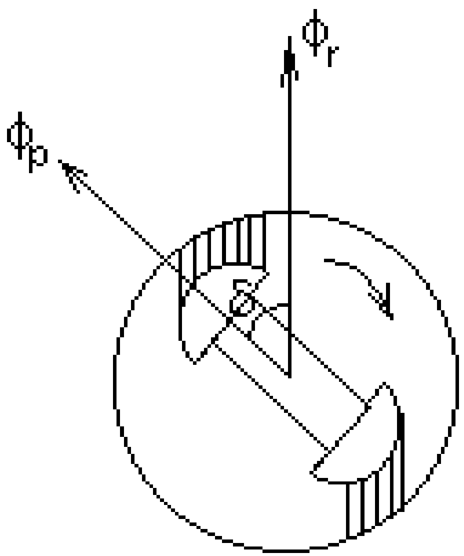
Curvas en V

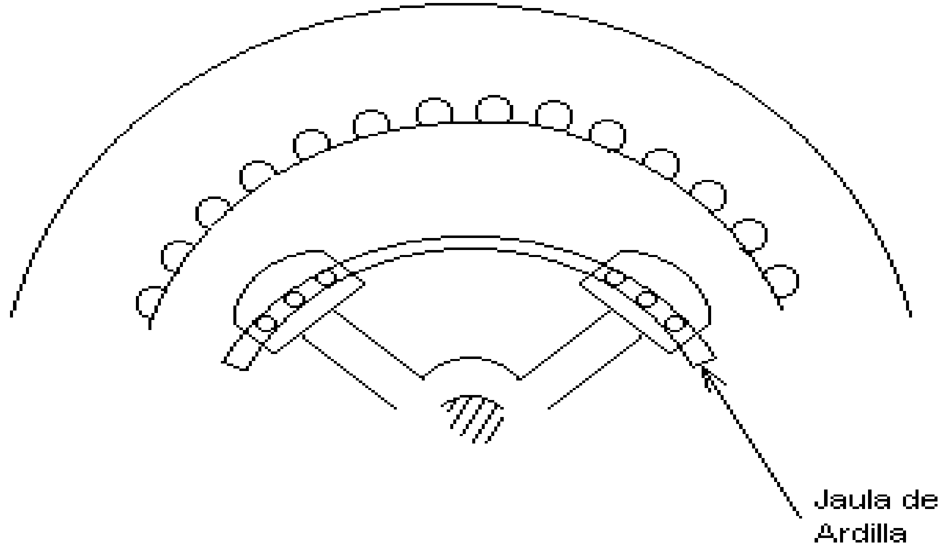

I
Límite de Estabilidad
PC
I_2
1'
2'
½ PC
I_1
1
2
¼ PC
Subexcitada
inductiva
Sobreexcitada
capacitiva
cos φ = 1
I_{ex}

