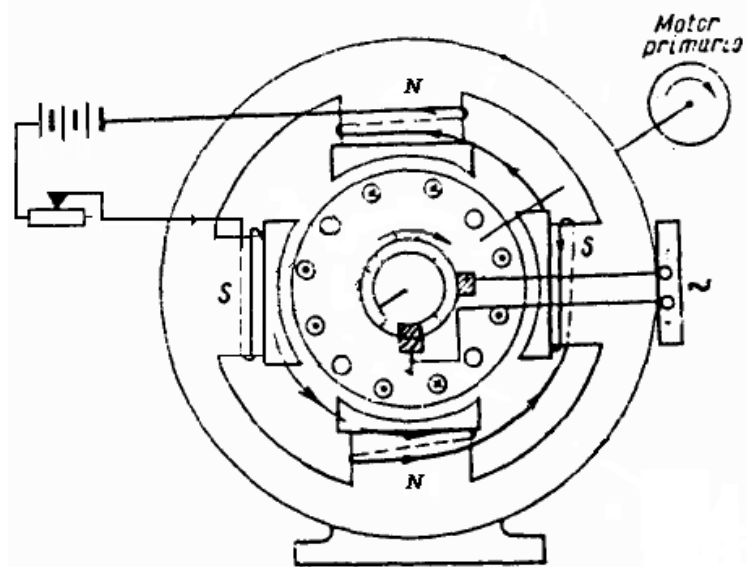


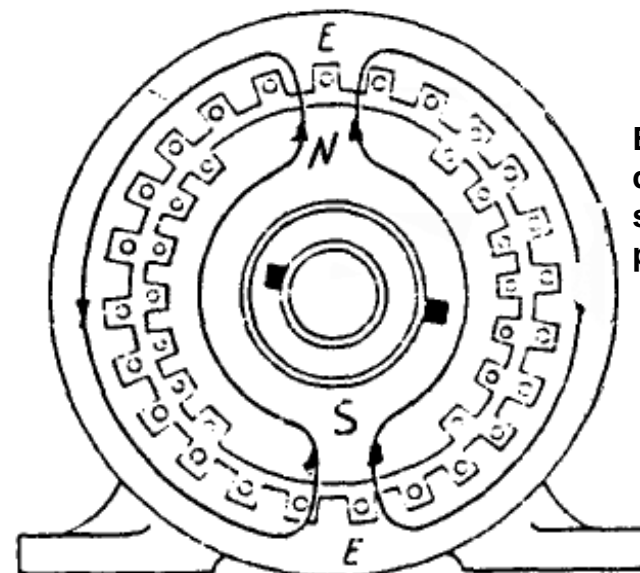
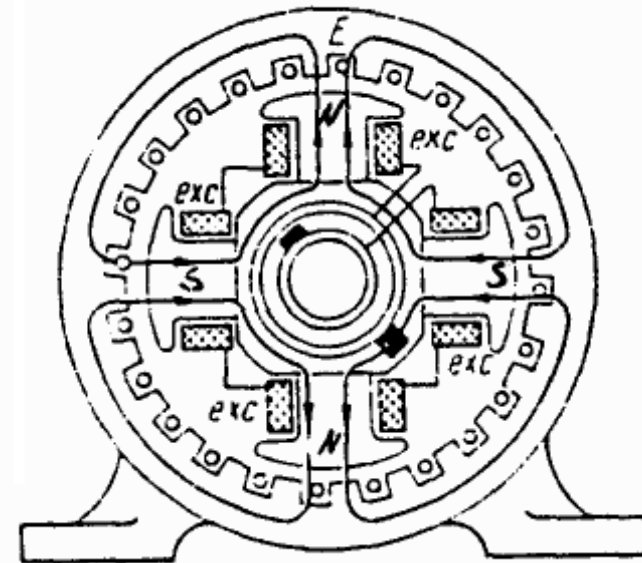


FACULTAD DE INGENIERIA
en acción continua...

GENERADOR SÍNCRONO



Diseño de un generador de
Inducido rotante



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

Diagram illustrating a four-terminal device. A central circular region is connected to four external leads. The top and bottom leads are labeled 'N', and the left and right leads are labeled 'S'. A clockwise current n is indicated in the central region. Terminals 1 and 2 are marked on the left and right leads respectively.



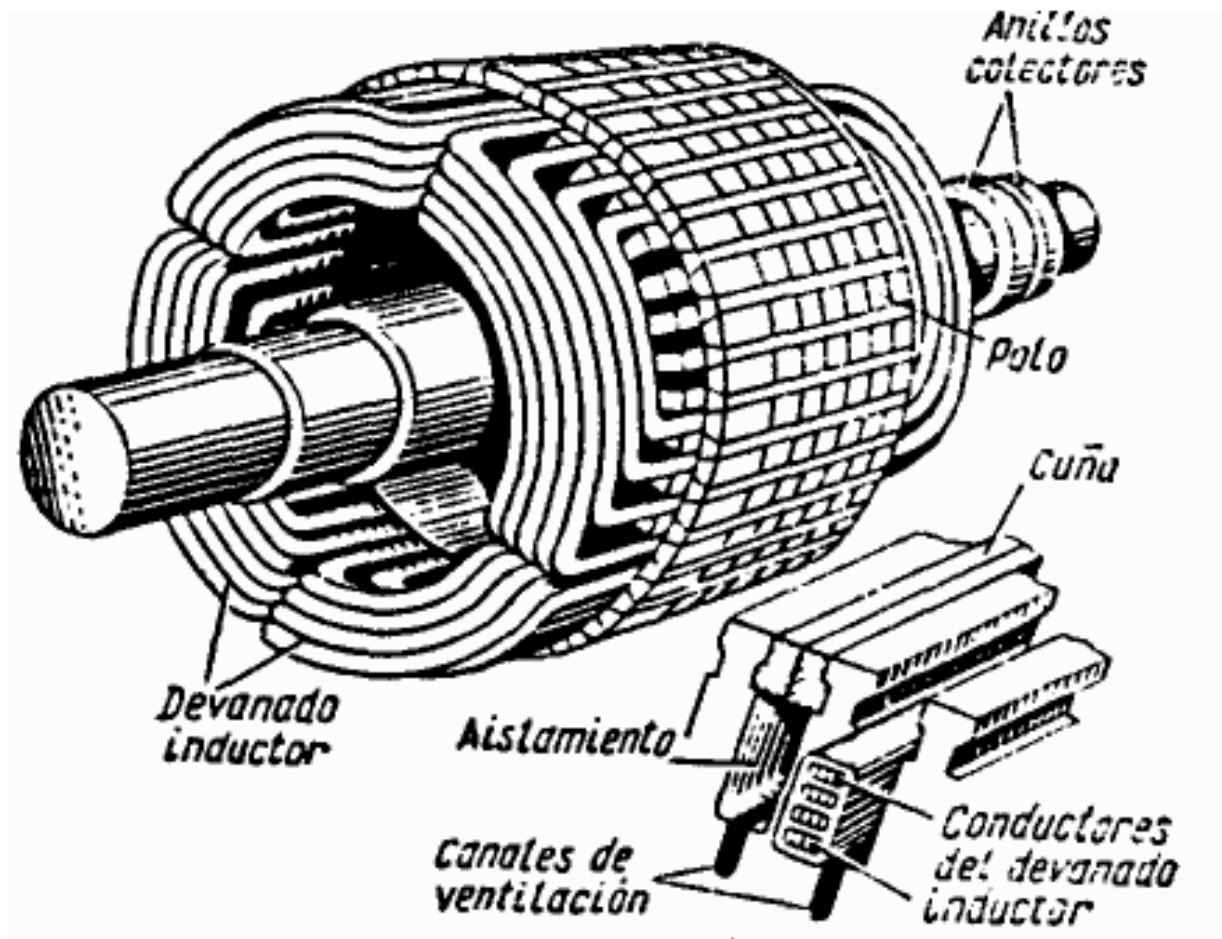


Fig. 5 Aspecto general de un rotor liso montado tetrapolar

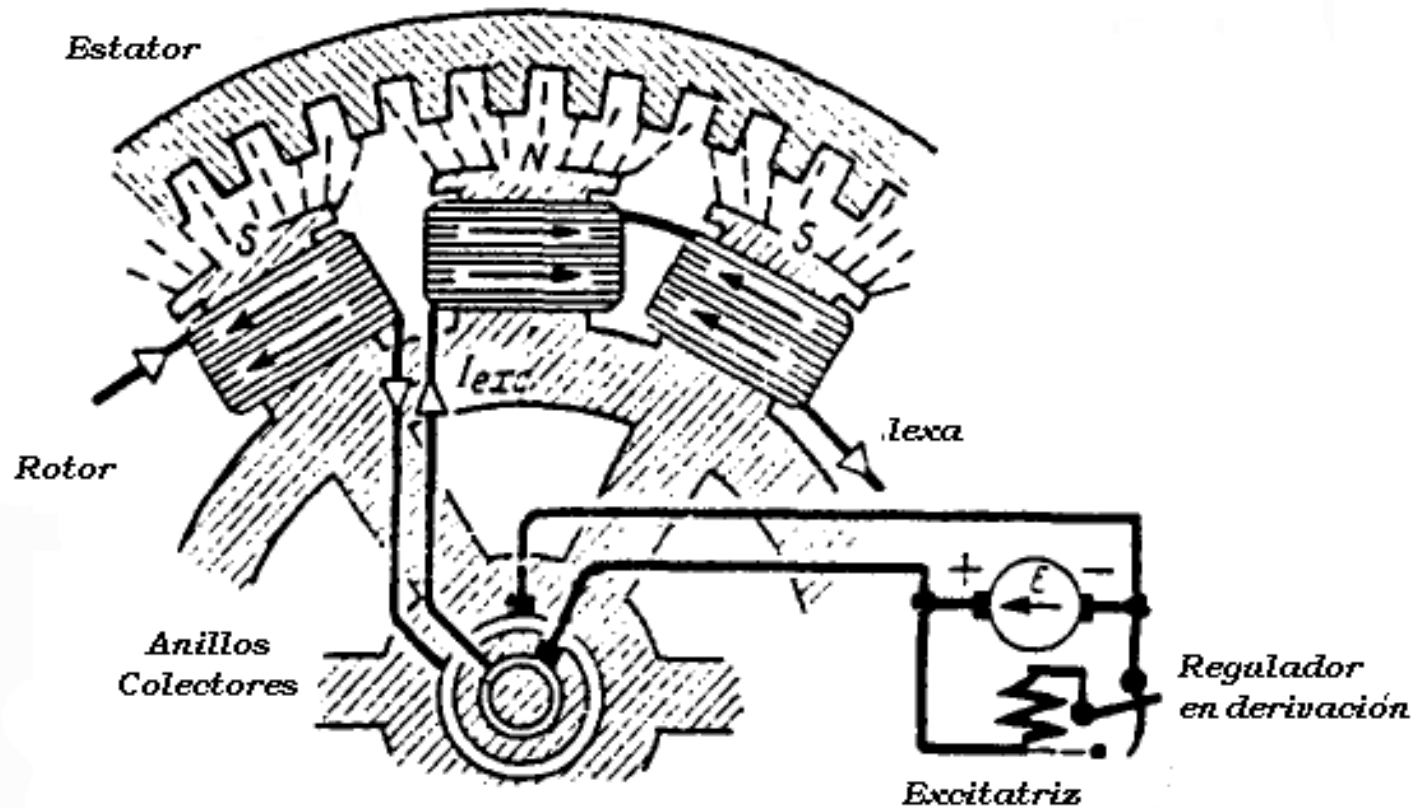


Fig. 6 Esquema de excitación de una máquina síncronica

Expresión de la F.E.M.

$$E = 4,44 \cdot f \cdot \phi \cdot N \cdot K$$

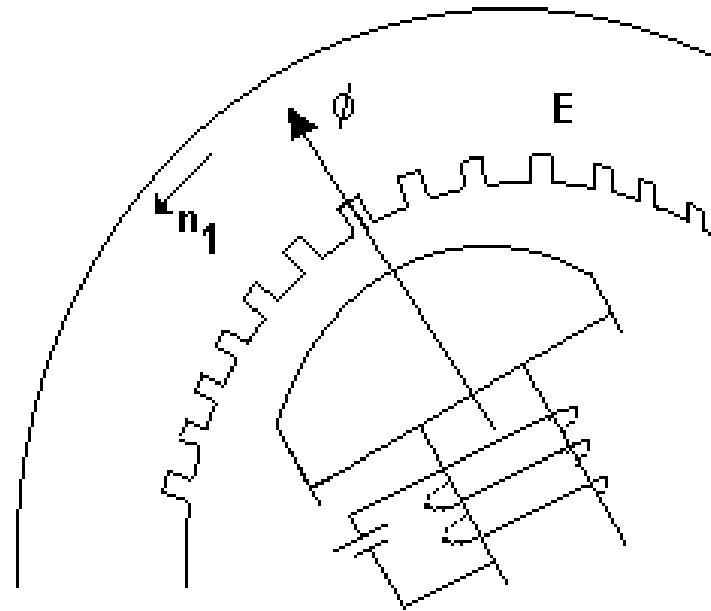
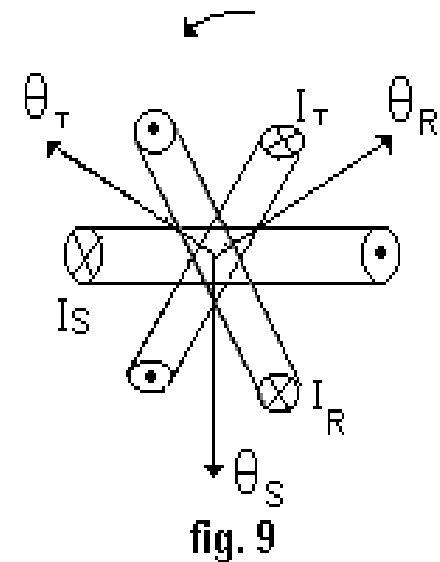
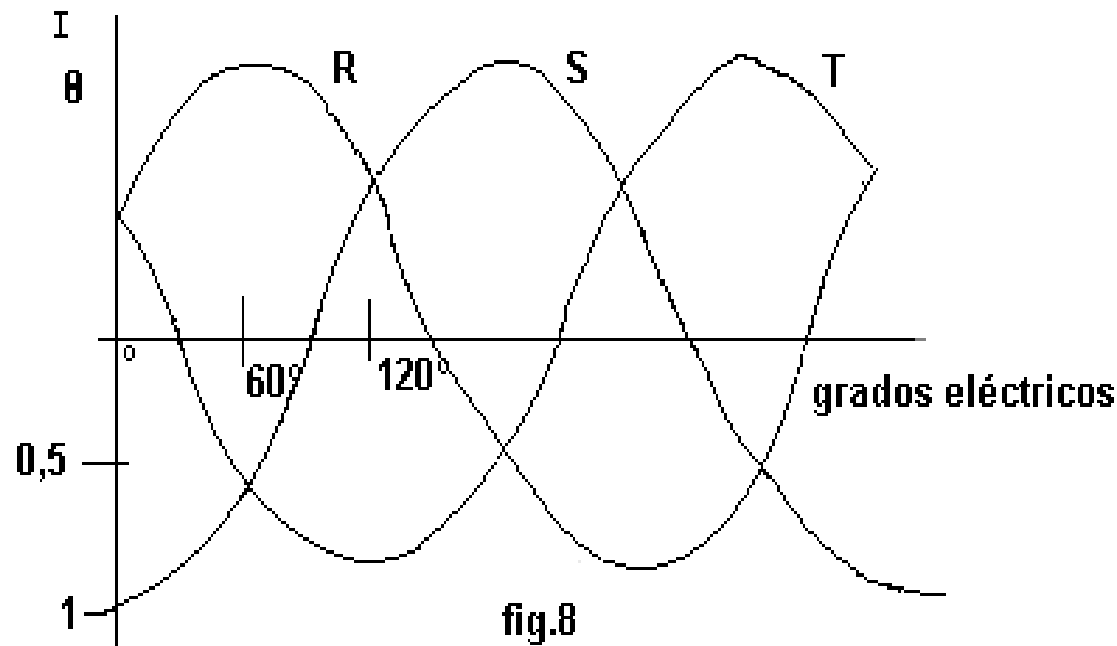
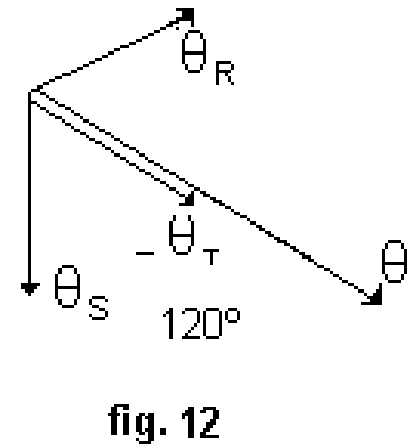
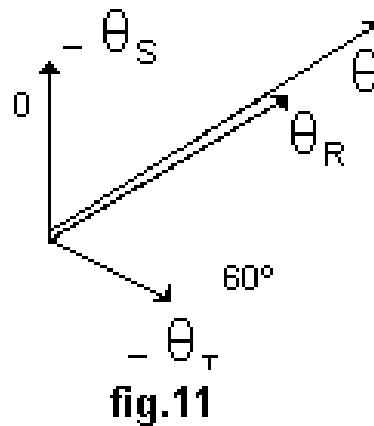
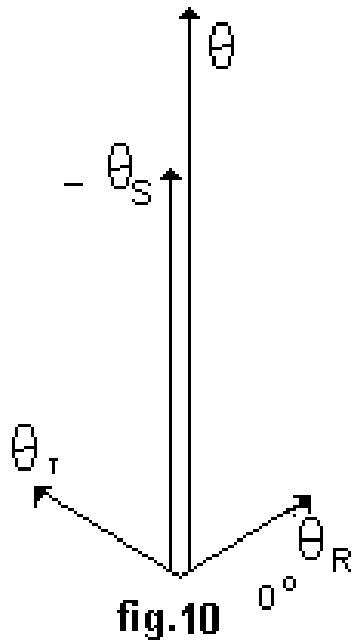


