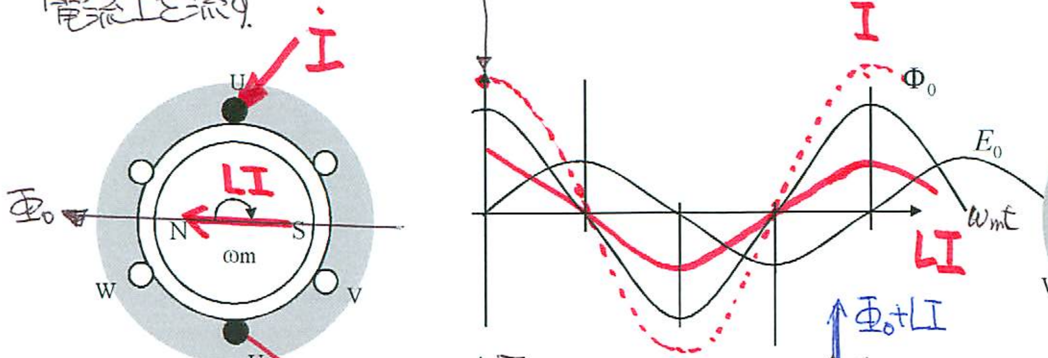
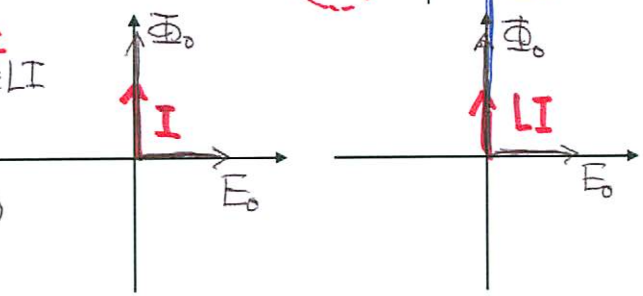
morizane

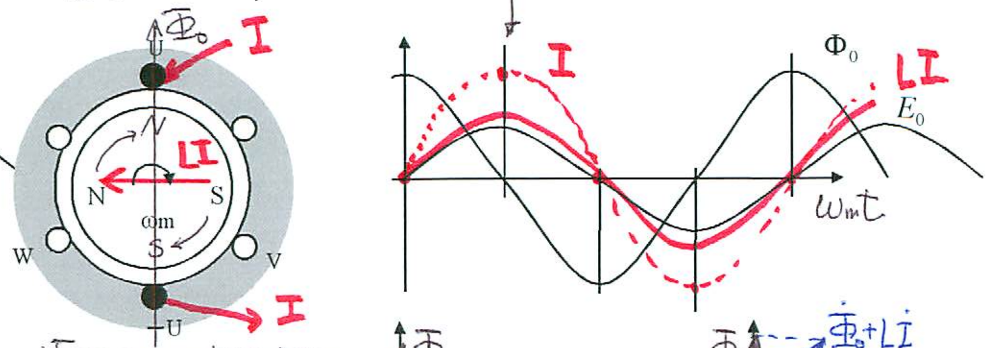
磁束Φ_0の回転角$\omega_m t=0$のとき
電流Iを流す。



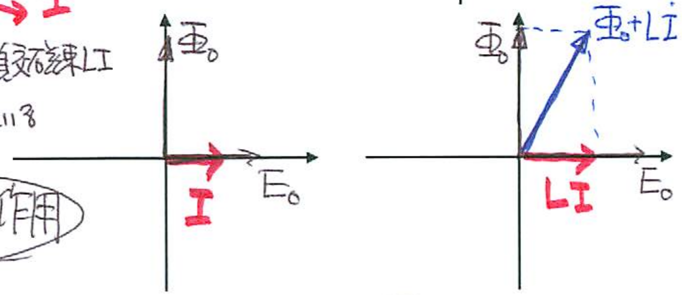
電流Iによる鎖交磁束LI
+
Φ_0と同位相
⇓
増磁作用



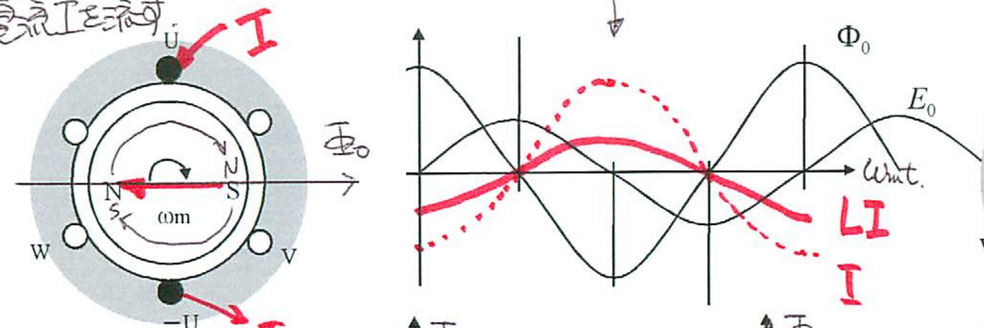
磁束Φ_0の回転角$\omega_m t=\frac{\pi}{2}$のとき
電流Iを流す。



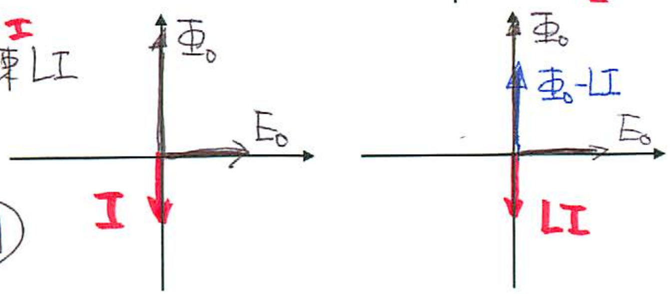
電流Iによる鎖交磁束LI
Φ_0と$\frac{\pi}{2}$ずれている
⇓
交鎖磁化作用