Arranque del motor síncrono

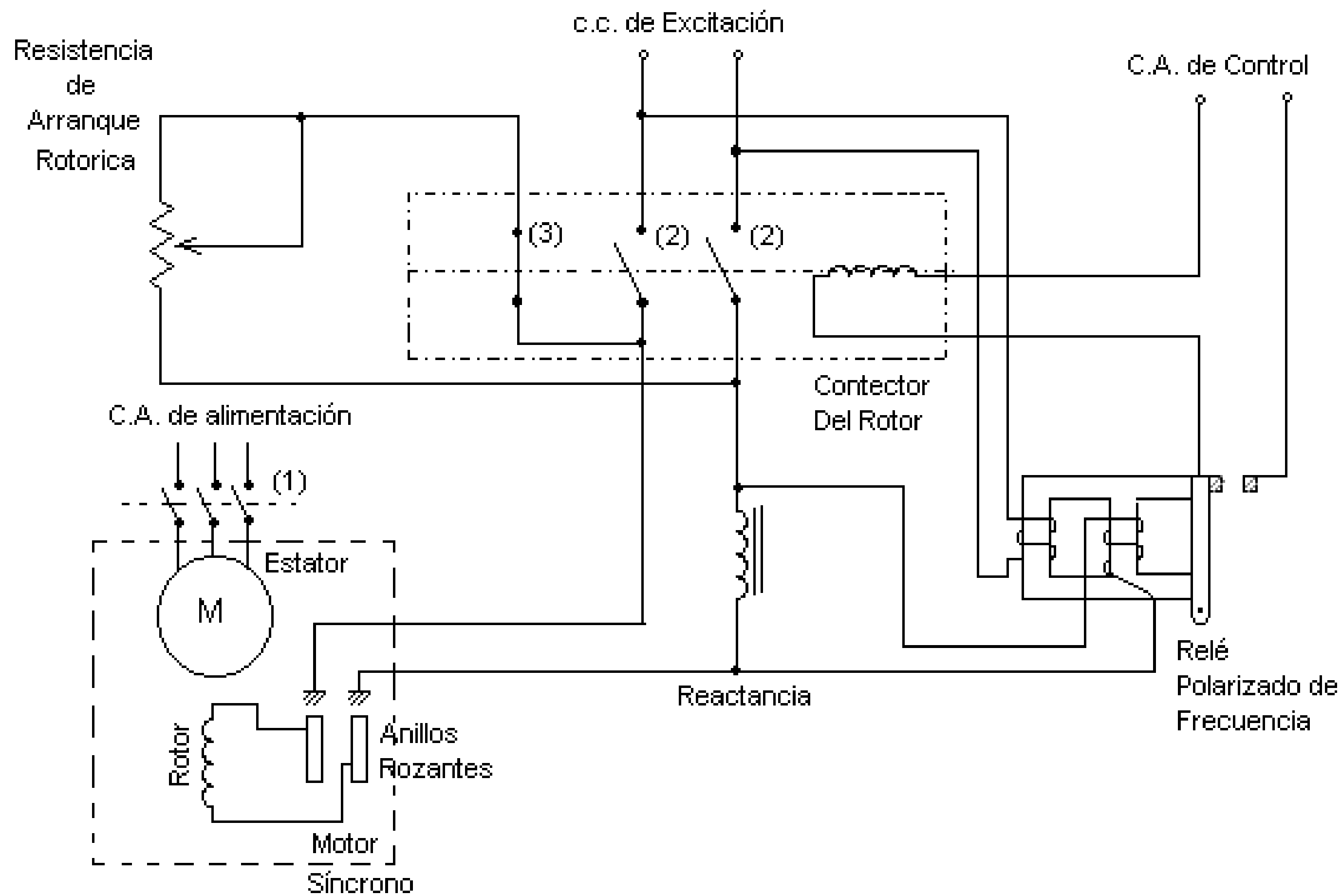


Arranque del motor síncrono



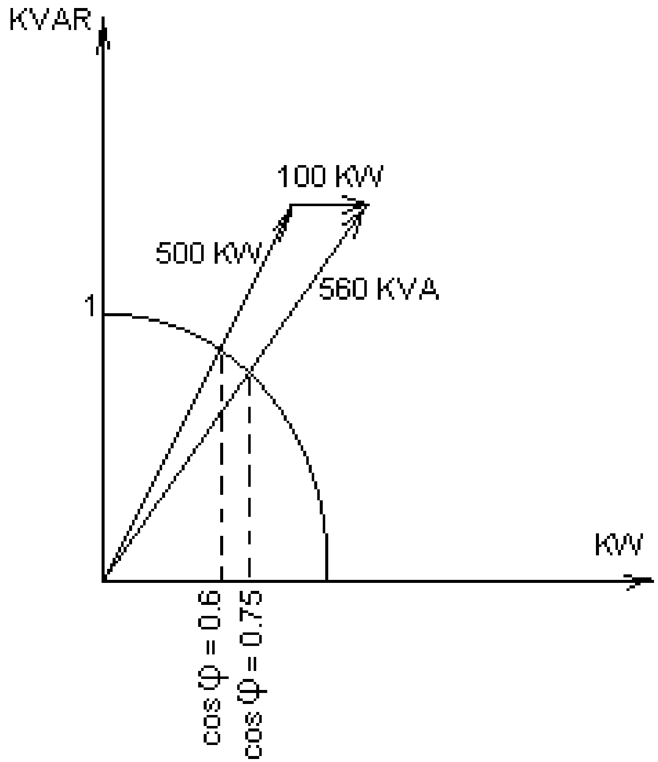