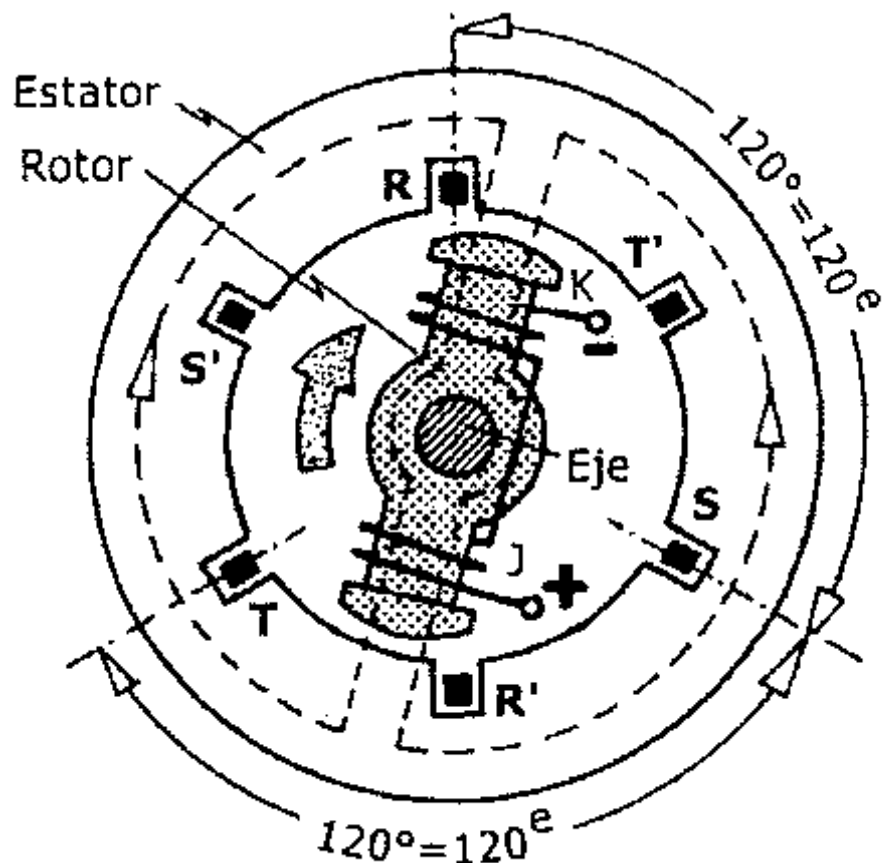
fig. 7

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

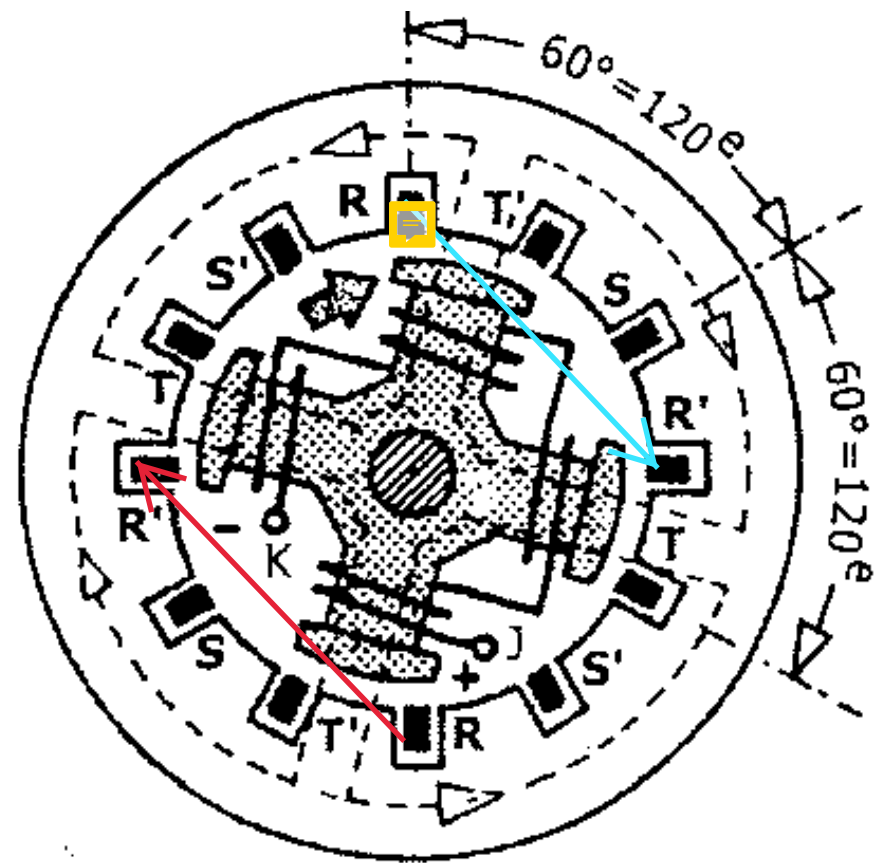


Campo rodante trifásico





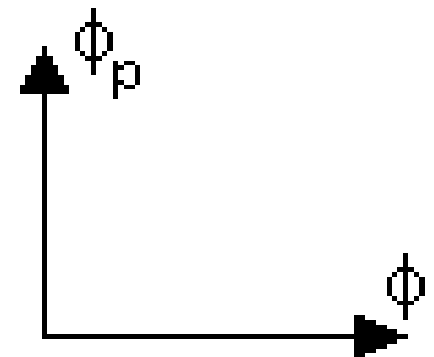
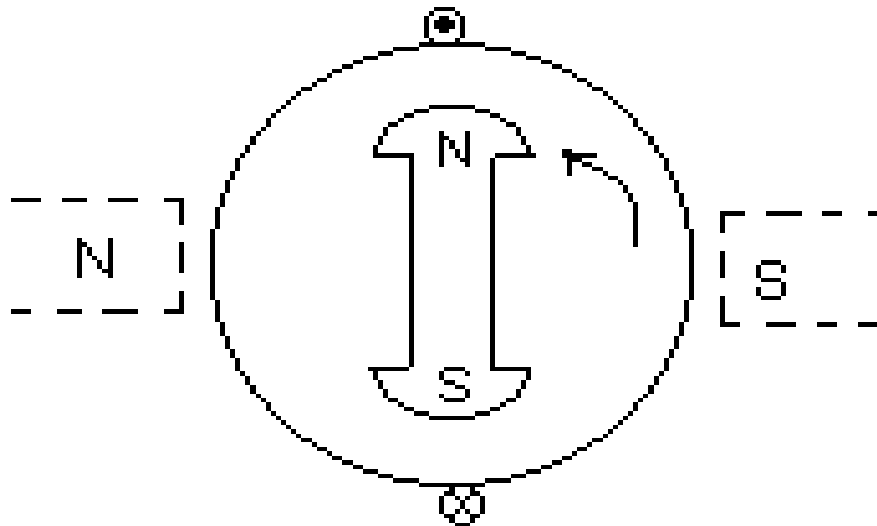
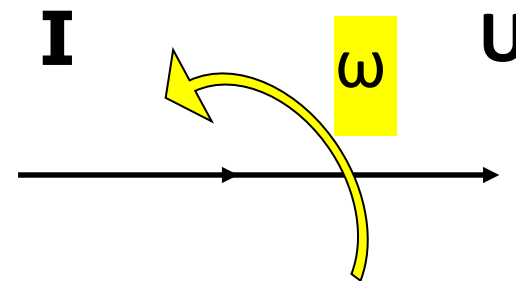
Alternador elemental de dos polos



Alternador elemental de cuatro polos

Reacción de Inducido

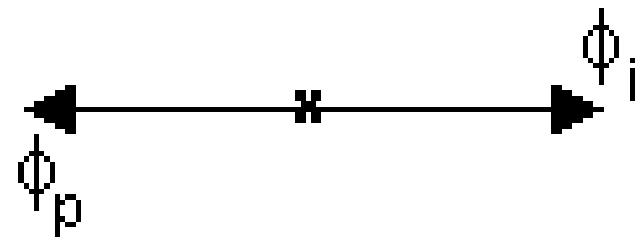
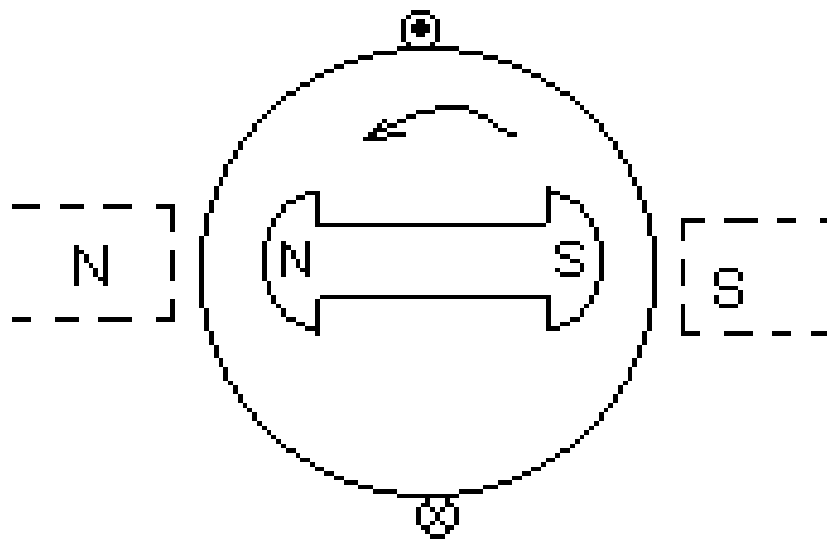
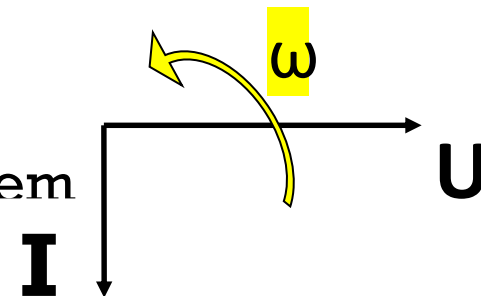
- CARGA RESISTIVA PURA



Reacción de Inducido

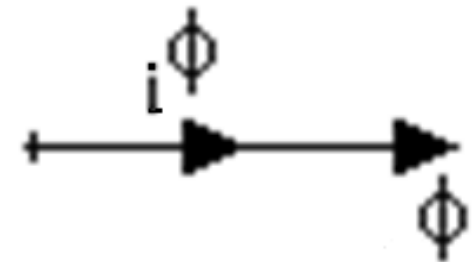
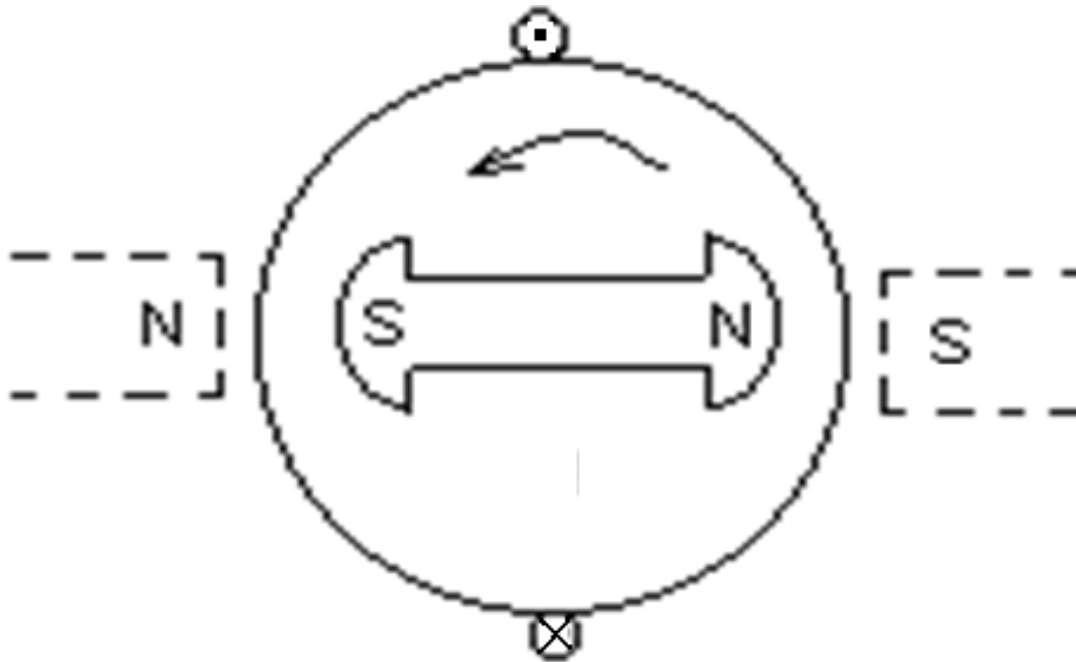
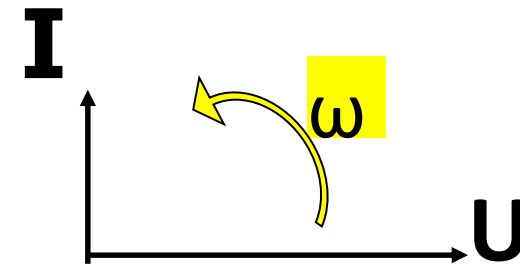
- CARGA INDUCTIVA PURA

Efecto Desmagnetizante – Menor fem



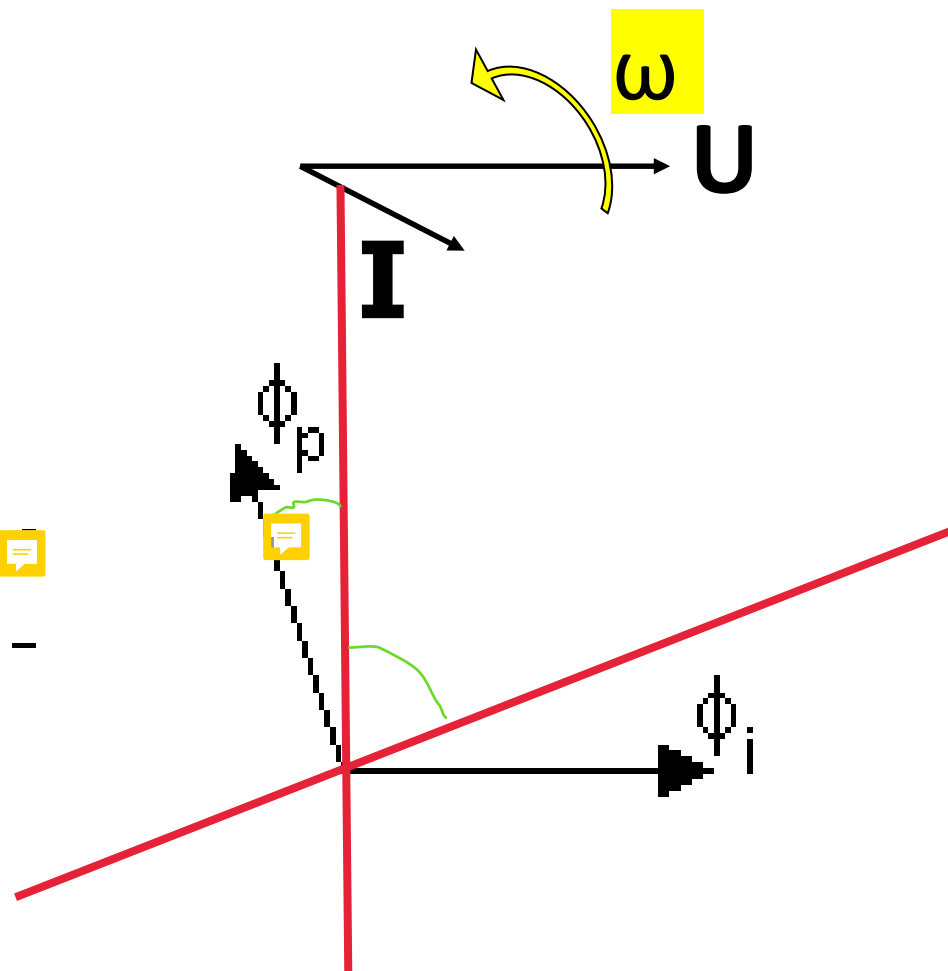
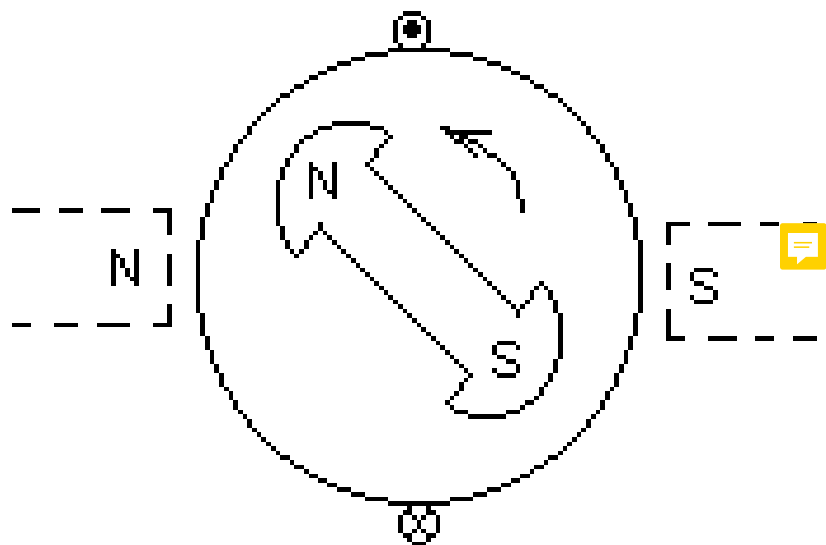
Reacción de Inducido

- CARGA CAPACITIVA PURA
- Efecto Magnetizante – Mayor fem

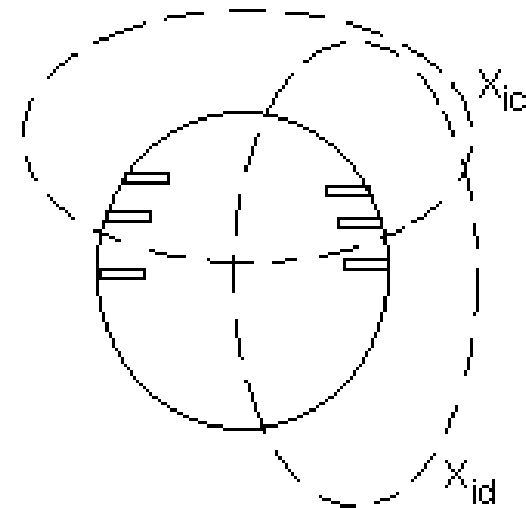
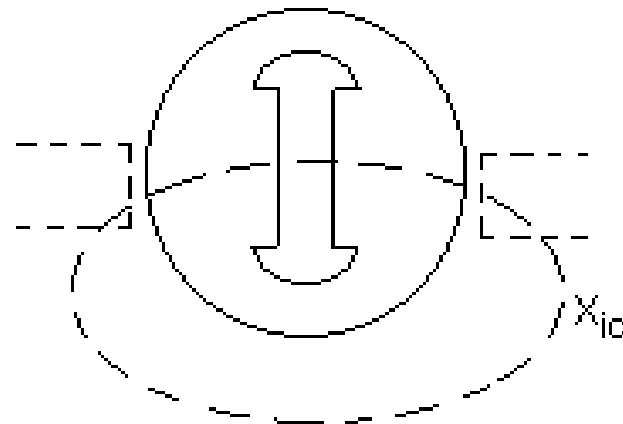
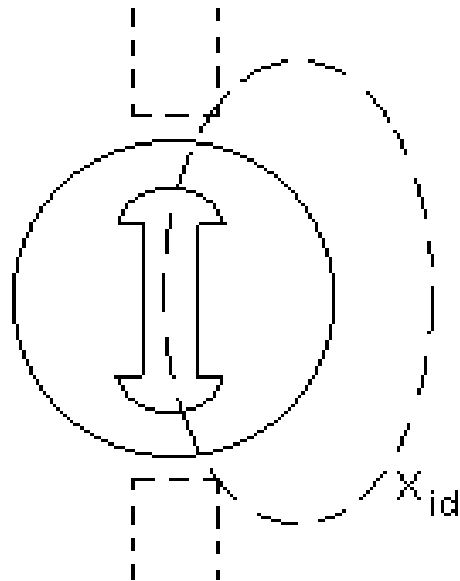