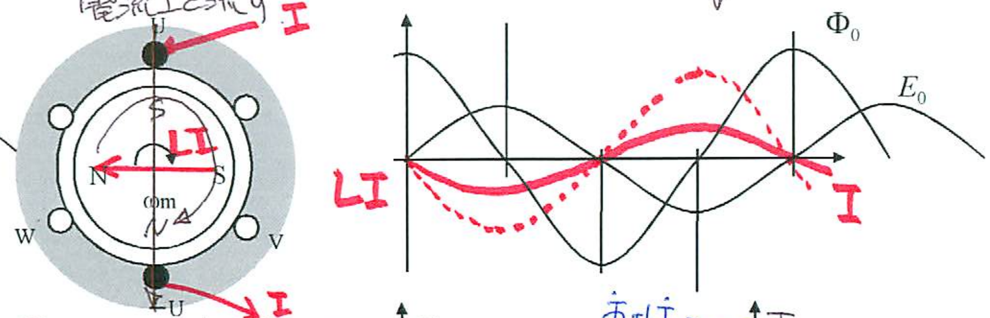
磁束Φ_0の回転角$\omega_m t=\pi$のとき
電流Iを流す。



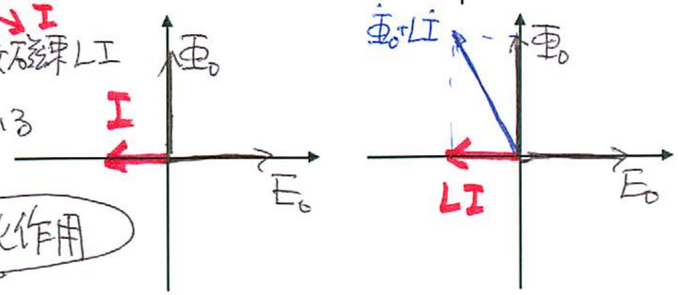
電流Iによる鎖交磁束LI
Φ_0と逆位相
⇓
減磁作用



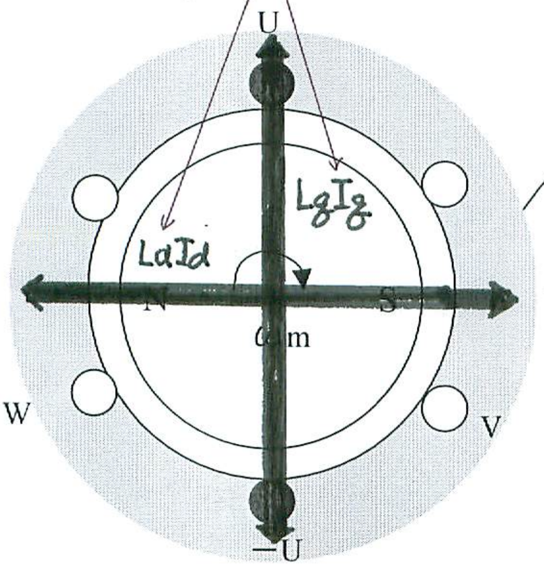
磁束Φ_0の回転角$\omega_m t=\frac{3}{2}\pi$のとき
電流Iを流す

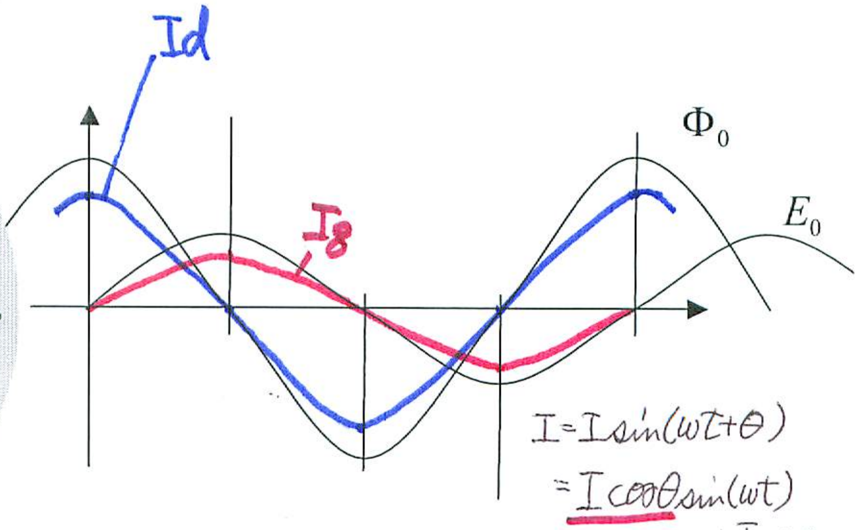


電流Iによる鎖交磁束LI
Φ_0と$\frac{\pi}{2}$ずれている
⇓
交さ磁化作用

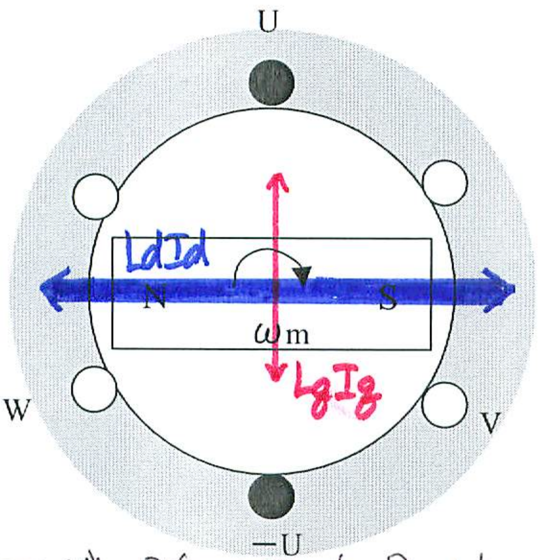


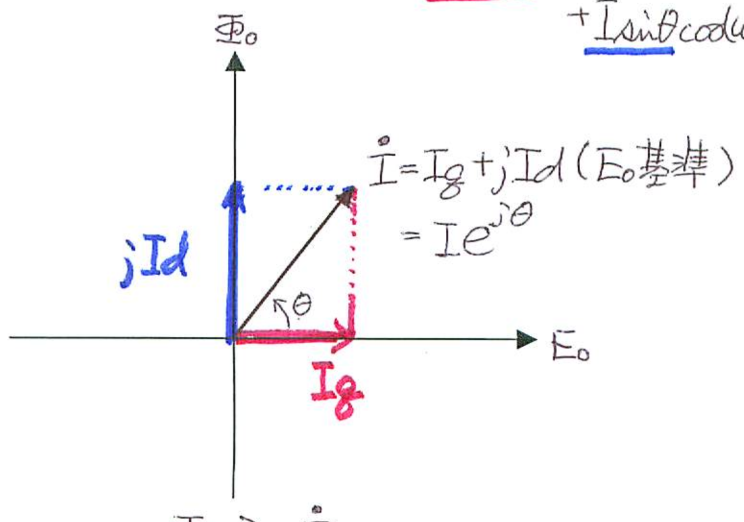
非突極機の場合
磁界の作り易さは同じ $L_d = L_q$.