Arranque automático del motor síncrono



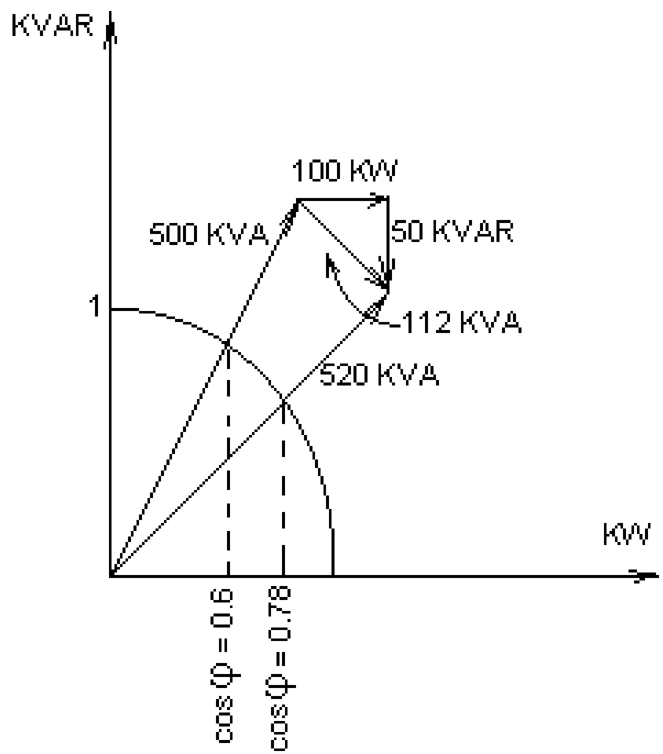
Aplicaciones del motor síncrono

- Trabajando como motor, entregando potencia útil solamente.