Reacción de Inducido

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



Reacción de Inducido

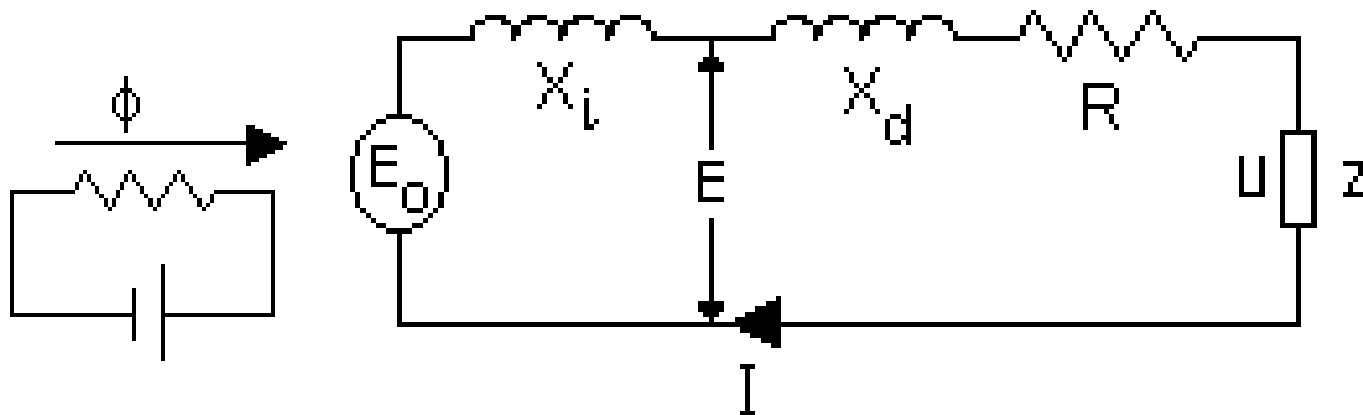


REACTANCIAS POR REACCIÓN DE INDUCIDO

Circuito Equivalente

- Rotor cilíndrico

$$\vec{E}_0 = \vec{U} + R \cdot \vec{I} + jX_i \cdot \vec{I} + jX_d \cdot \vec{I}$$



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

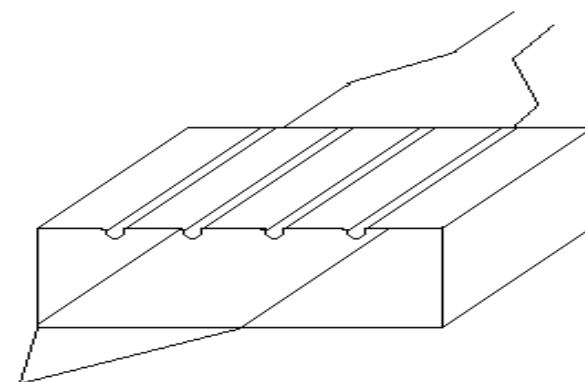
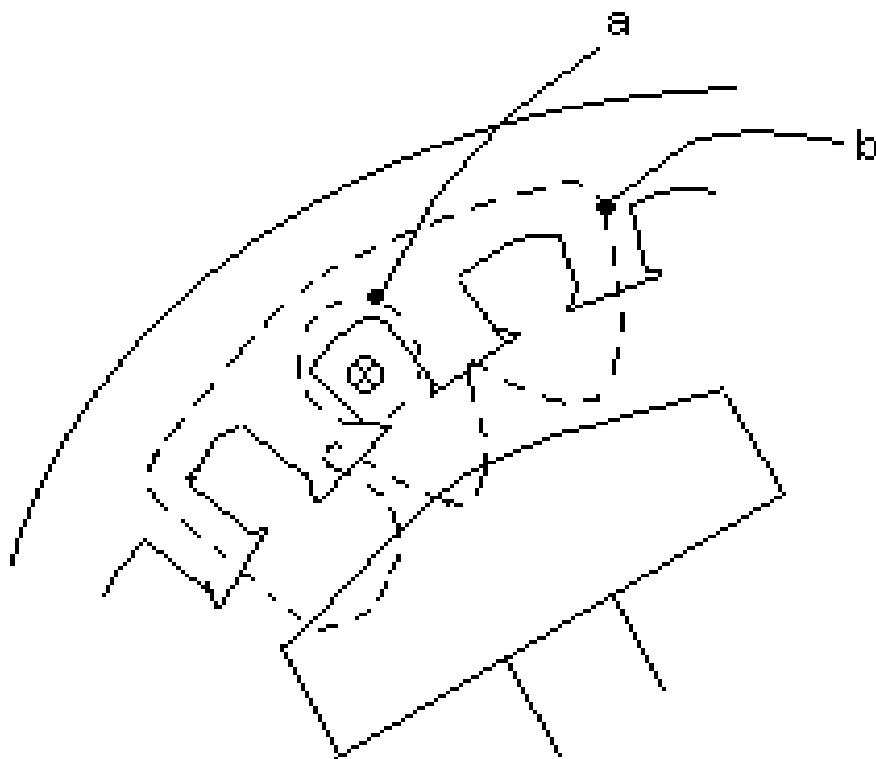
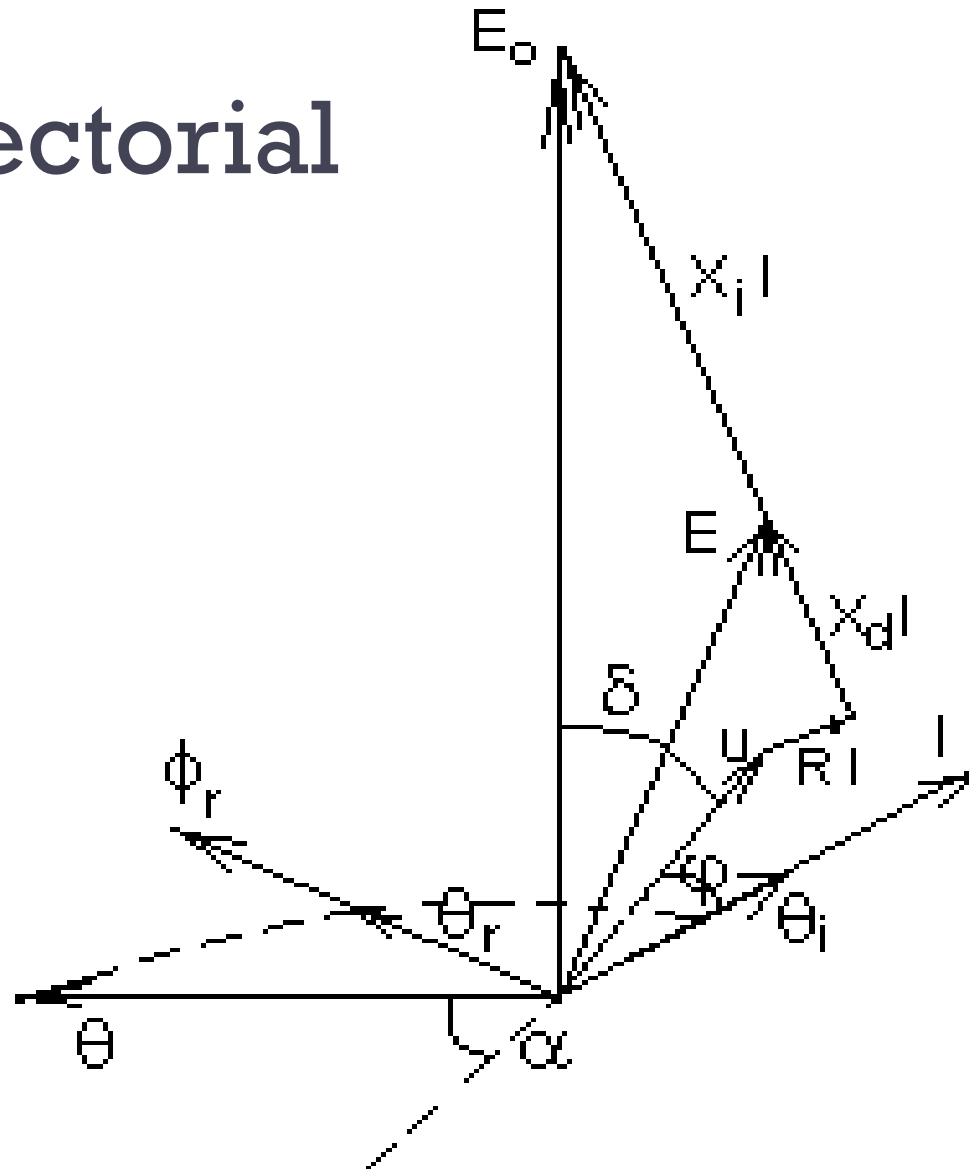


Diagrama Vectorial

- De rotor liso



Diagramas Vectoriales

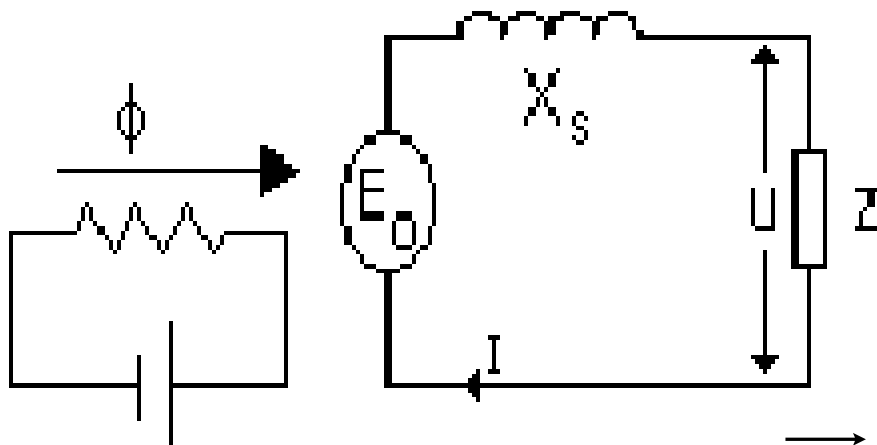
- Componentes del diagrama vectorial

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

Diagrama Vectorial Simplificado

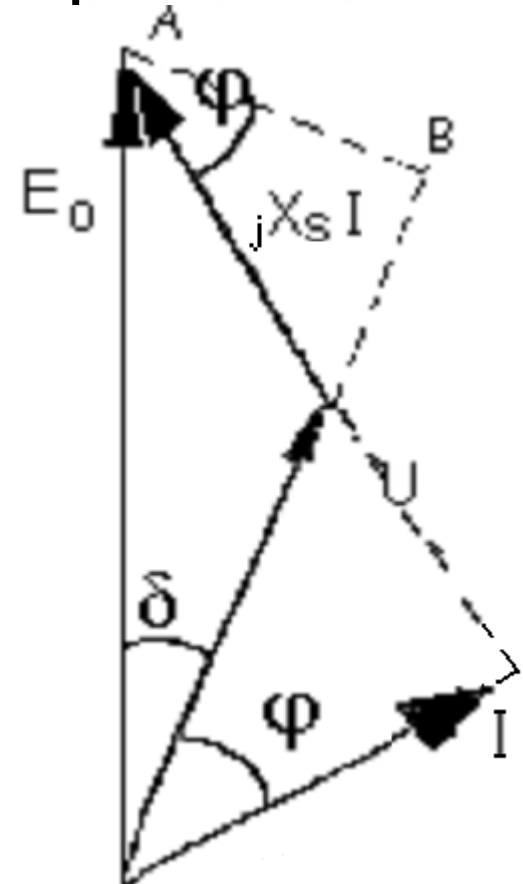
- Surge del Circuito Equivalente Simplificado

$$X_s = X_i + X_d$$



Circuito Simplificado

$$\vec{E}_0 = \vec{U} + jX_s \cdot \vec{I}$$



- **Ángulo de carga**



Diagrama Vectorial Simplificado

Análisis:

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

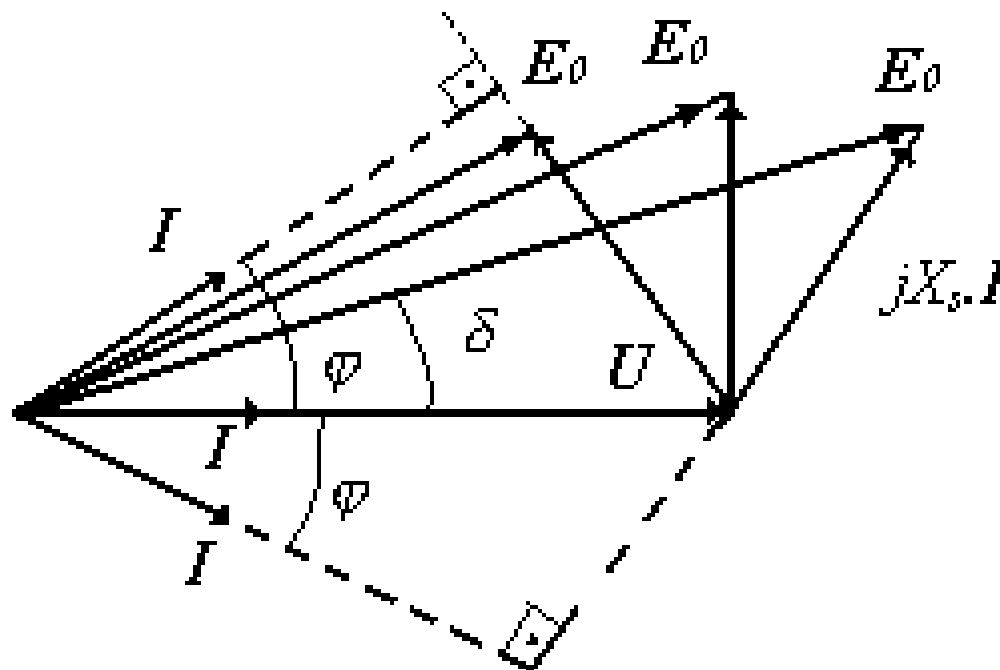


Diagrama Vectorial Simplificado

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

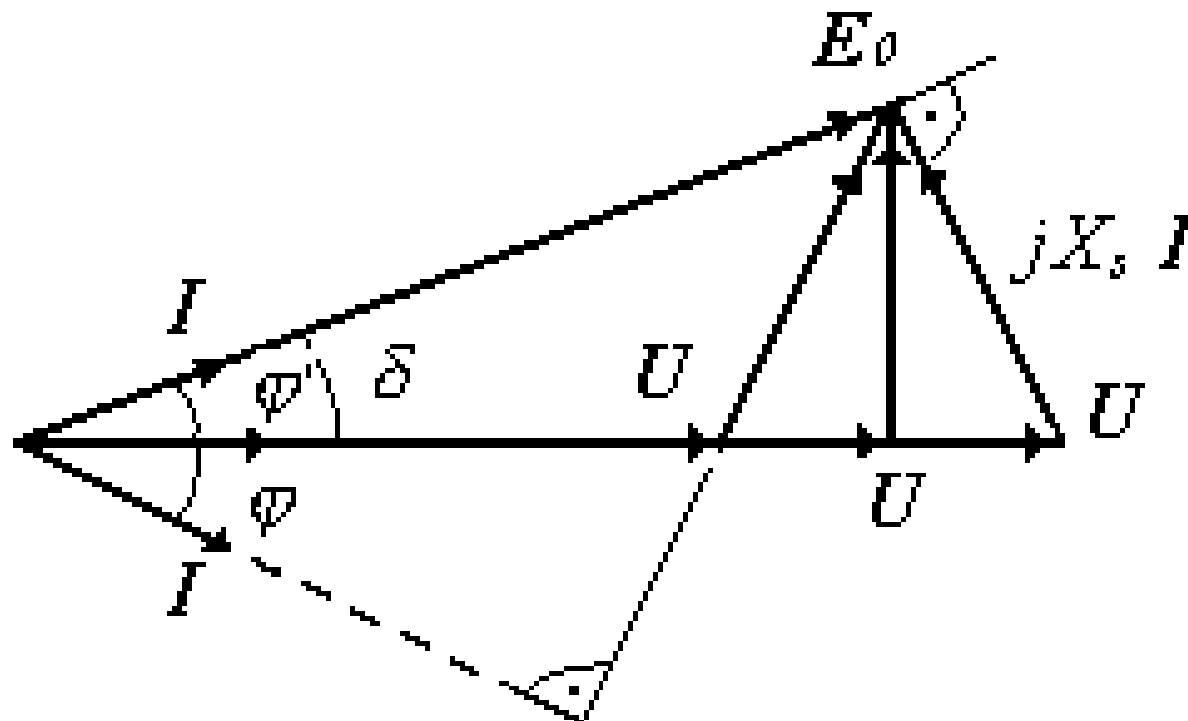
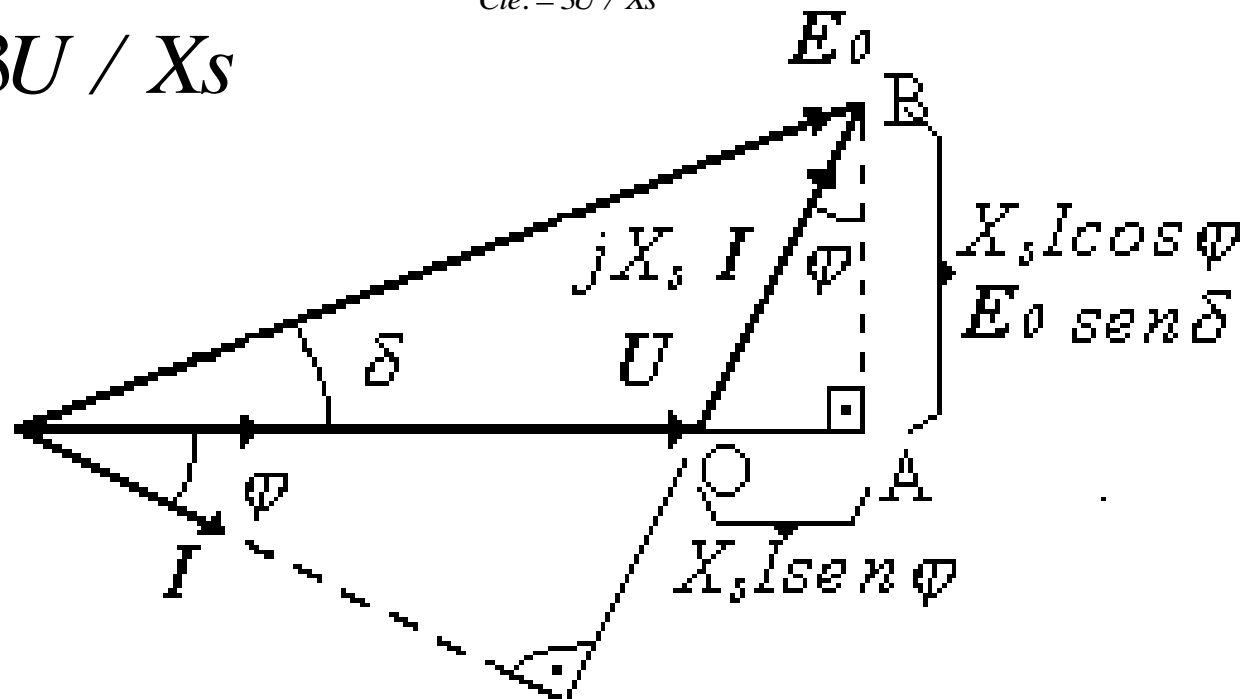