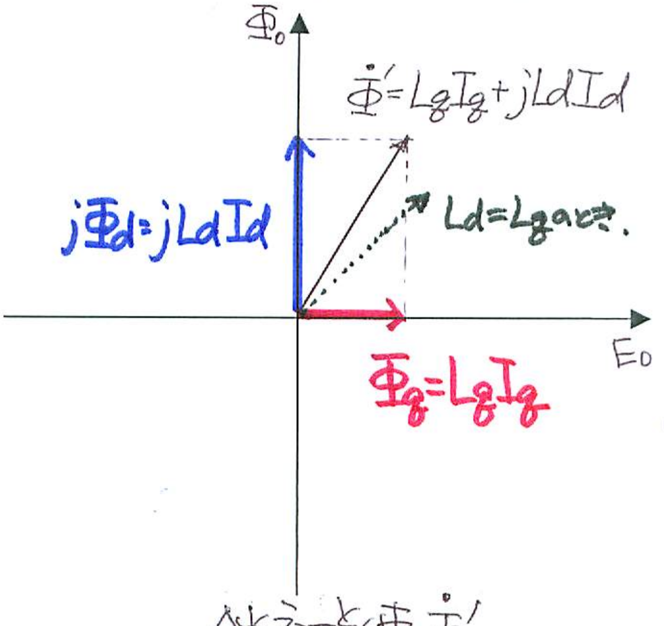
$$I = I\sin(\omega t + \theta)$$
$$= \underline{I\cos\theta}\sin(\omega t) + \underline{I\sin\theta}\cos(\omega t)$$



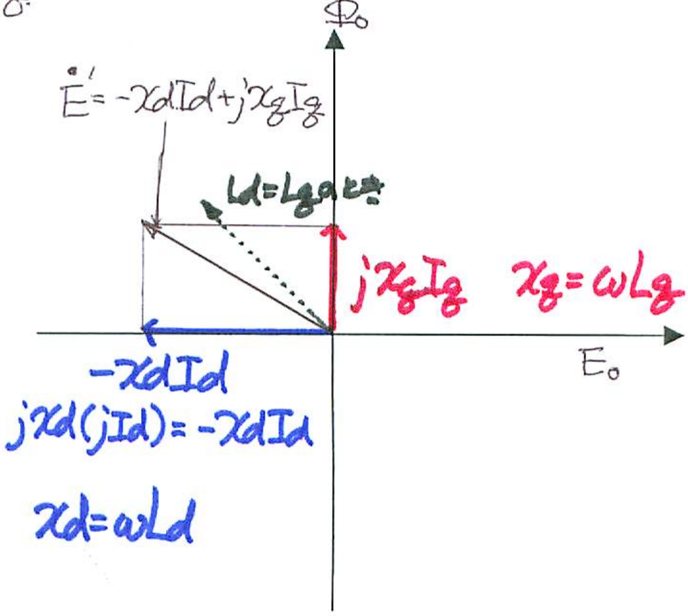


電流 $\dot{I}$

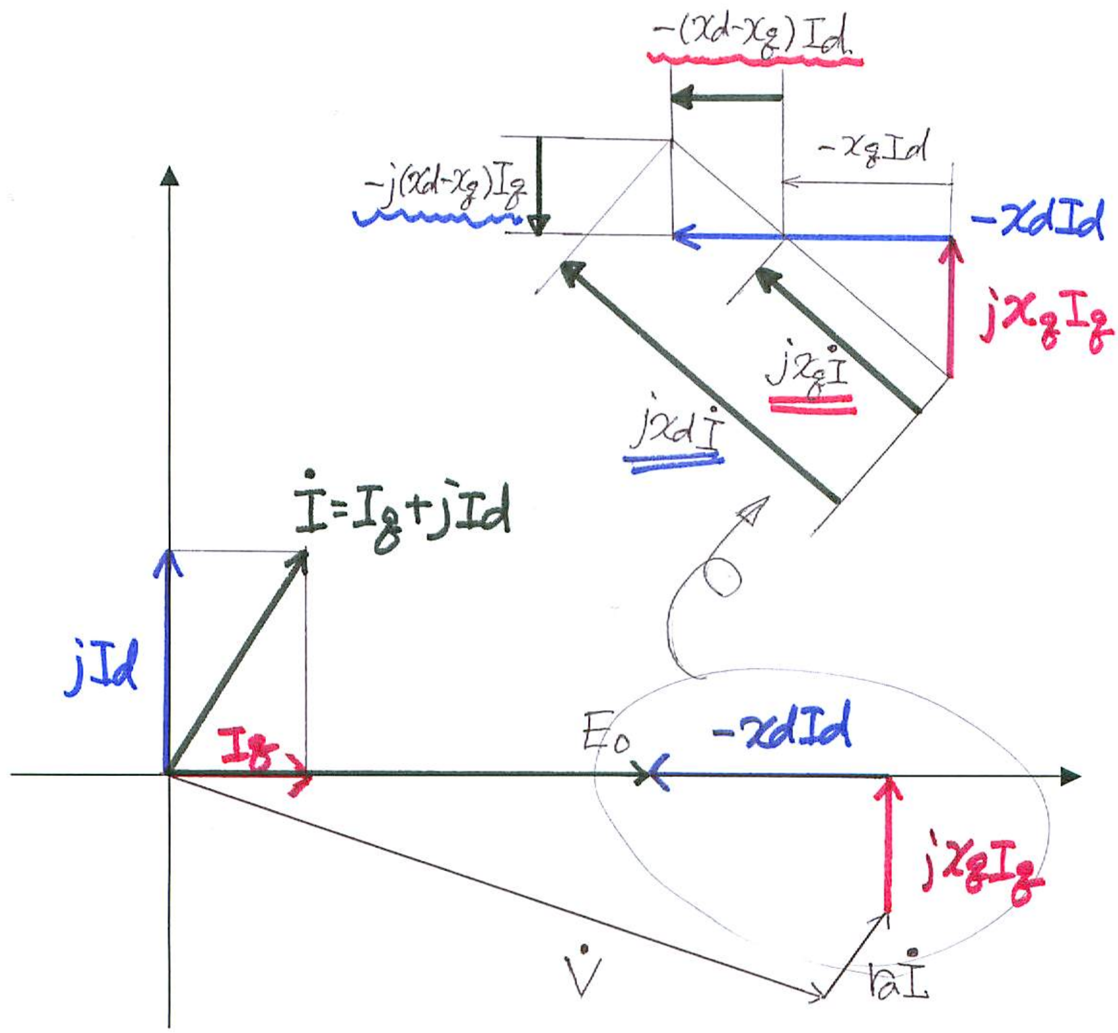
突極機の場合 磁界の作り易さが違う. $L_d \neq L_q$.