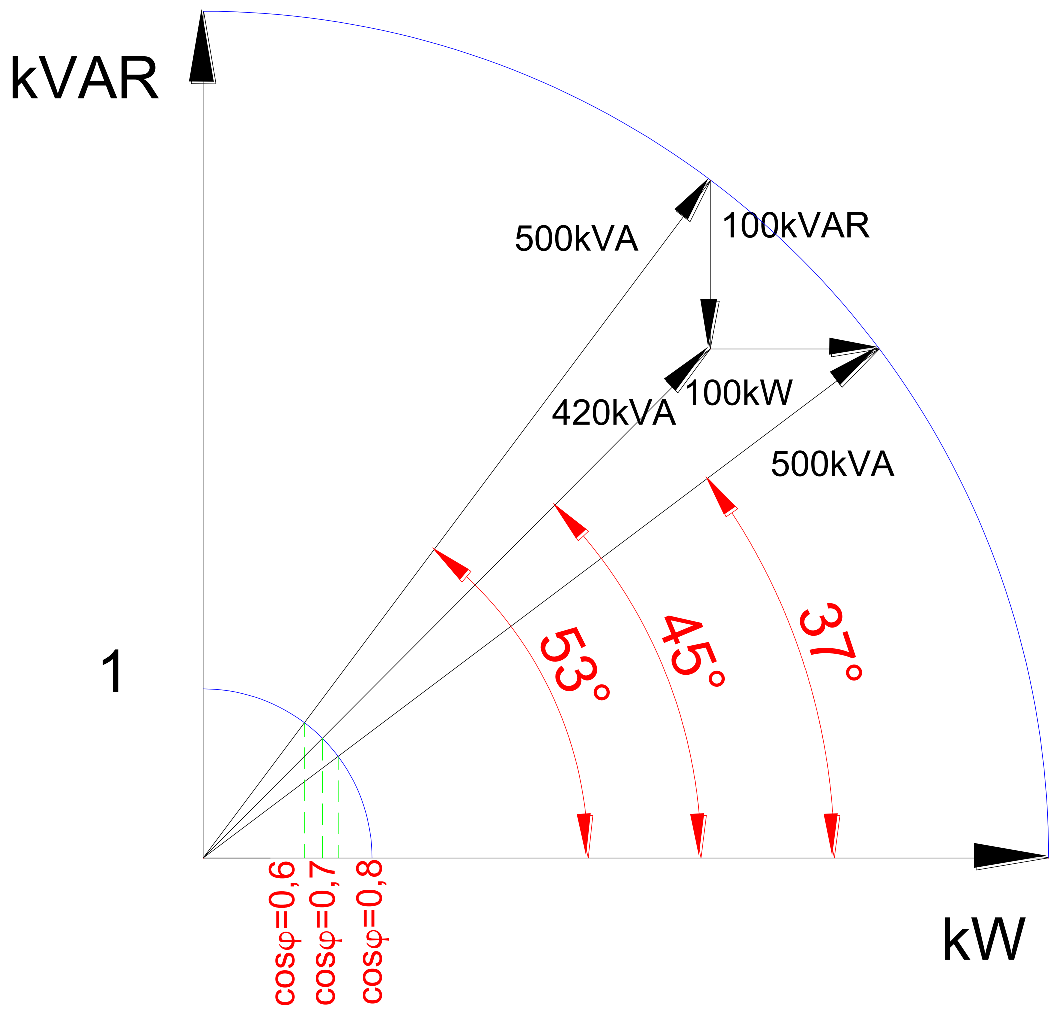
Aplicaciones del motor síncrono

- Trabajando como motor, entregando potencia útil y sobreexcitada



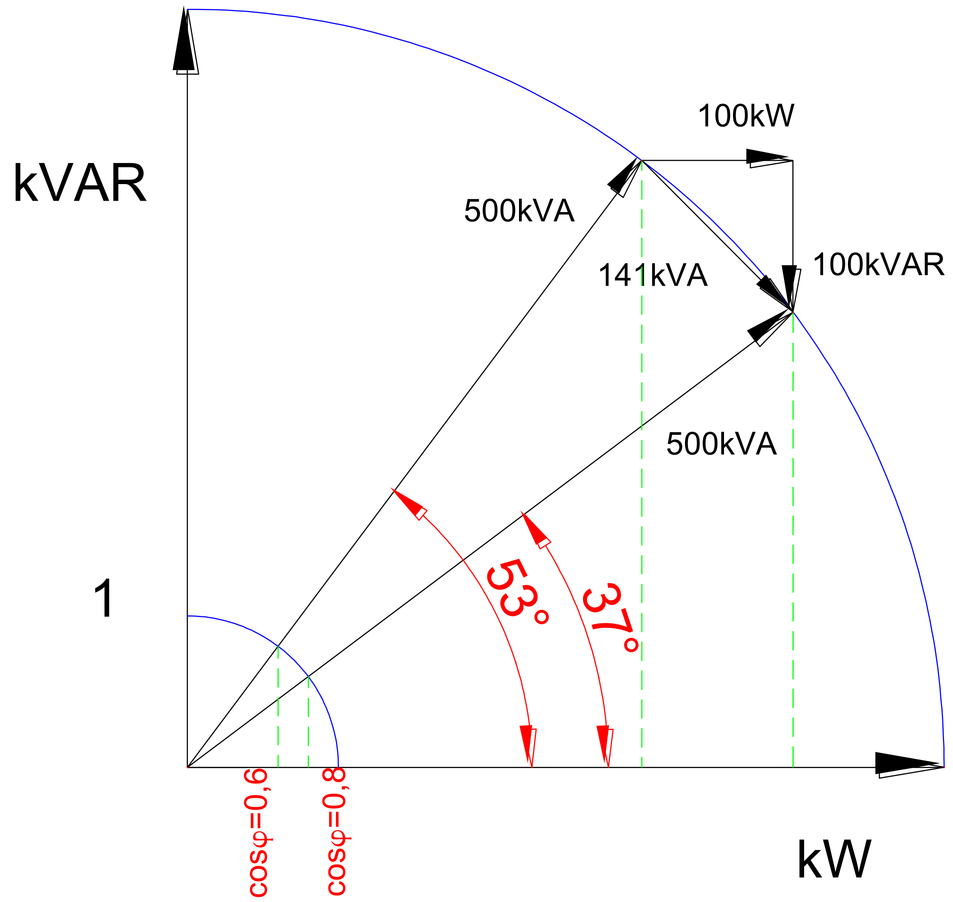
Aplicaciones del motor síncrono