Diagrama Vectorial Simplificado

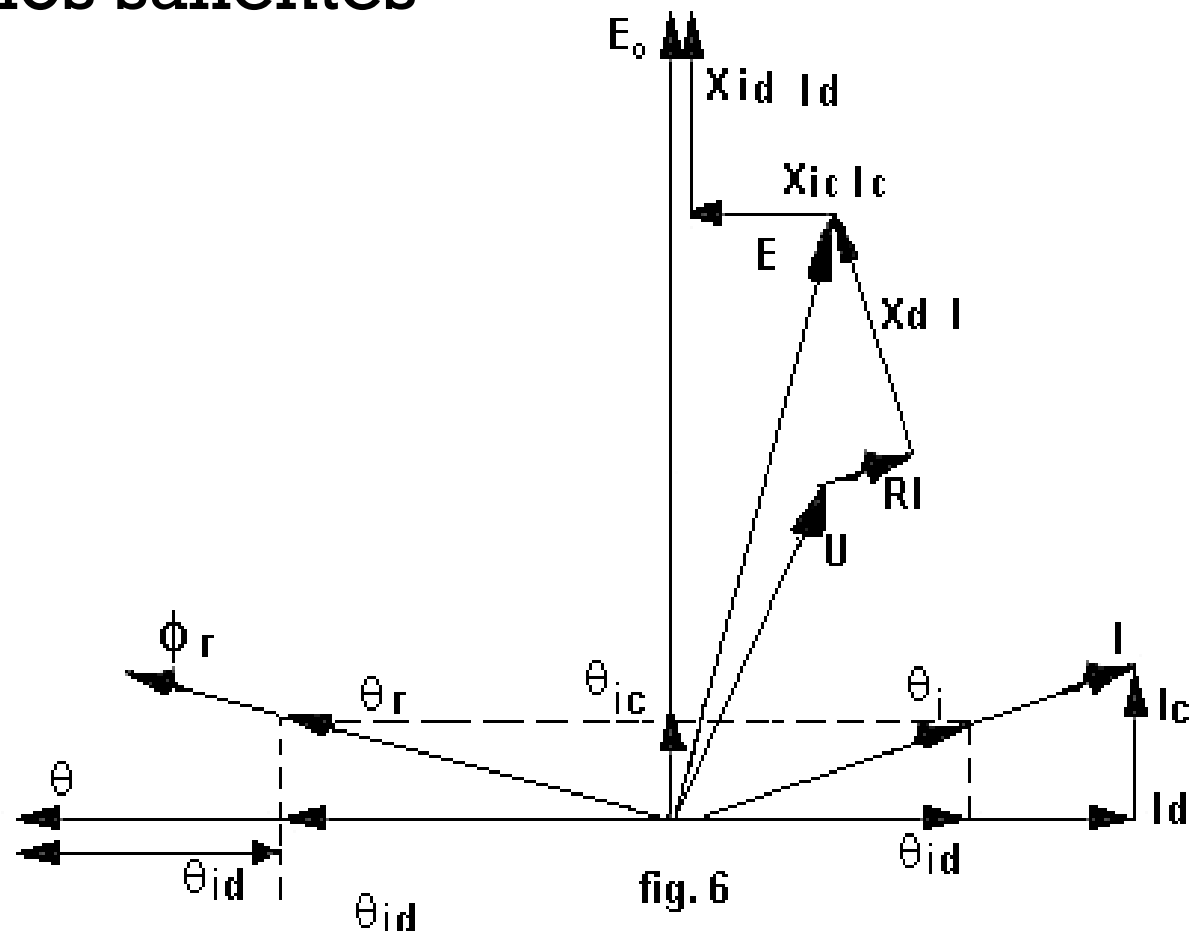
- 3) Diagrama de tensiones x cte . de escala = Diagrama de potencias.

$$Cte. = 3U / X_s$$

$$Cte. = 3U / X_s$$



- De polos salientes

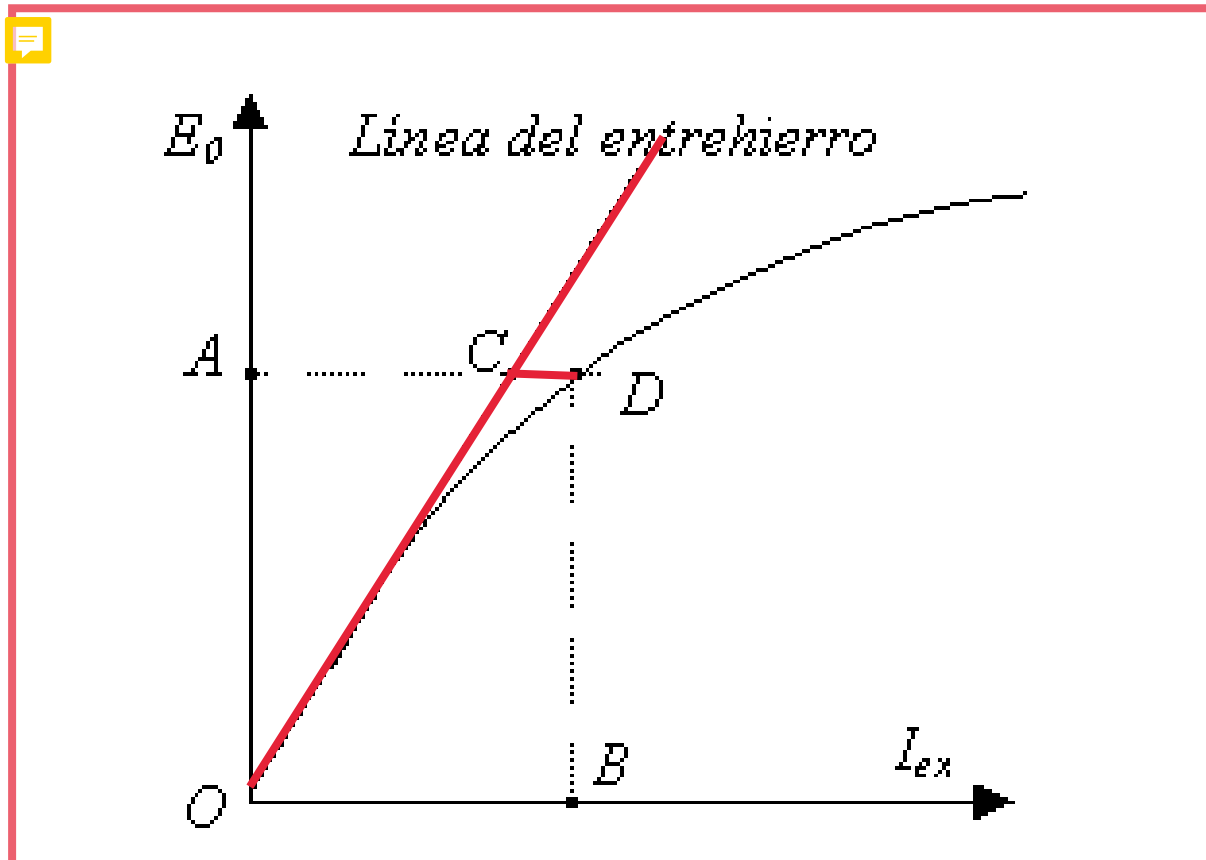


CURVAS CARACTERÍSTICAS

1º) Característica en vacío:

$$n_s = \text{cte.}$$

$$E_0 = f(I_{ex})$$



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

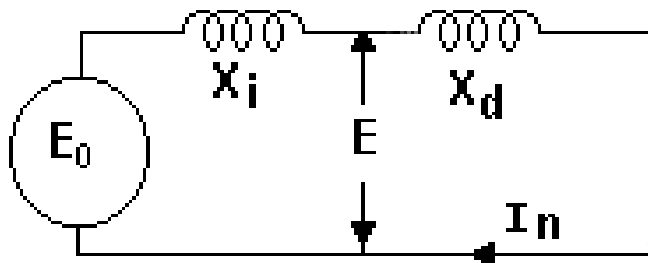


fig. 2

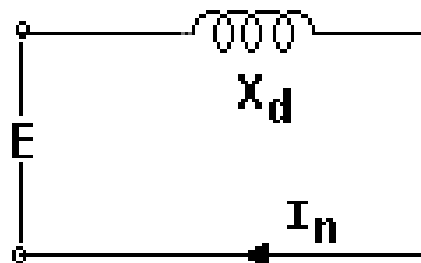


fig. 3

Circuito Equivalente

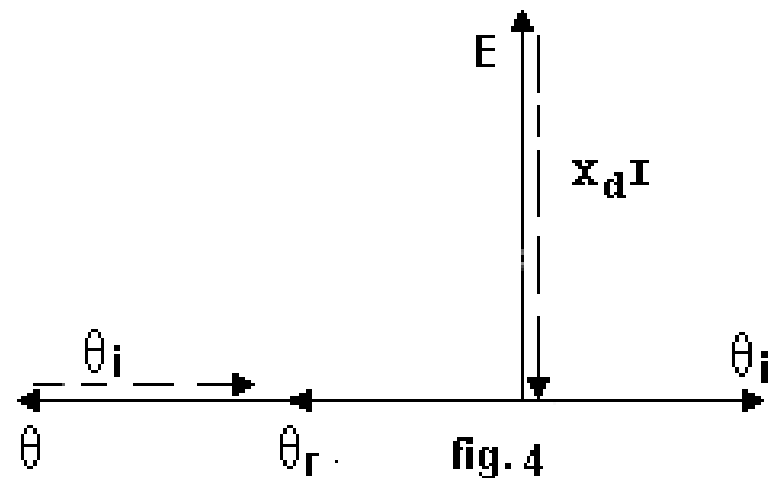
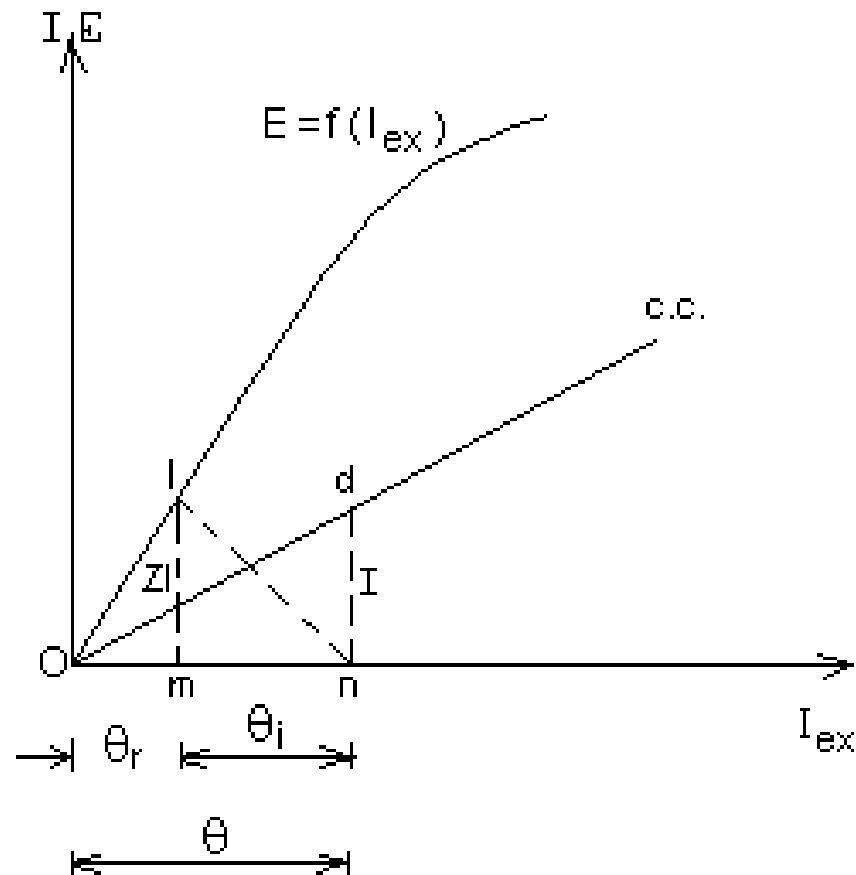


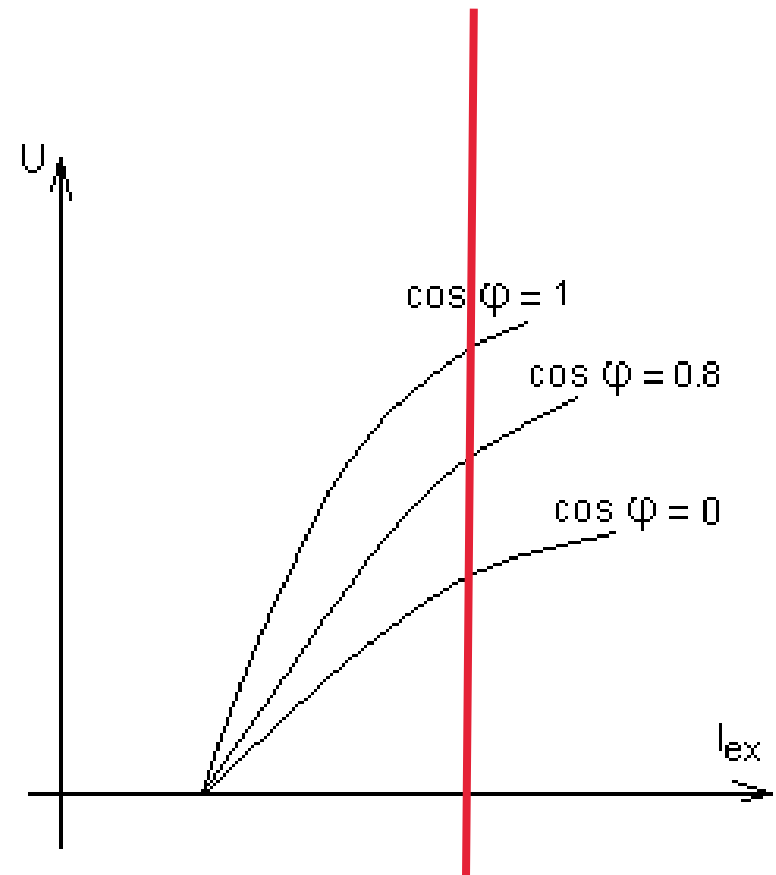
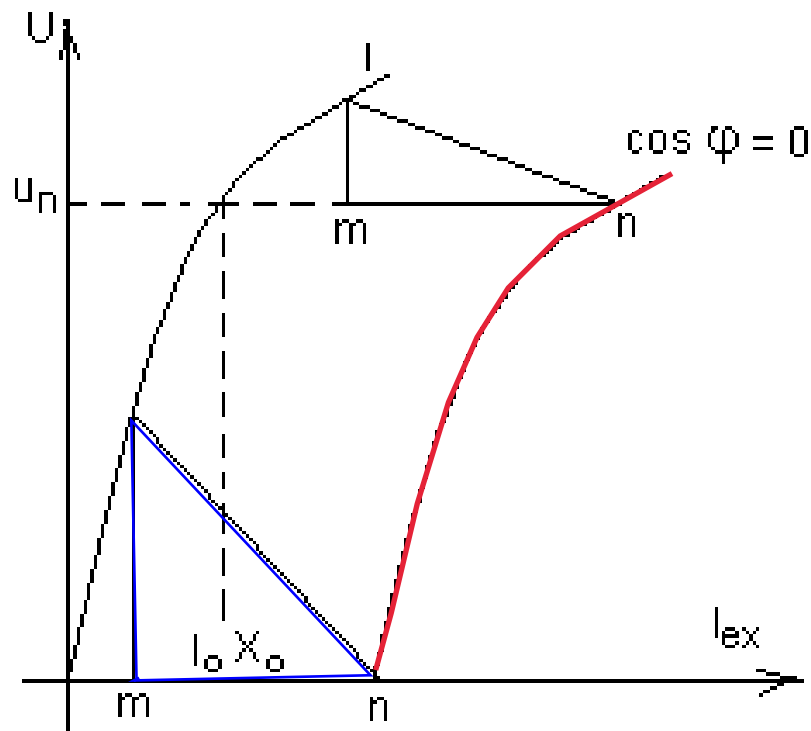
fig. 4