鎖交磁束 $\dot{\Phi}'$



逆起電力 $\dot{E}'$



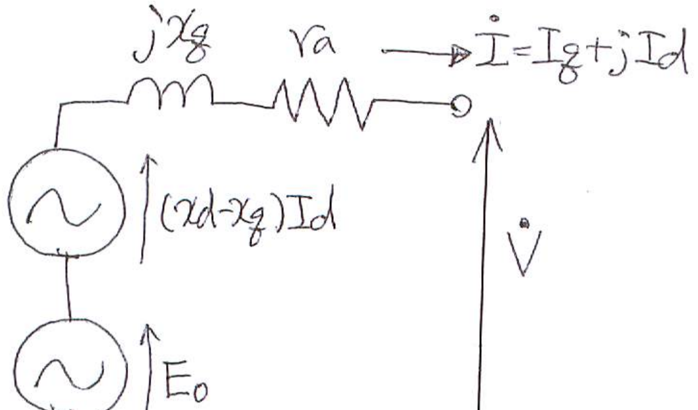
$$E_0 = \dot{V} + r_a\dot{I} + jx_q I_q - x_d I_d, \quad \dot{I} = I_q + jI_d$$

$\dot{I} = I_q + jI_d$ より $I_q = \dot{I} - jI_d$

$$E_0 = \dot{V} + r_a\dot{I} + jx_q(\dot{I} - jI_d) - x_d I_d$$

$$= \dot{V} + r_a\dot{I} + jx_q\dot{I} - (x_d - x_q)I_d$$

$$\therefore E_0 + (x_d - x_q)I_d = \dot{V} + r_a\dot{I} + jx_q\dot{I}$$

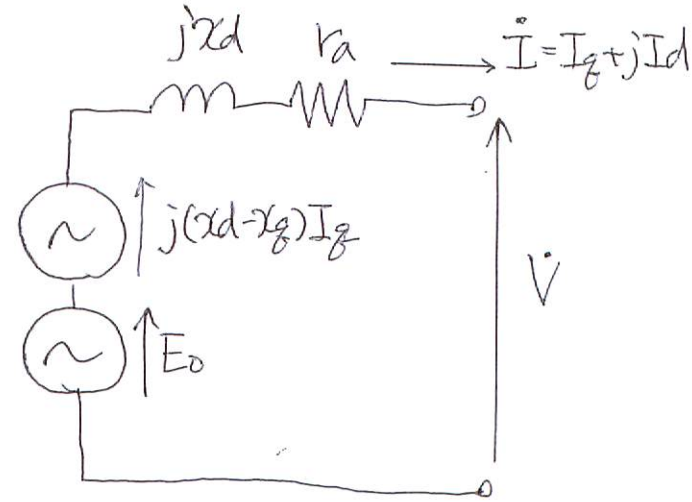


$\dot{I} = I_q + jI_d$ より $I_d = -j\dot{I} + jI_q$

$$E_0 = r_a\dot{I} + jx_q I_q - x_d(-j\dot{I} + jI_q) + \dot{V}$$

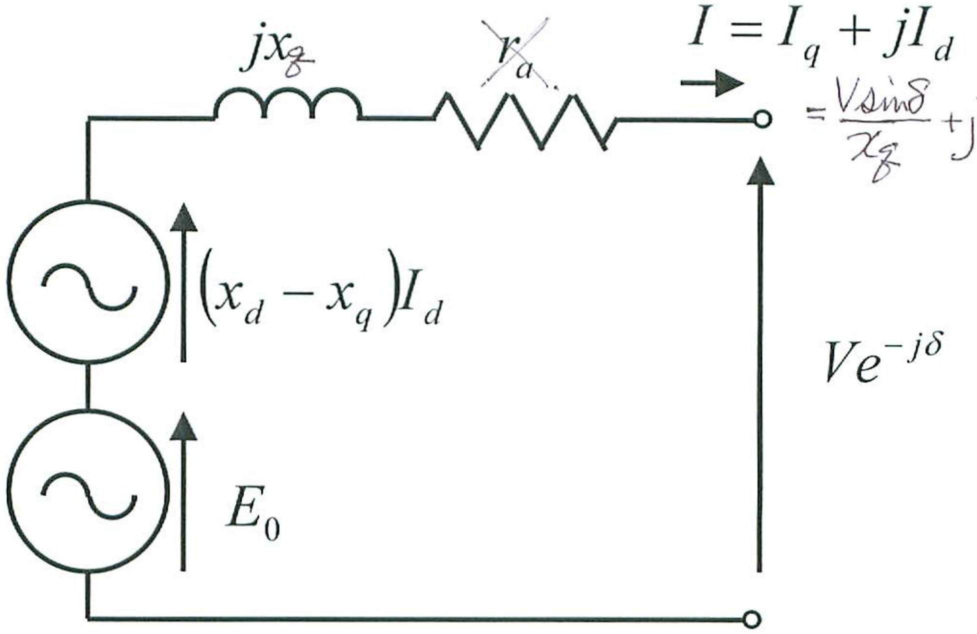
$$= \dot{V} + r_a\dot{I} + jx_d\dot{I} - j(x_d - x_q)I_q$$

$$\therefore E_0 + j(x_d - x_q)I_q = \dot{V} + r_a\dot{I} + jx_d\dot{I}$$



E_0に対し$\dot{V}$がδ遅れているとする。この時の突極機の消費電力を求める。($r_a \ll x_q$)

$$\dot{I} = \frac{\{E_0+(x_d-x_q)I_d\} - Ve^{-j\delta}}{jx_q} = \underline{\frac{V\sin\delta}{x_q}} + j\underline{\frac{V\cos\delta - \{E_0+(x_d-x_q)I_d\}}{x_q}} = \underline{I_q} + j\,\underline{I_d}.$$



$$= \frac{V\sin\delta}{x_q} + j\frac{V\cos\delta - E_0}{x_d}$$

$$E_0+(x_d-x_q)I_d = E_0+(x_d-x_q)\frac{V\cos\delta - E_0}{x_d}$$

$$= \frac{x_q}{x_d}E_0 + \frac{x_d-x_q}{x_d}V\cos\delta.$$

突極機での複素電力$\dot{P}_s$は

$$\dot{P}_s = \left(\frac{x_q}{x_d}E_0 + \frac{x_d-x_q}{x_d}V\cos\delta\right)^*\underline{(-\dot{I})}$$

消費電力は電圧と電流の向きが逆.

$$= \left(\frac{x_q}{x_d}E_0 + \frac{x_d-x_q}{x_d}V\cos\delta\right)\left(-\frac{V\sin\delta}{x_q} - j\frac{V\cos\delta - E_0}{x_d}\right).$$

よって消費電力P_sは(一相当り)

$$P_s = R_e(\dot{P}_s) = -\frac{VE_0}{x_d}\sin\delta - \frac{x_d-x_q}{x_dx_q}V^2\sin\delta\cos\delta$$

$$= -\frac{VE_0}{x_d}\sin\delta - \frac{1}{2}\left(\frac{1}{x_q} - \frac{1}{x_d}\right)V^2\sin 2\delta$$

$\sin\delta<0$ すなわち $\delta<0$.