- Conectado como compensador síncrono

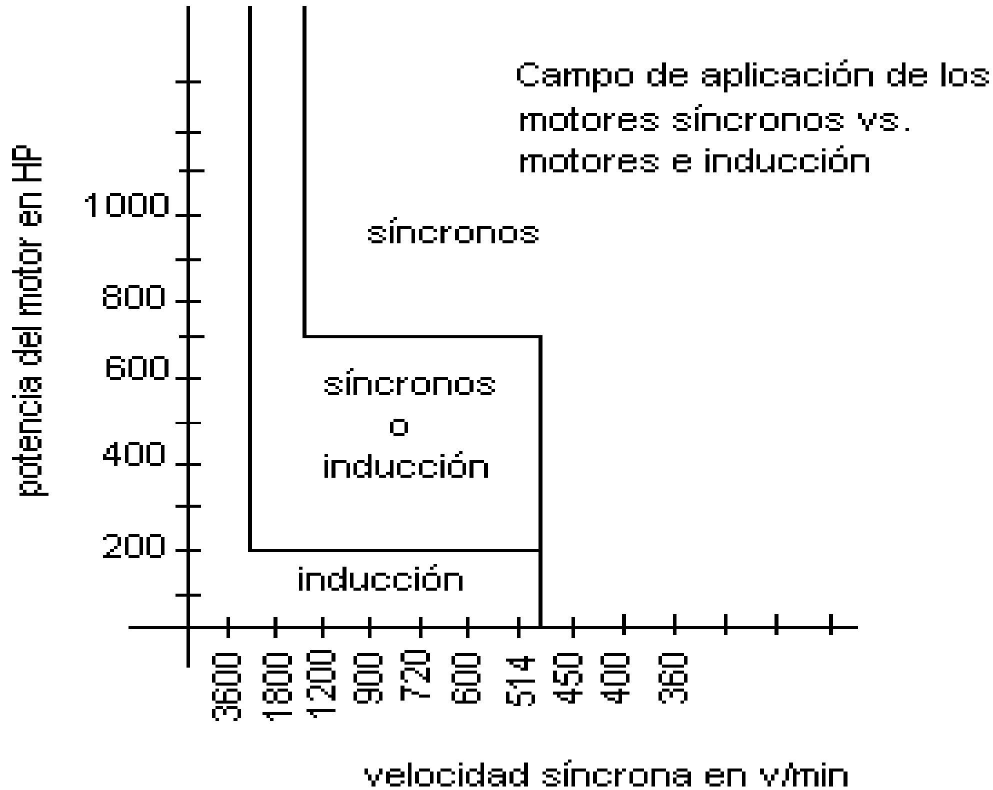


Aplicaciones del motor síncrono

- Caso que no se disponga de mayor potencia aparente



Comparación de costos de motores síncronos



Compensador síncrono