Diagrama Vectorial

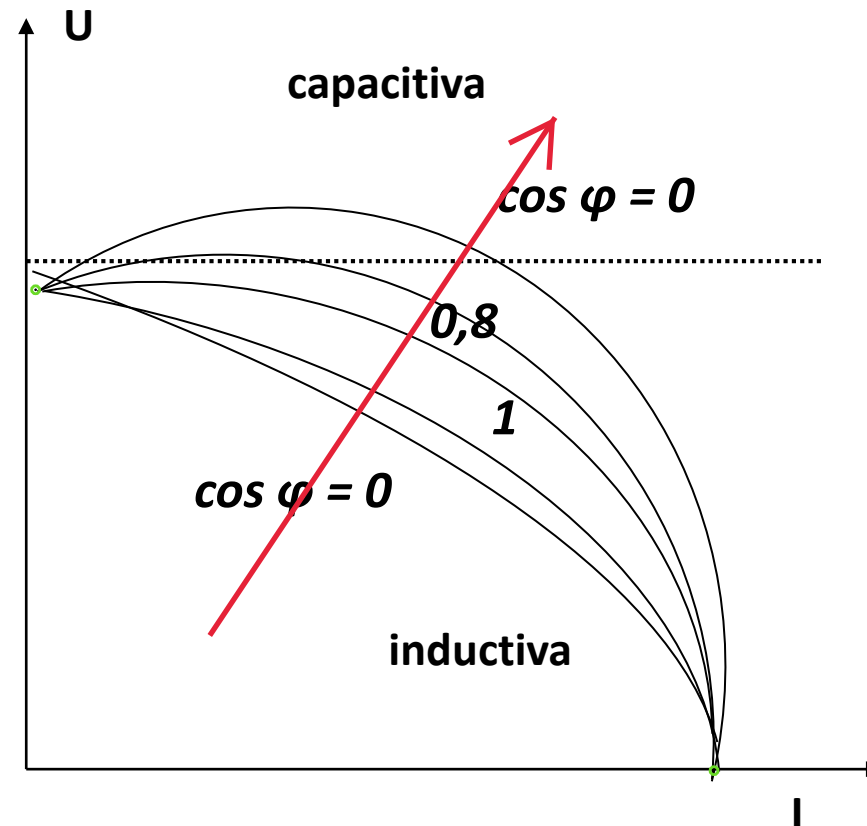
2º) C. de cortocircuito (c.c.): $I = f(I_{ex})$



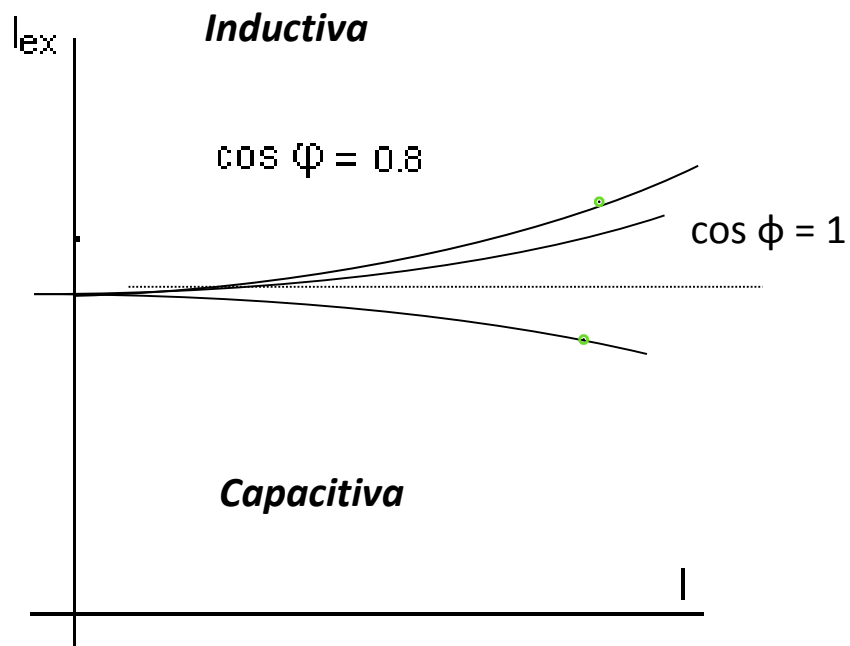
3º) Característica en carga: $U = f(I_{ex})$



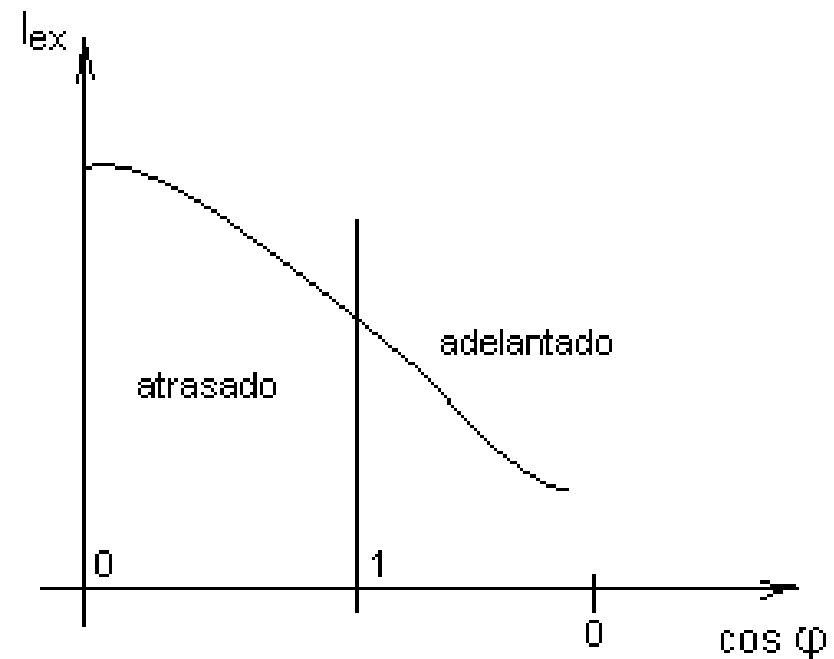
4º) C. Externa $U = f(I)$ ($I_{exc} = cte$; $\cos \varphi = cte$)



5º) Curva de regulación:

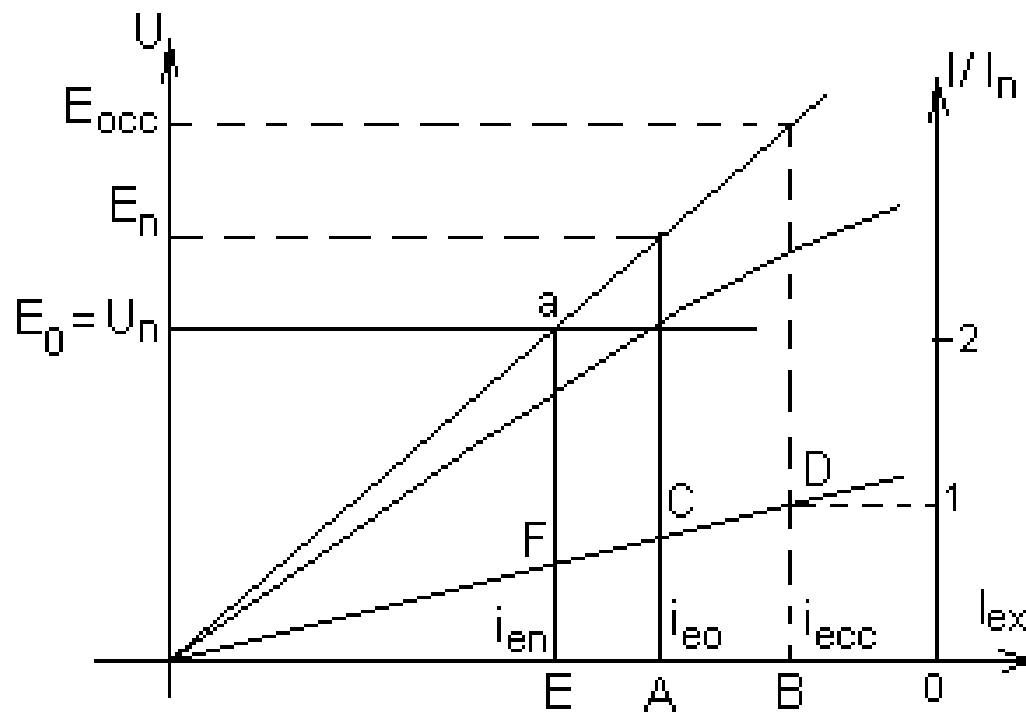


$$I_{ex} = f(I) \quad (U = cte. ; \cos \phi = cte.)$$

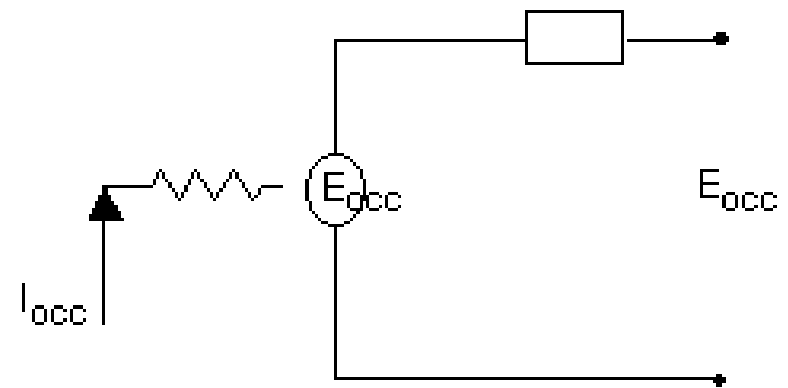
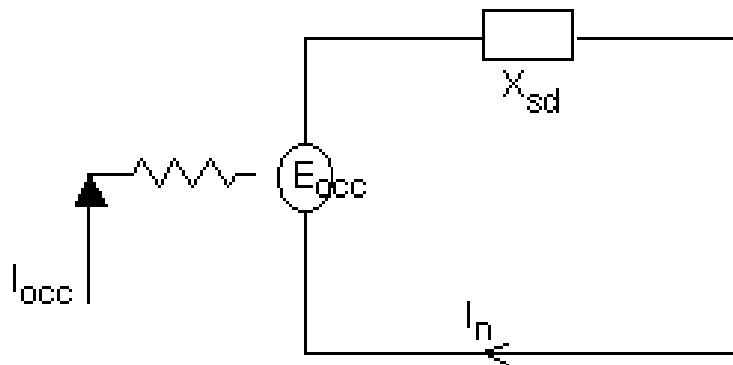
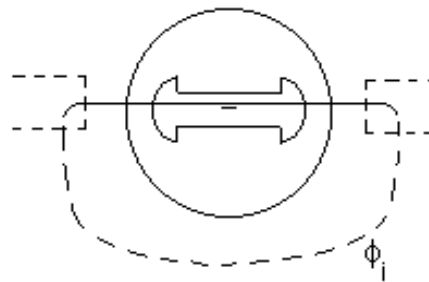


$$I_{ex} = f(\cos \phi) \quad (I = cte. ; U = cte.)$$

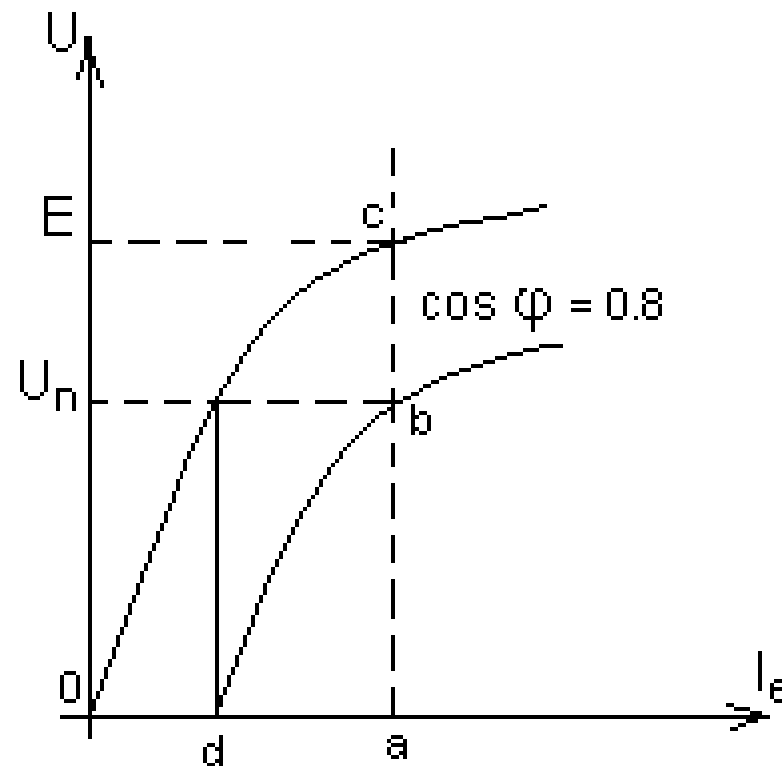
6º) Relación de cortocircuito



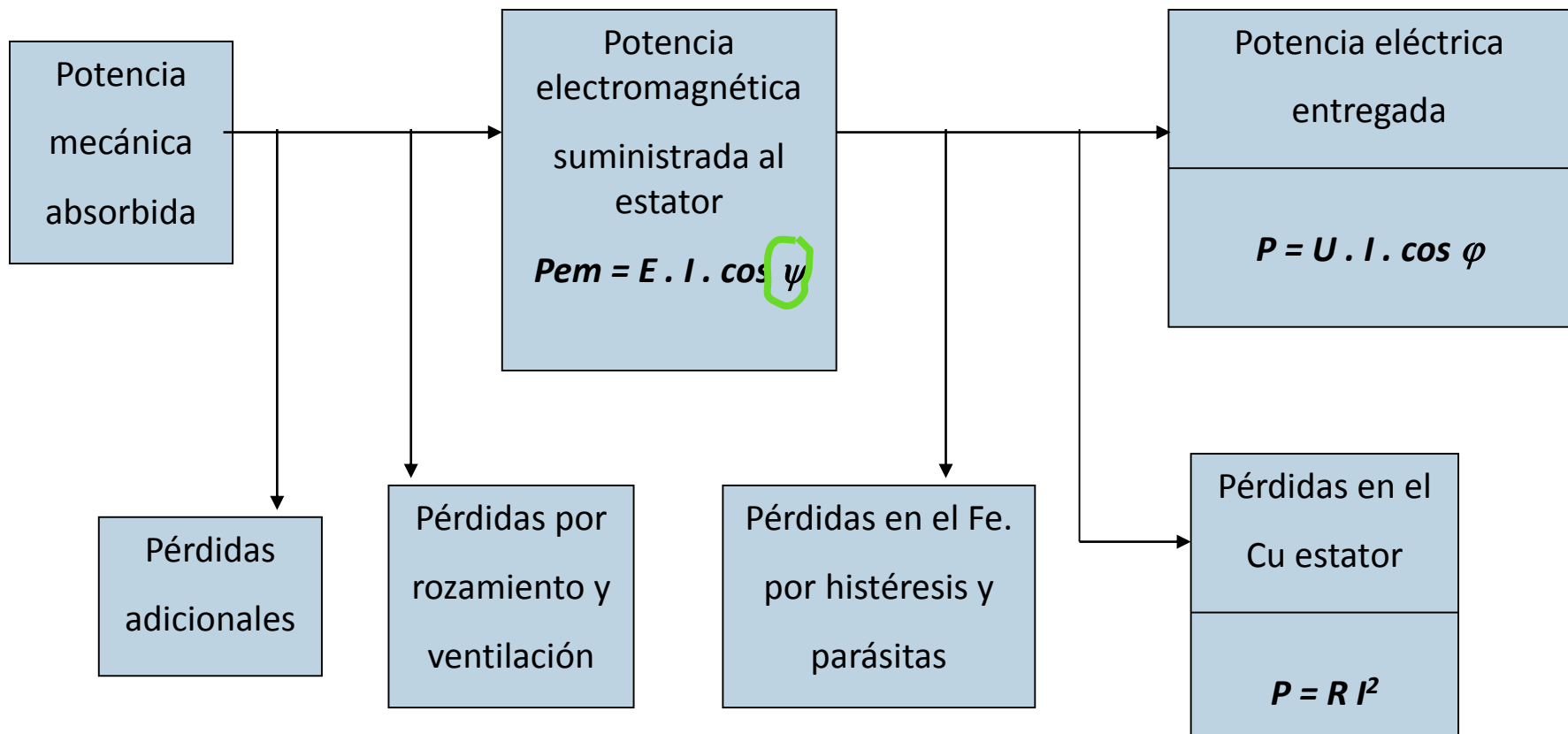
6º) Relación de cortocircuito



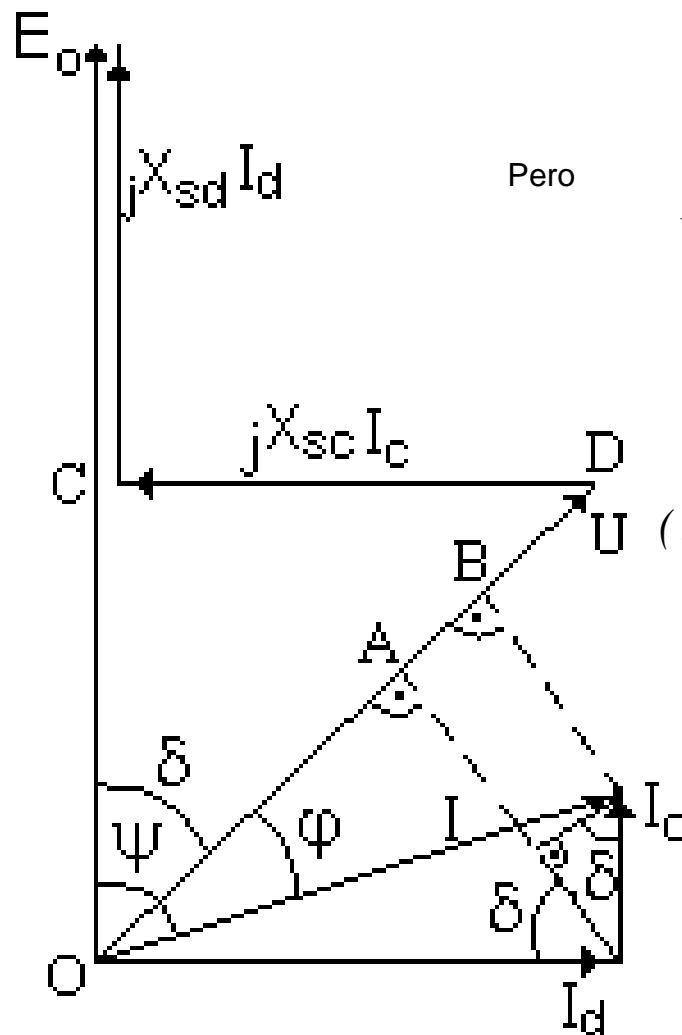
7º) Variación de tensión



Balance Energético



Potencia Electromagnética



Pero

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

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

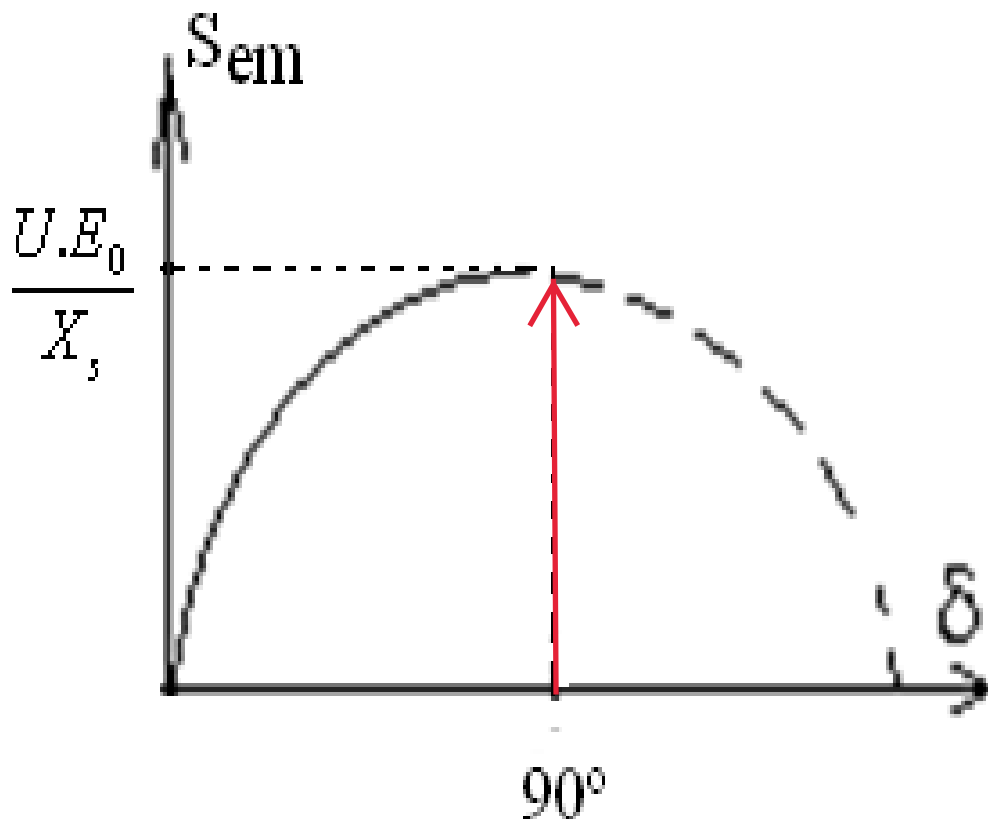
$$(3) \quad \overline{CD} = U \sin \delta = X_{sc} \cdot I_c \Rightarrow I_c = \frac{U}{X_{sc}} \cdot \sin \delta \quad (4)$$