E₀が遅れている
Vが進んでいる > 電動機($P_s>0$)

Pは極対数

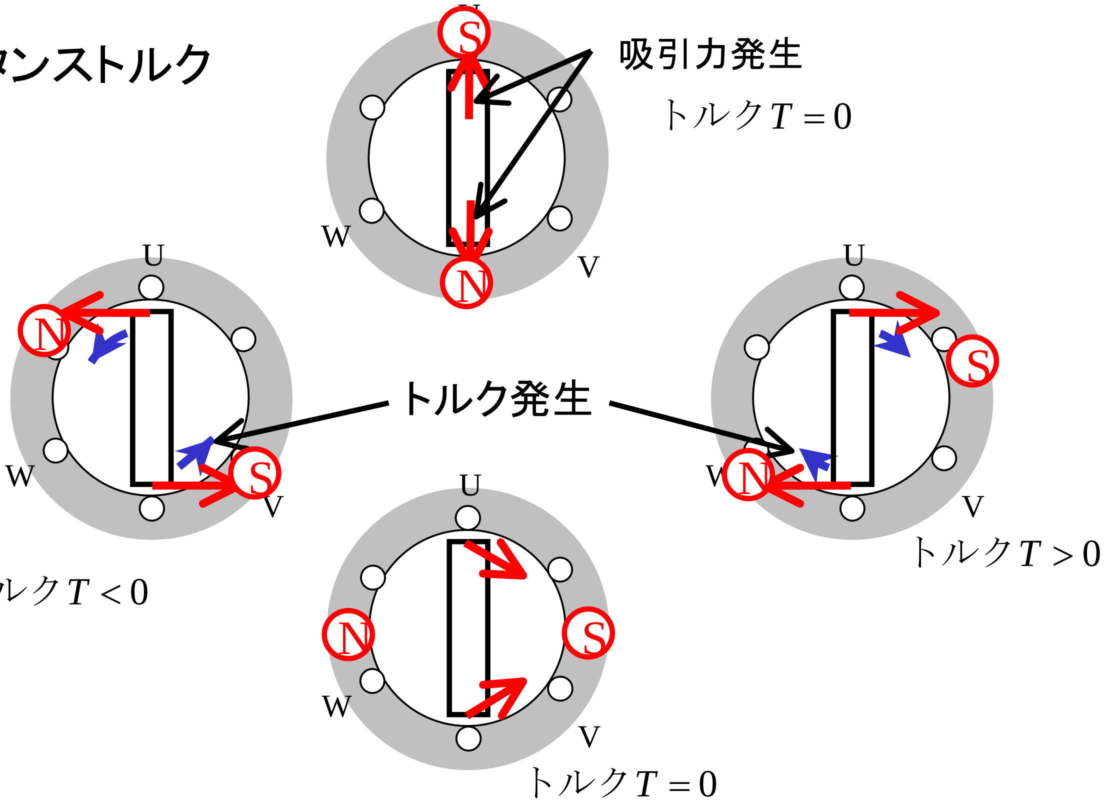
$$\text{トルク}\ T = \frac{3P_s}{\omega_s} = \frac{P}{2\pi f}\left\{-\frac{3VE_0}{x_d}\sin\delta - \frac{3}{2}\left(\frac{1}{x_q}-\frac{1}{x_d}\right)V^2\sin 2\delta\right\}$$

$$= \underbrace{-\frac{P}{2\pi f}\cdot\frac{3VE_0}{x_d}\sin\delta}_{\text{同期トルク}} \underbrace{- \frac{P}{2\pi f}\cdot\frac{3}{2}\left(\frac{1}{x_q}-\frac{1}{x_d}\right)V^2\sin 2\delta}_{\text{リラクタンストルク}}$$