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

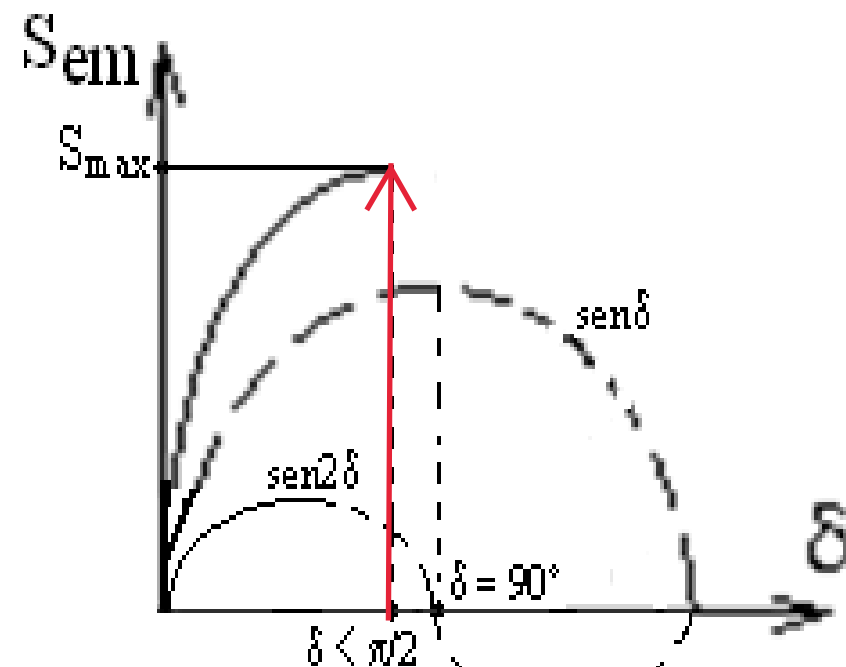
Sustituyendo (4) y (6) en (2) y luego en (1)

$$P_{em} = \frac{U \cdot E_0}{X_{sd}} \cdot \sin \delta + \frac{1}{2} U^2 \cdot \frac{X_{sd} - X_{sc}}{X_{sd} \cdot X_{sc}} \cdot \sin 2\delta$$

Característica angular

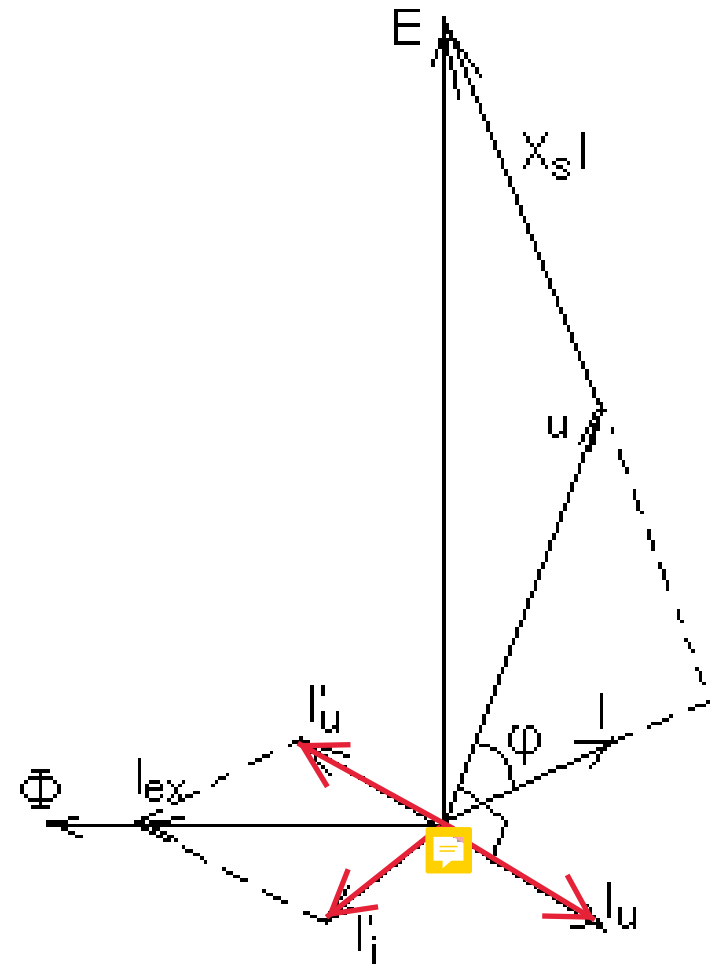
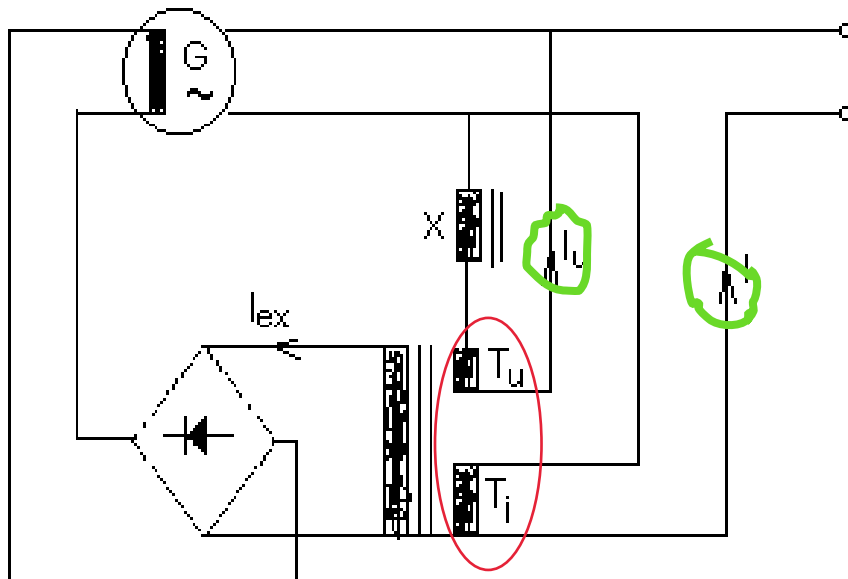


Característica angular
Rotor cilíndrico $\delta = 90^\circ \rightarrow S_{em} = S_{max}$



Característica angular
Rotor polos salientes $\delta < 90$

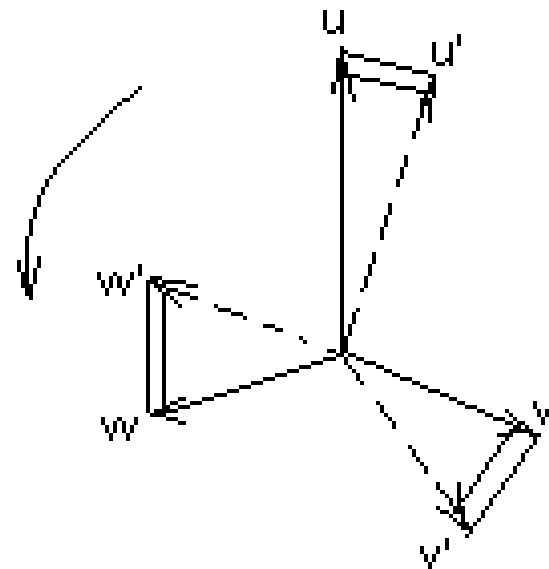
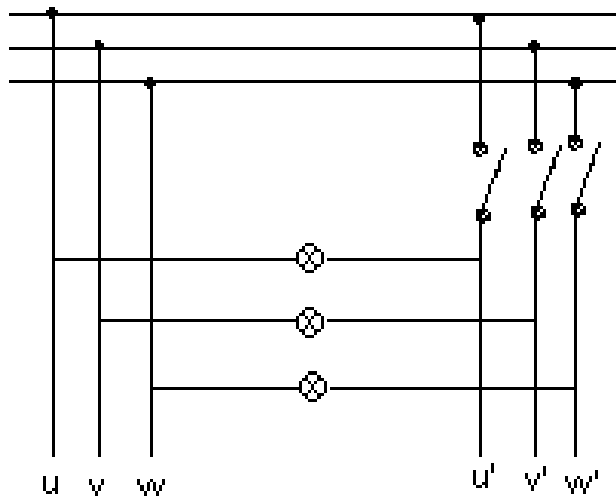
Generadores autoexcitados



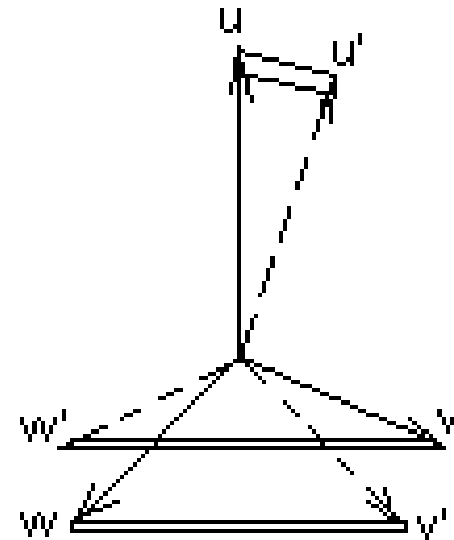
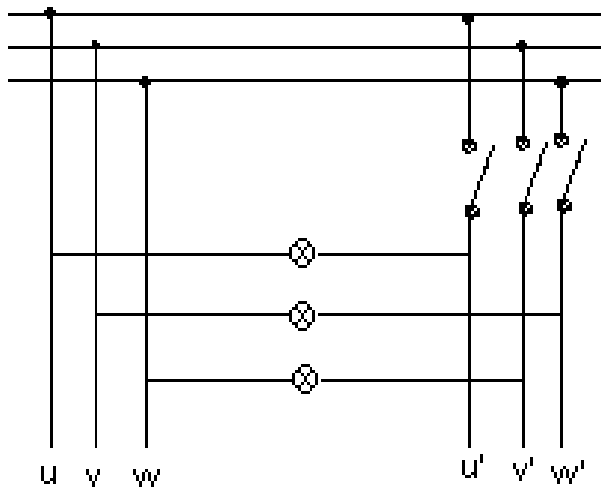
PARALELO DE GENERADORES SÍCRONOS

1) Acoplamiento:

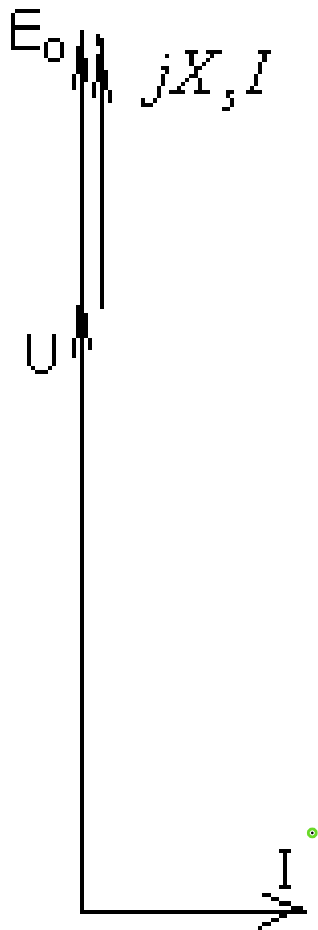
- El método de las "lámparas de fase apagadas"



- El método de las "luces rotantes"

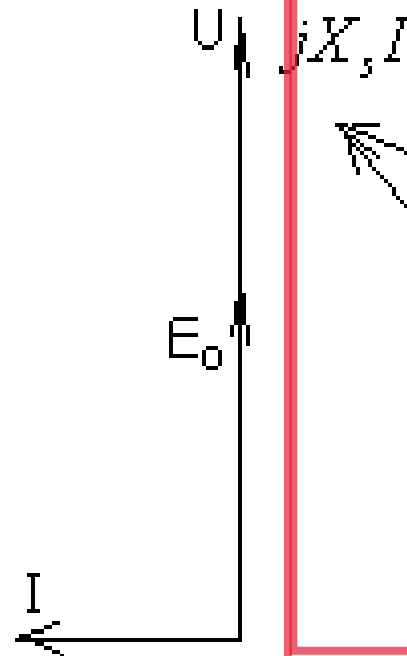


Como tomar carga



Sobreexcitado

3° Caso



Subexcitado

4° Caso

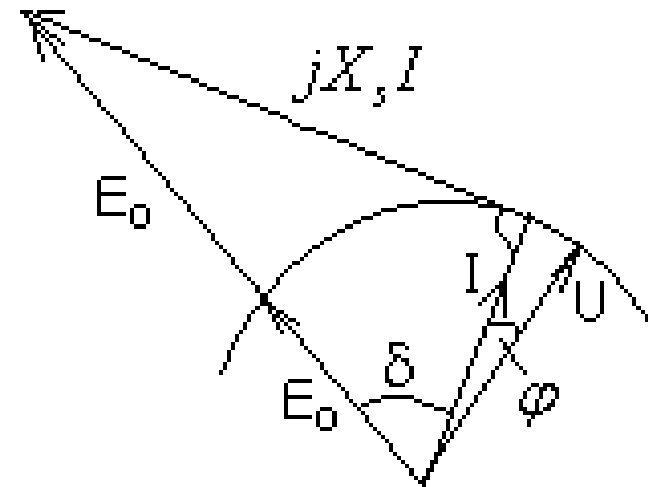
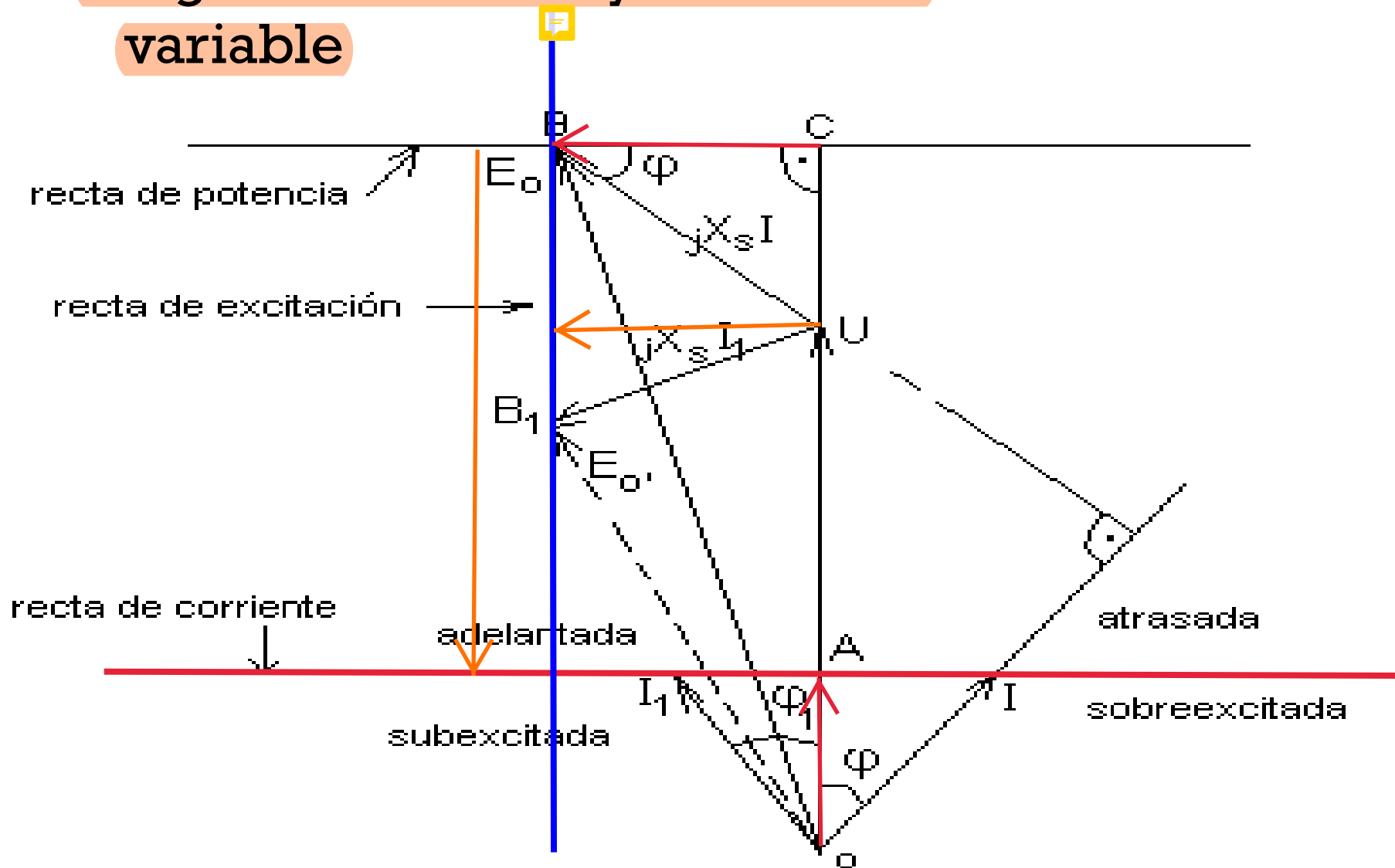
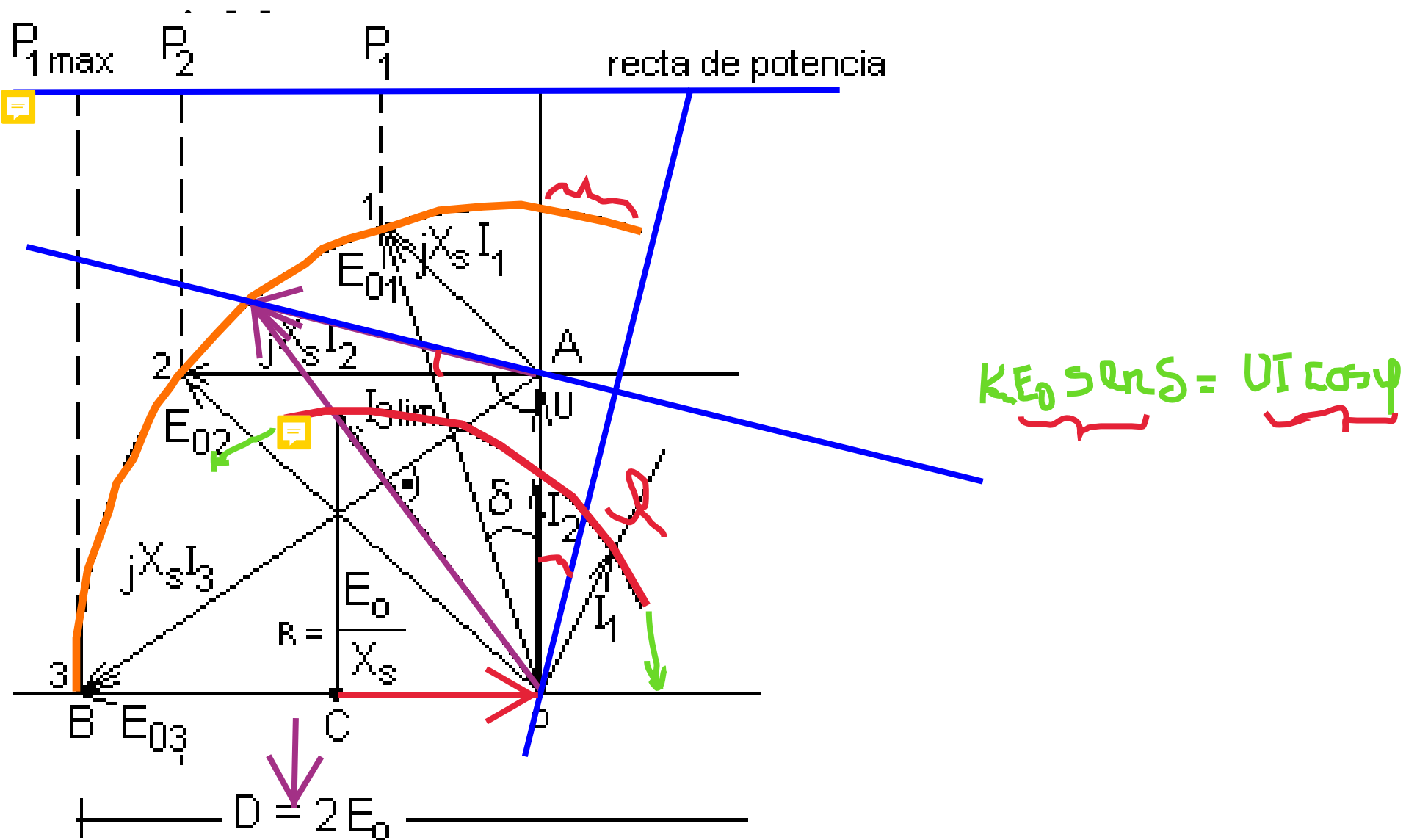


Diagrama a Pot. cte y Excitación variable

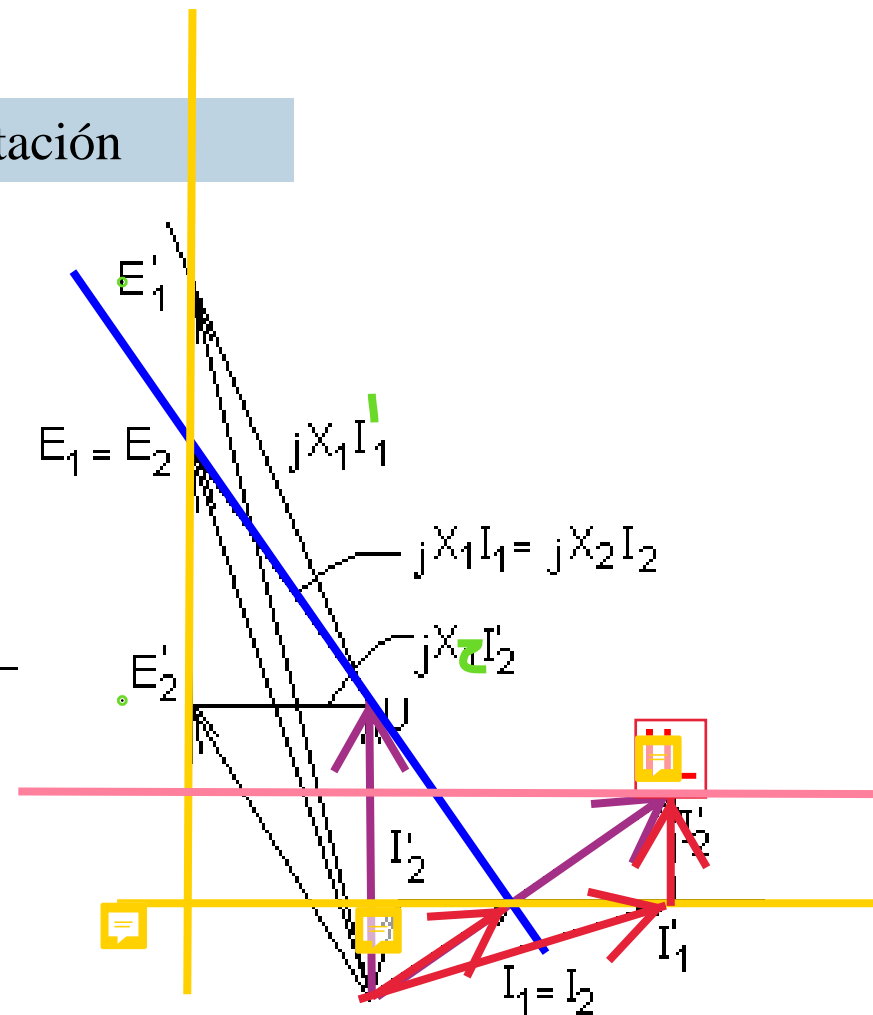
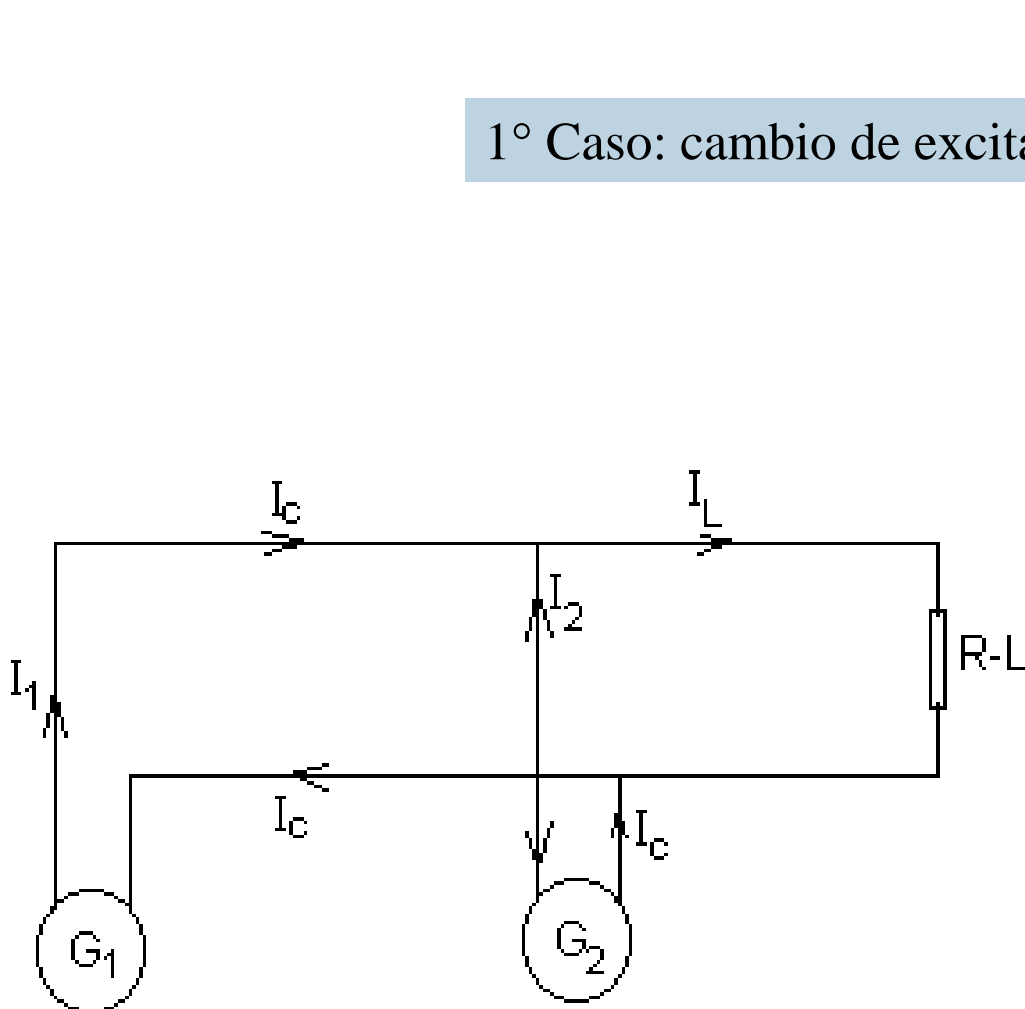


2.3 Diagrama a Excitación cte y Potencia

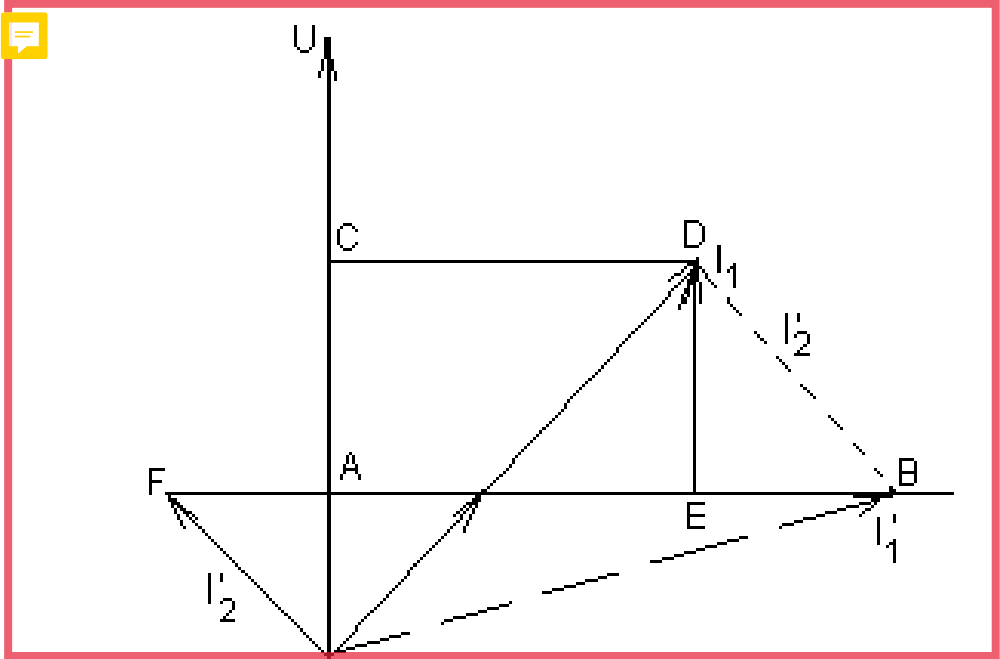


3. Análisis de dos máquinas en paralelo

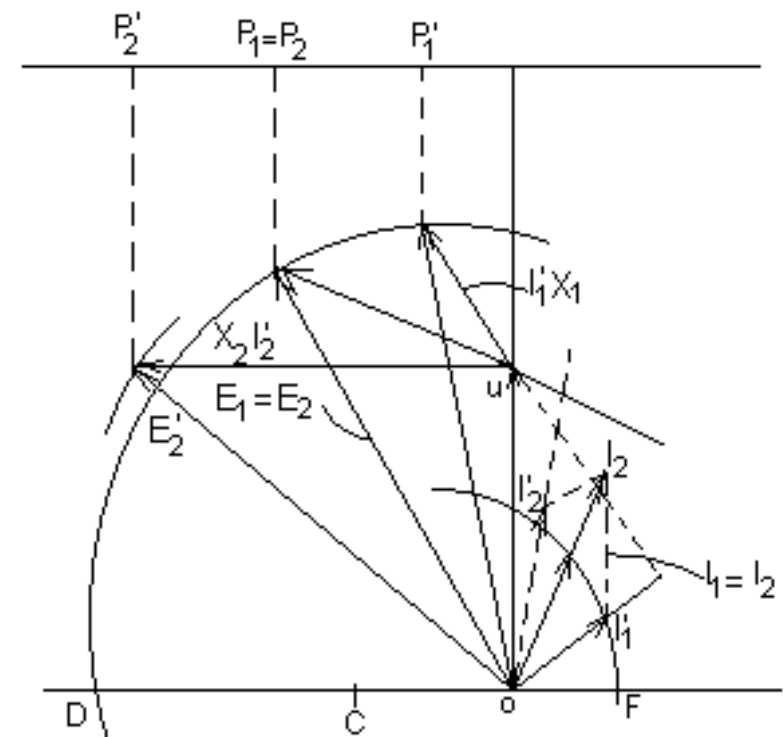
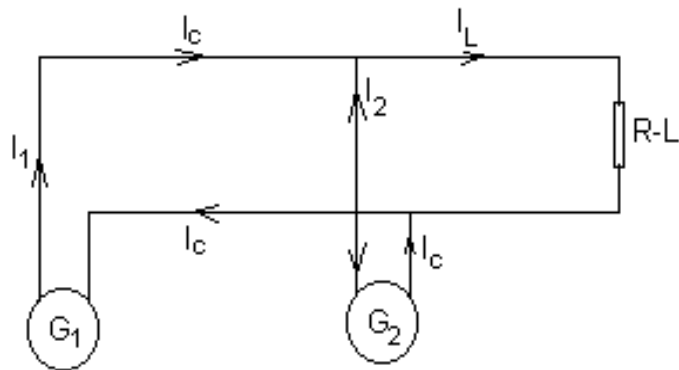
1º Caso: cambio de excitación



2º Caso



3° Caso: cambio de potencia

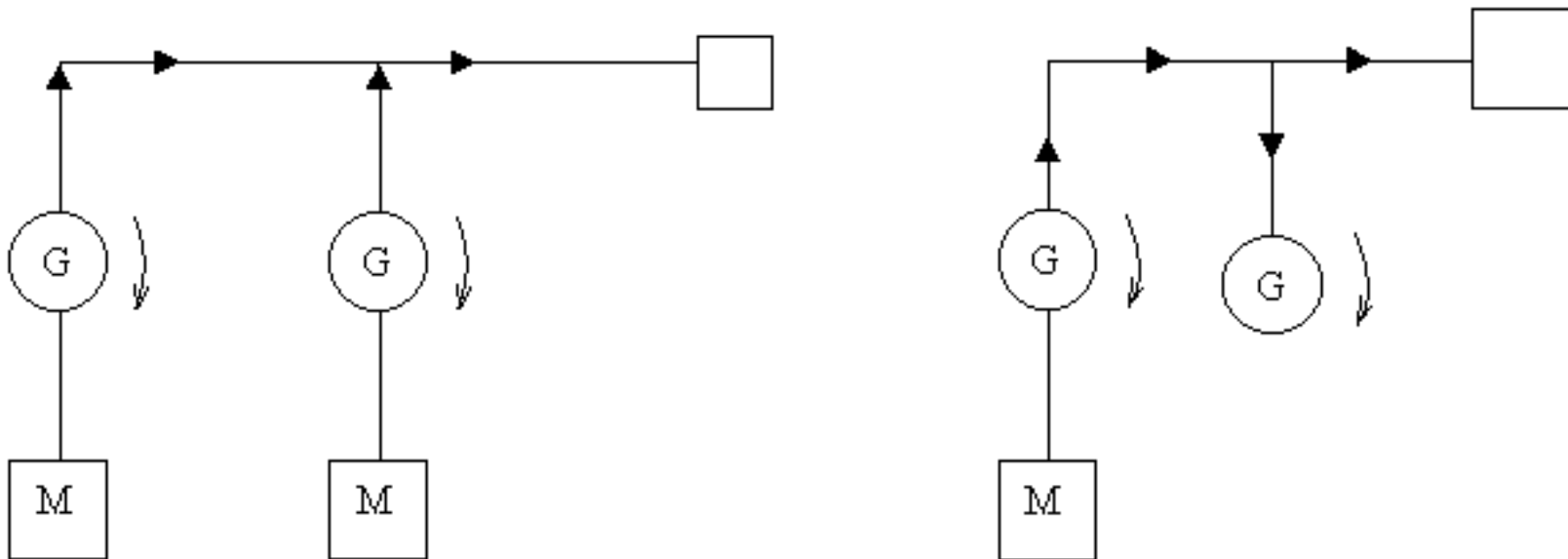




FACULTAD DE INGENIERIA
en acción continua...