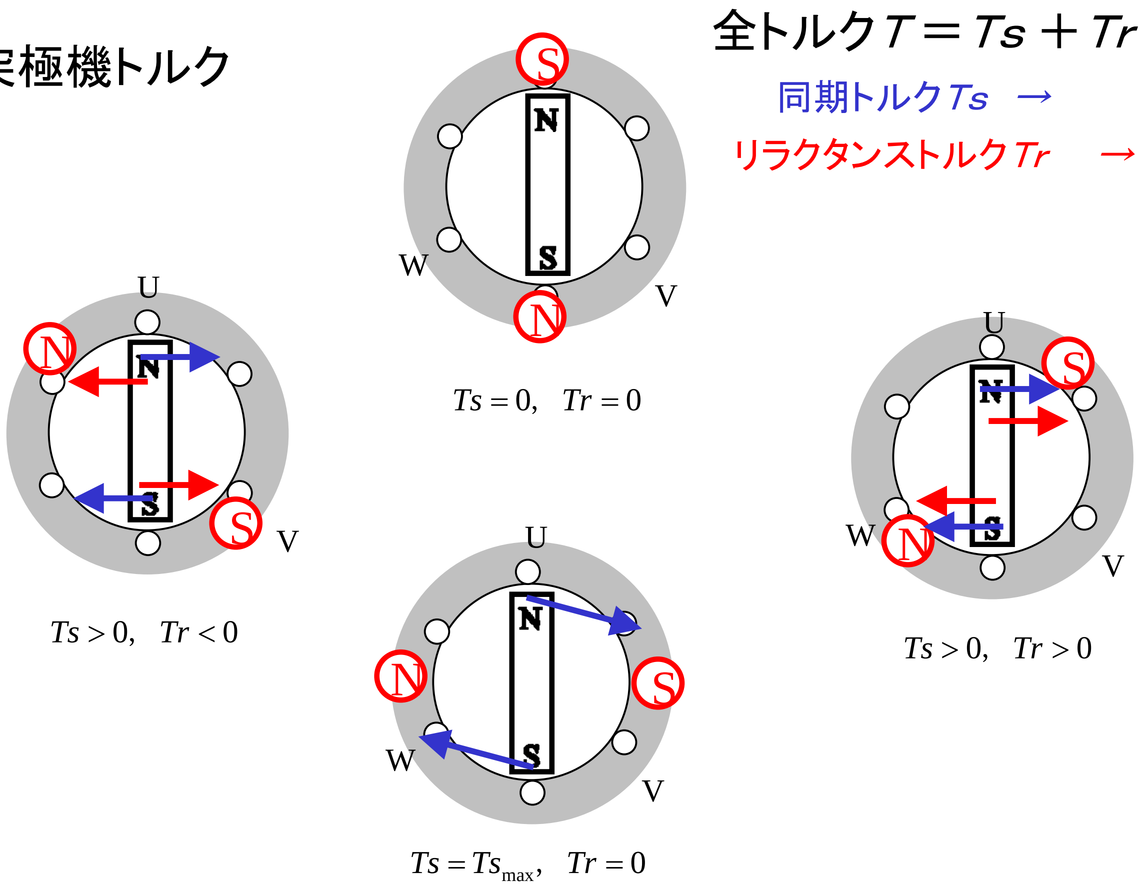
$\sin\delta>0$ すなわち $\delta>0$

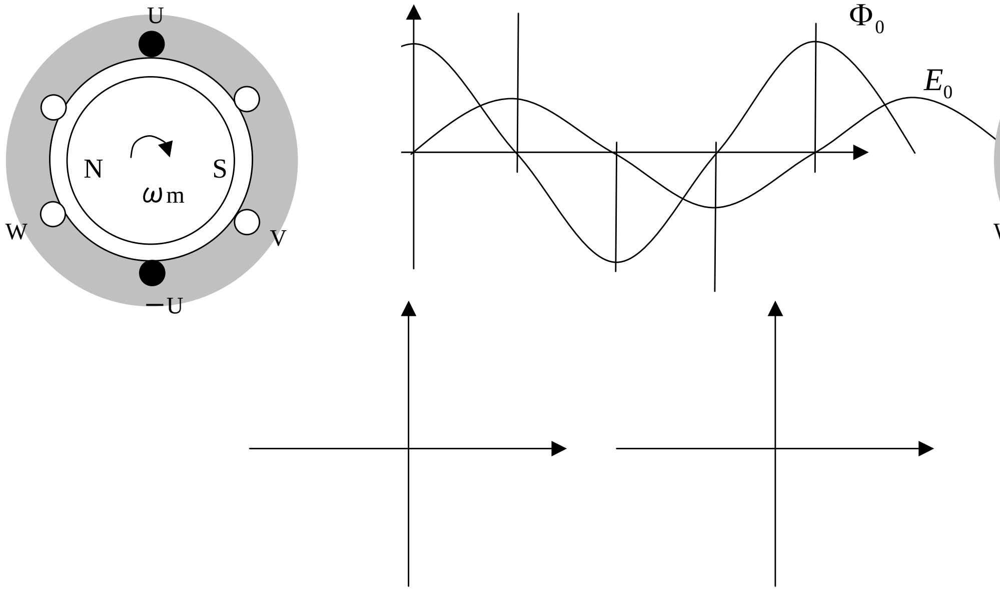
E₀が進んでいる
Vが遅れている > 発電機($P_s<0$)

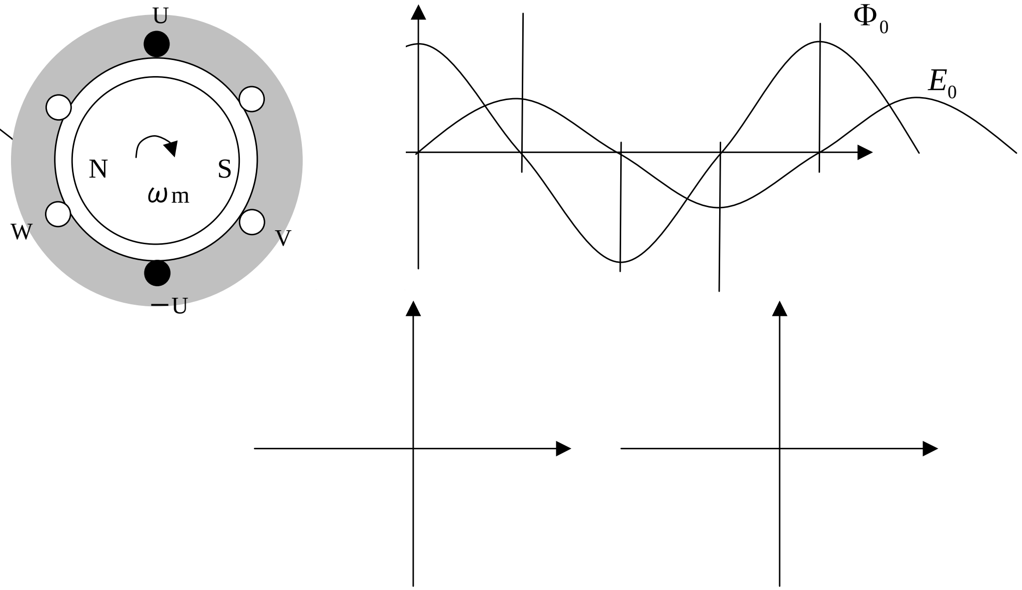
リラクタンストルク

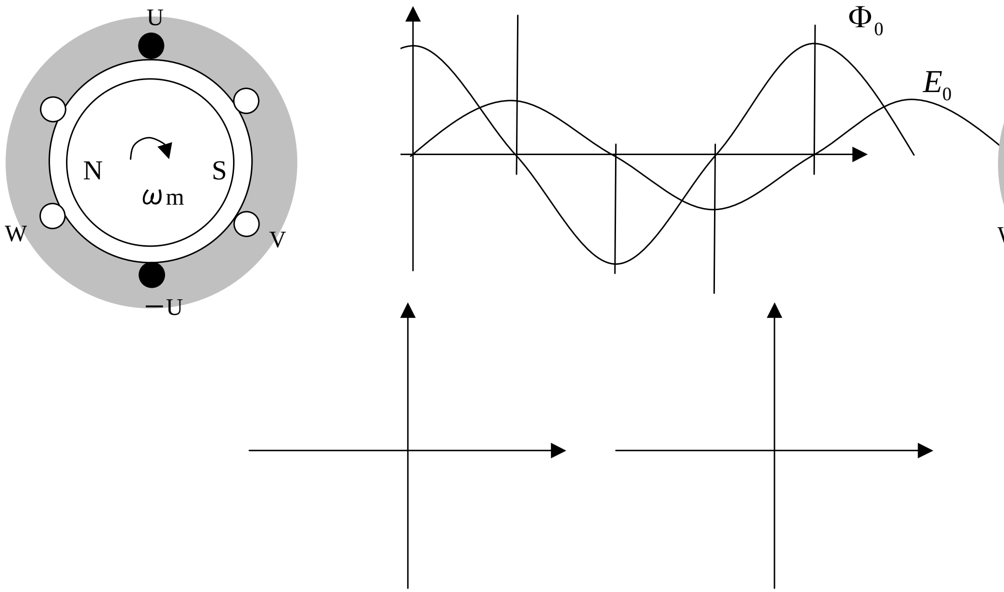


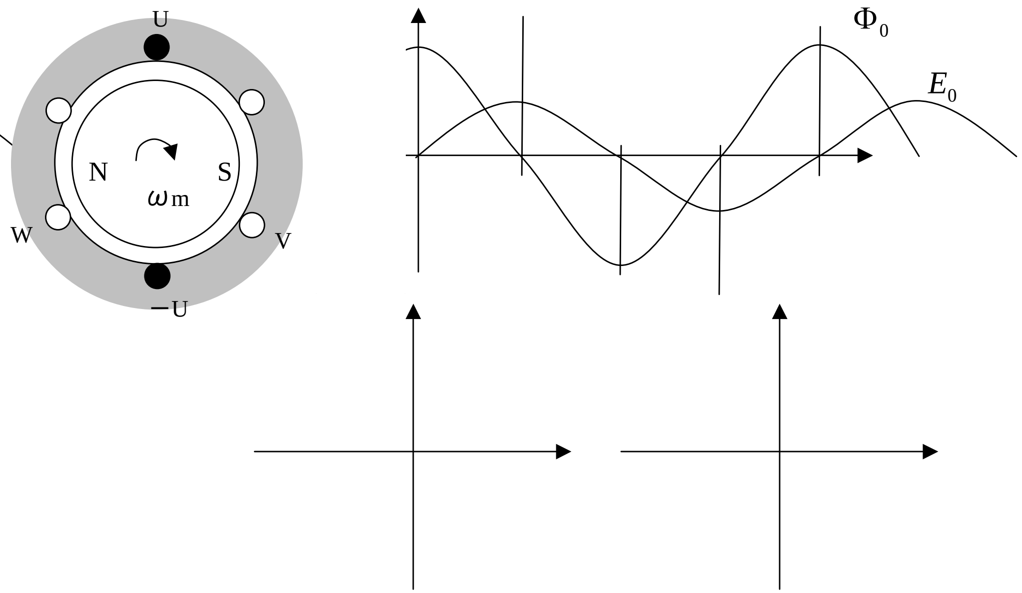
突極機トルク

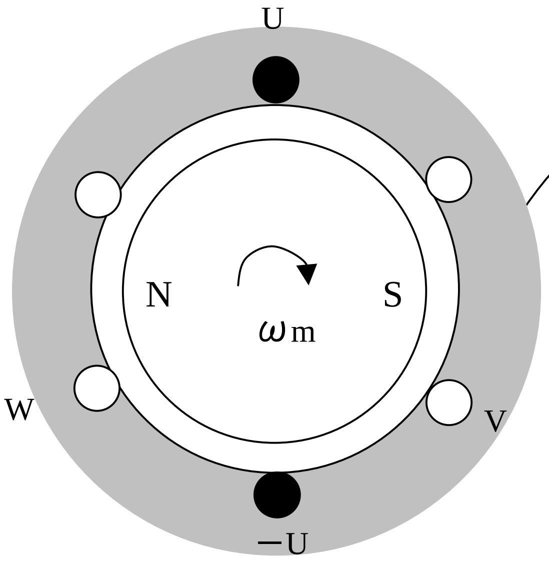


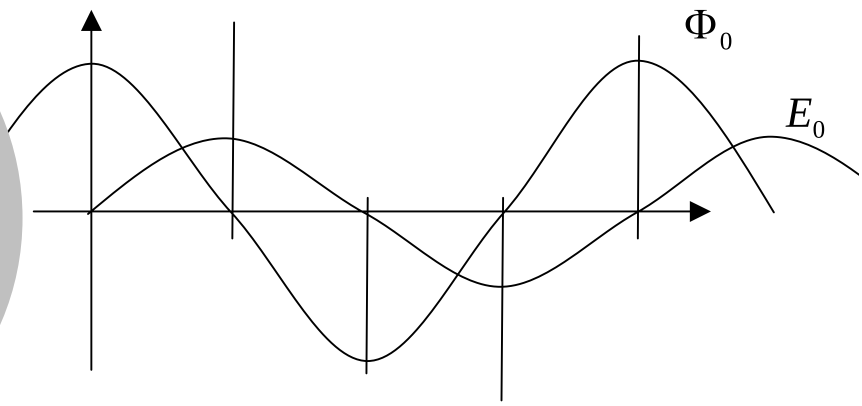

U
N
S
ωm
W
V
−U
Φ0
E0

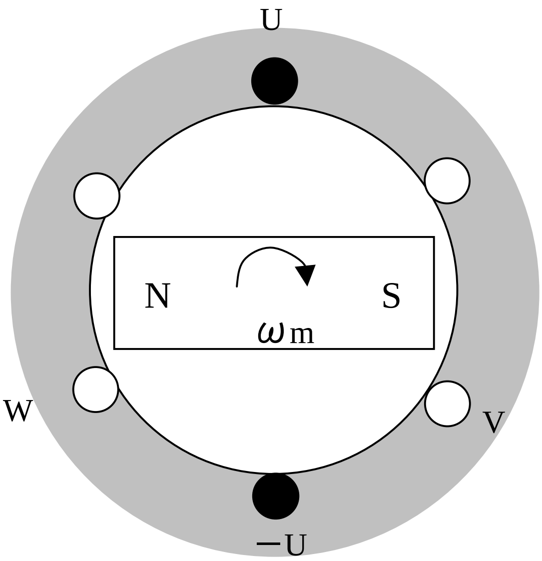