MOTOR SÍNCRONO

Principio de funcionamiento



Principio de funcionamiento

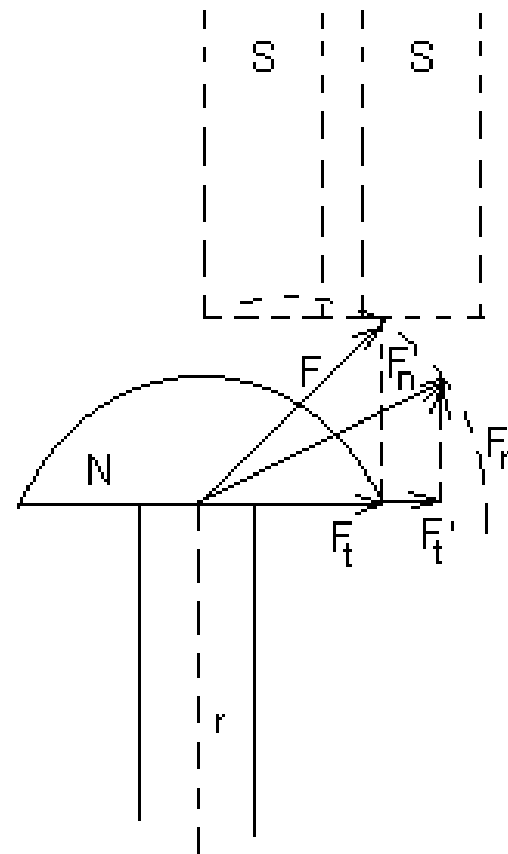
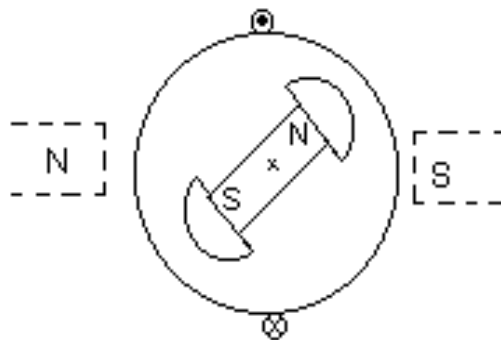
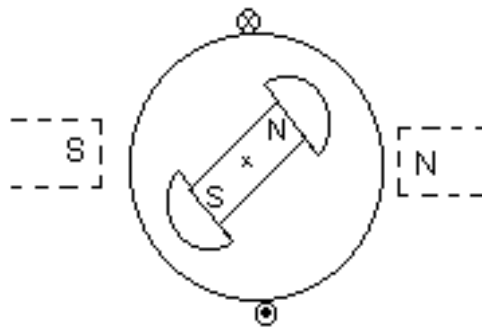
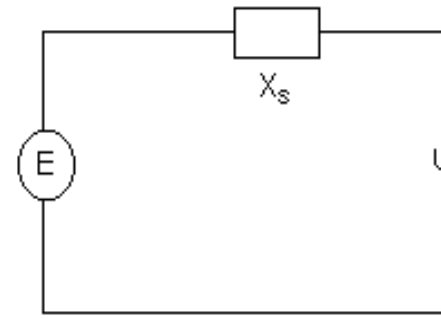


Diagrama Vectorial

Circuito equivalente
para generador y motor



- **Generador:**

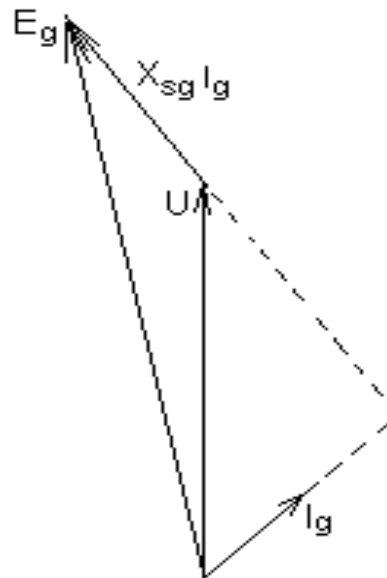
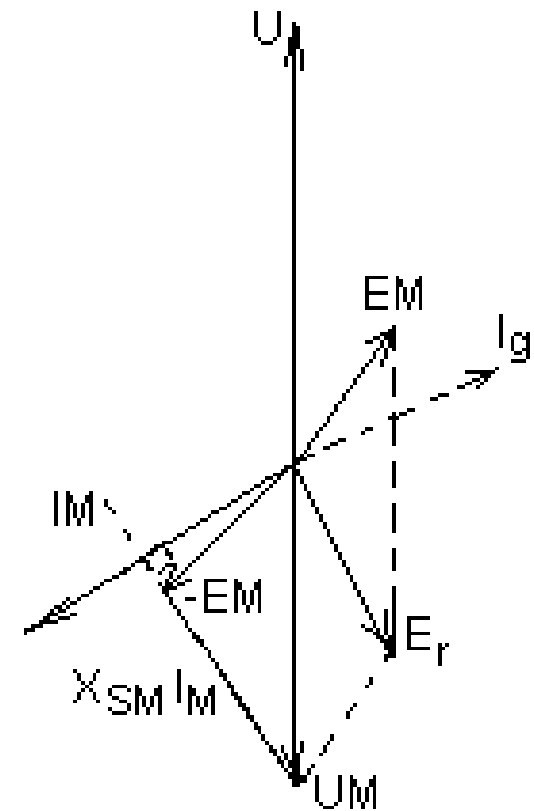
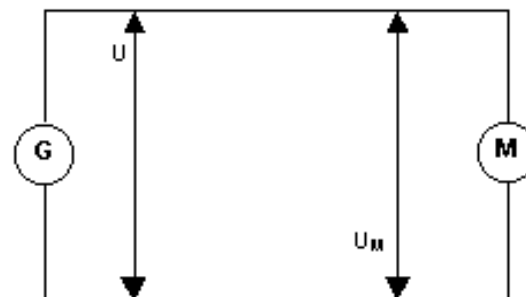
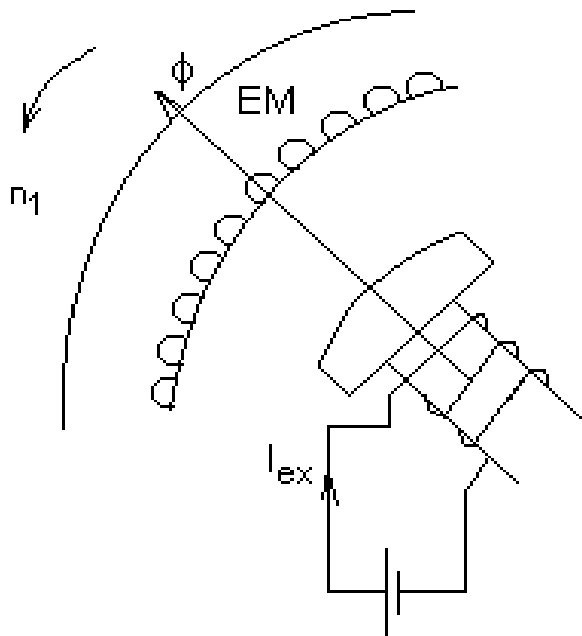
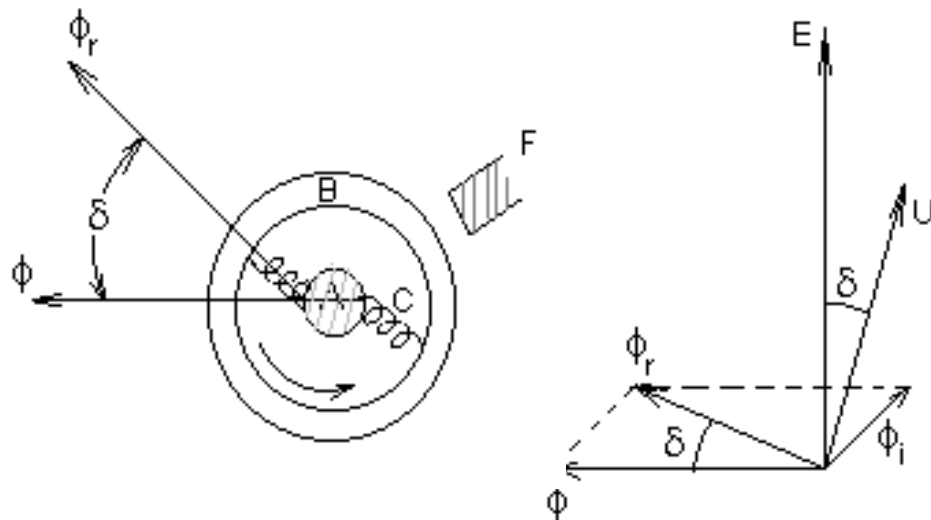


Diagrama Vectorial

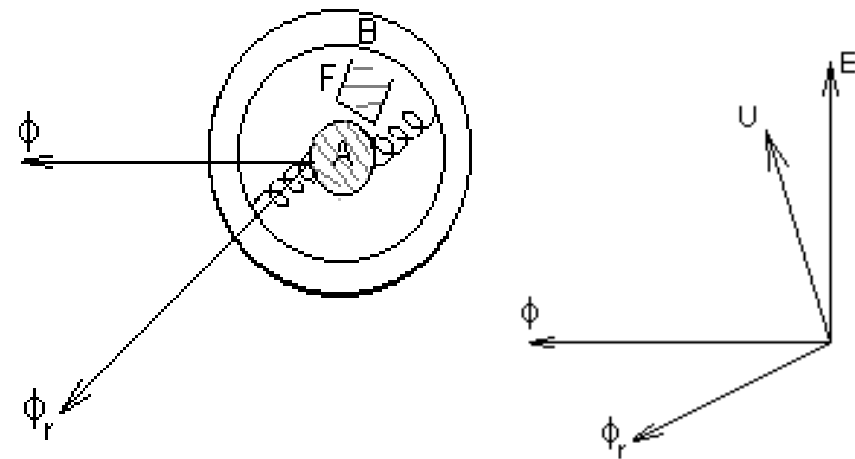
- Motor



- Generador



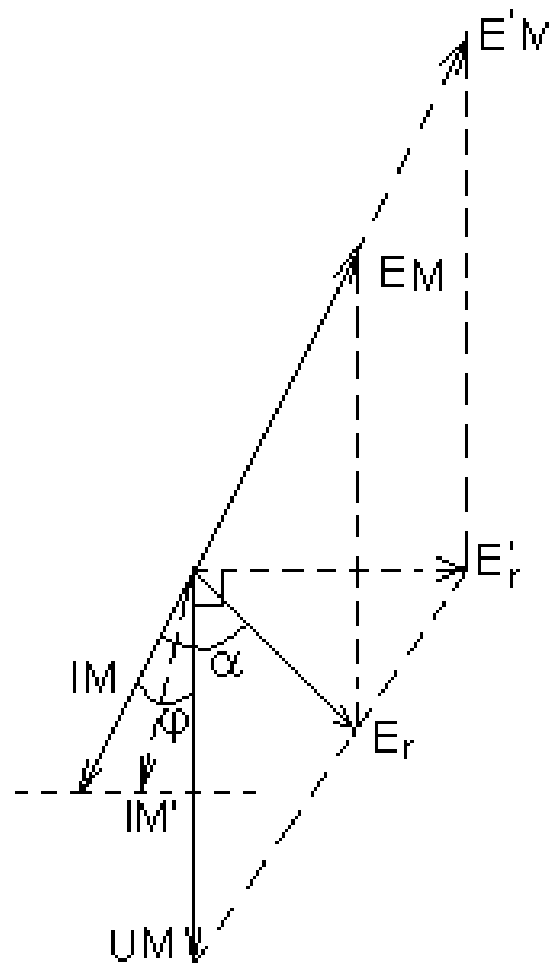
- Motor



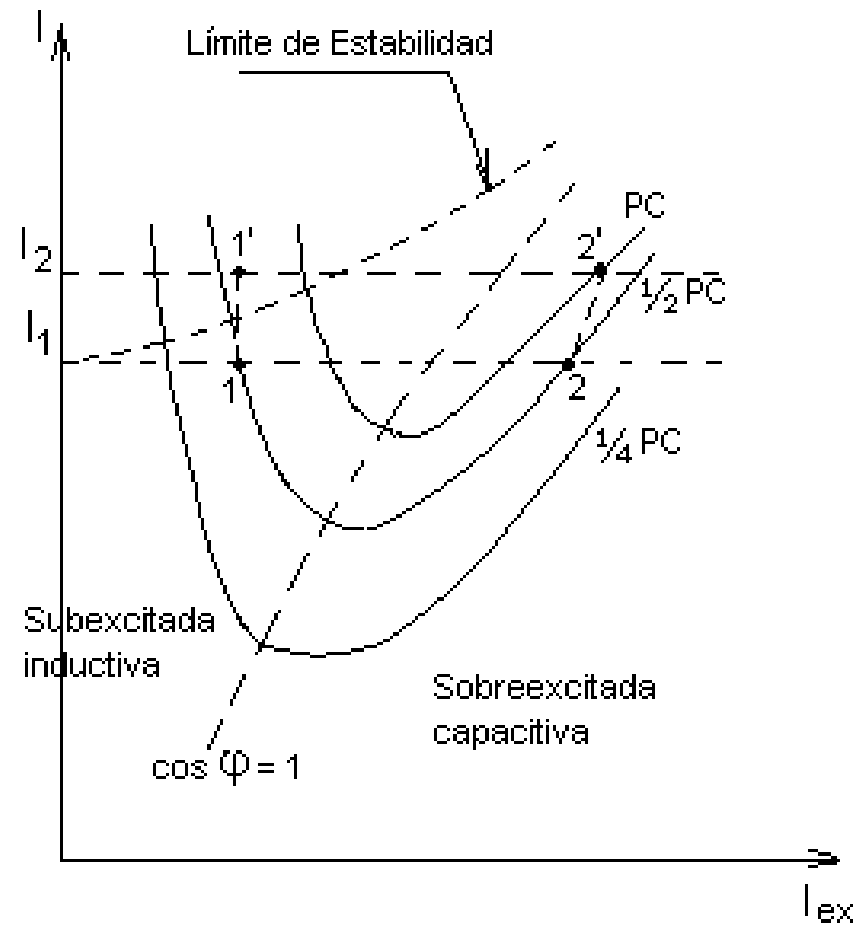
Un símil mecánico de la máquina síncrona como generador - fig. 10 – Podría representarse como un eje A (rueda polar) que gira accionado por un motor y esta ligado a una corona B (inducido) por resortes C (flujo resultante). Al hacer girar el eje, aplicando un freno F a la corona (carga de la máquina) 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).-

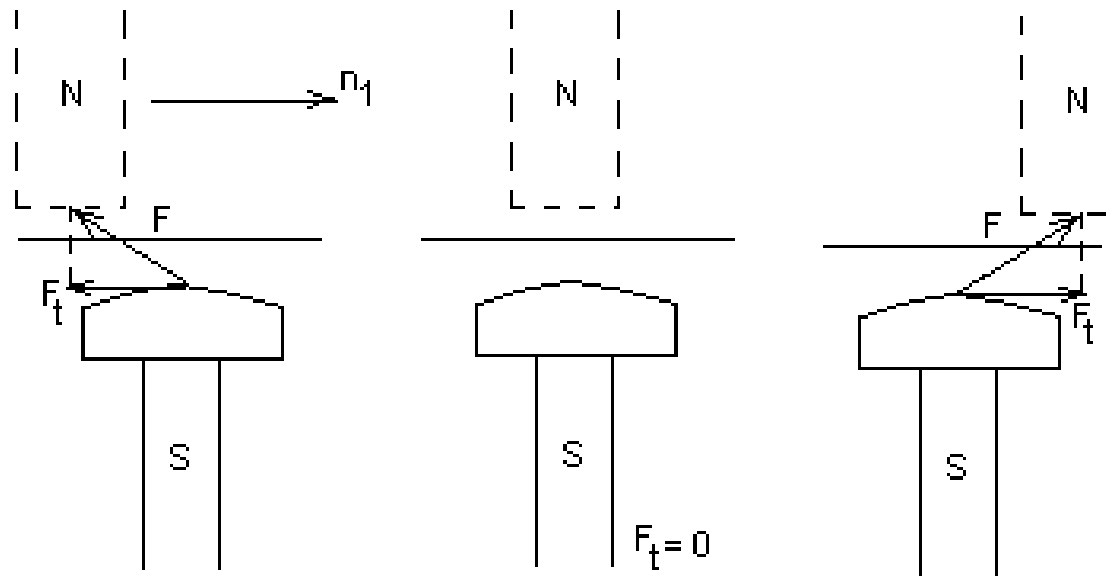
Medición del $\cos\varphi$



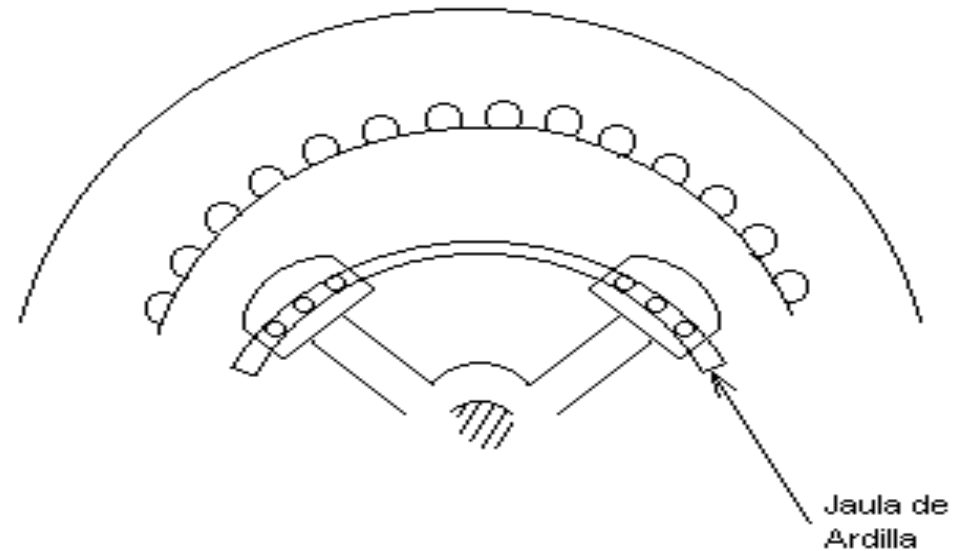
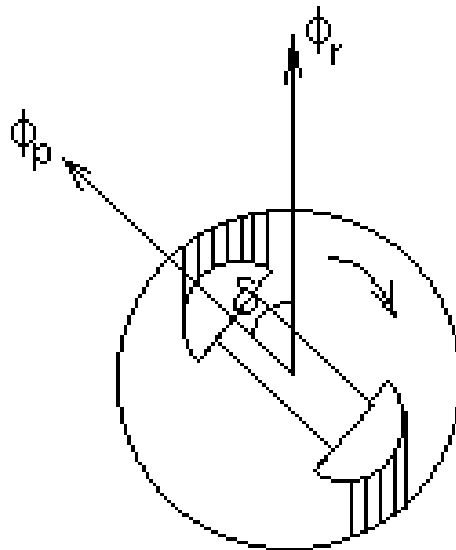
Curvas en V



Arranque del motor síncrono



Arranque del motor síncrono



Arranque automático del motor síncrono