U
N
S
ωm
W
V
−U
Φ0
E0

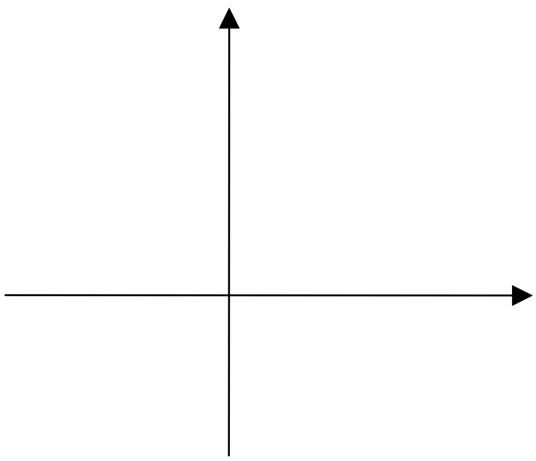

U
N
S
ωm
W
V
−U
Φ0
E0

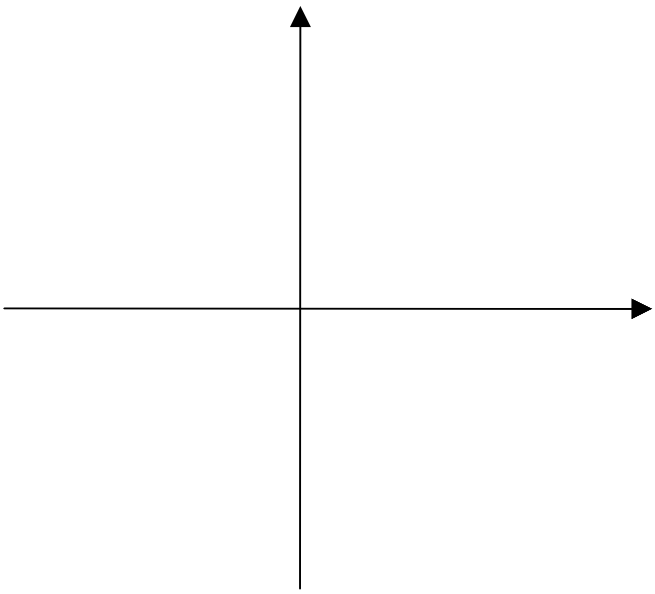

U
N
S
ωm
W
V
−U
Φ0
E0

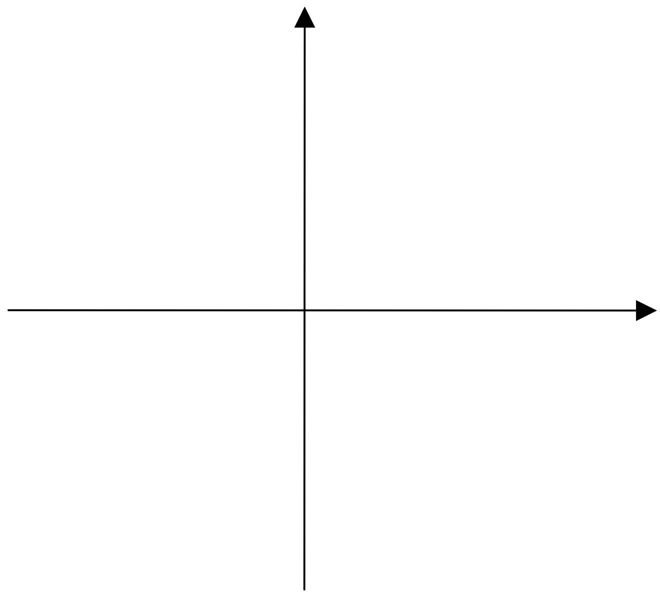

U
N
S
ω_m
W
V
−U

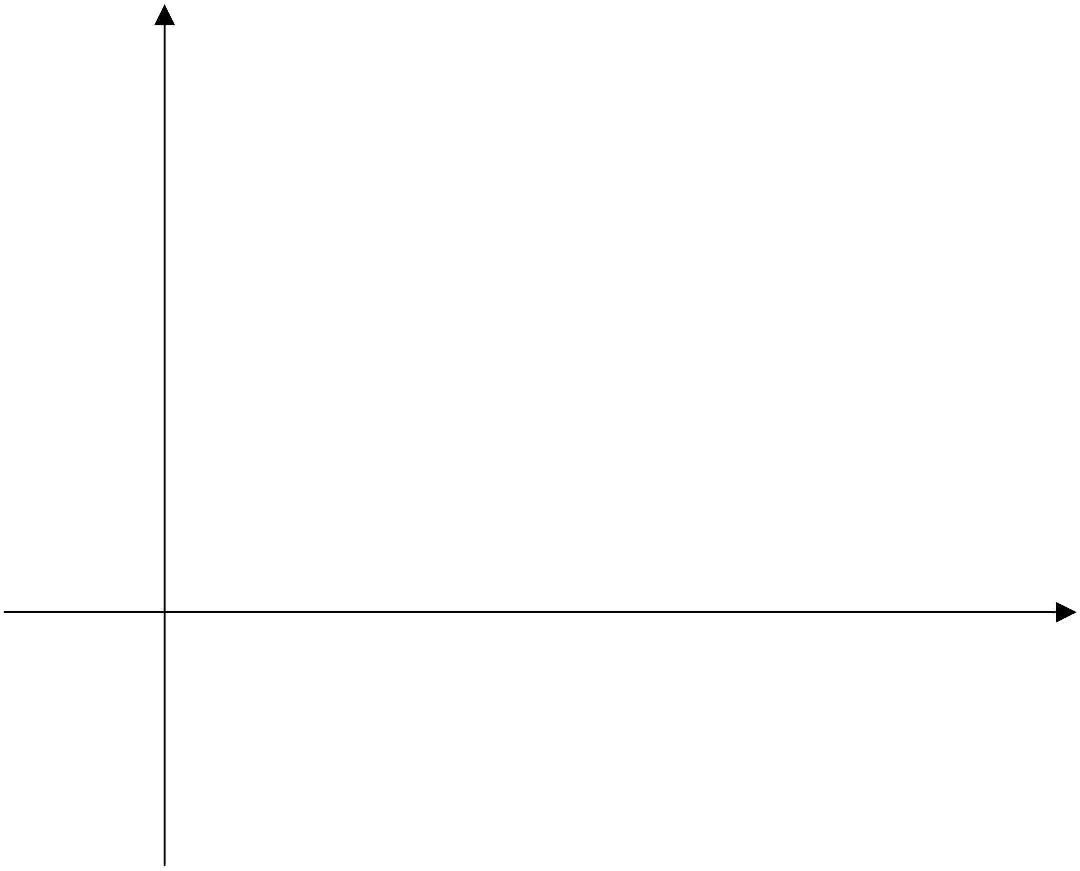

Φ_0
E_0

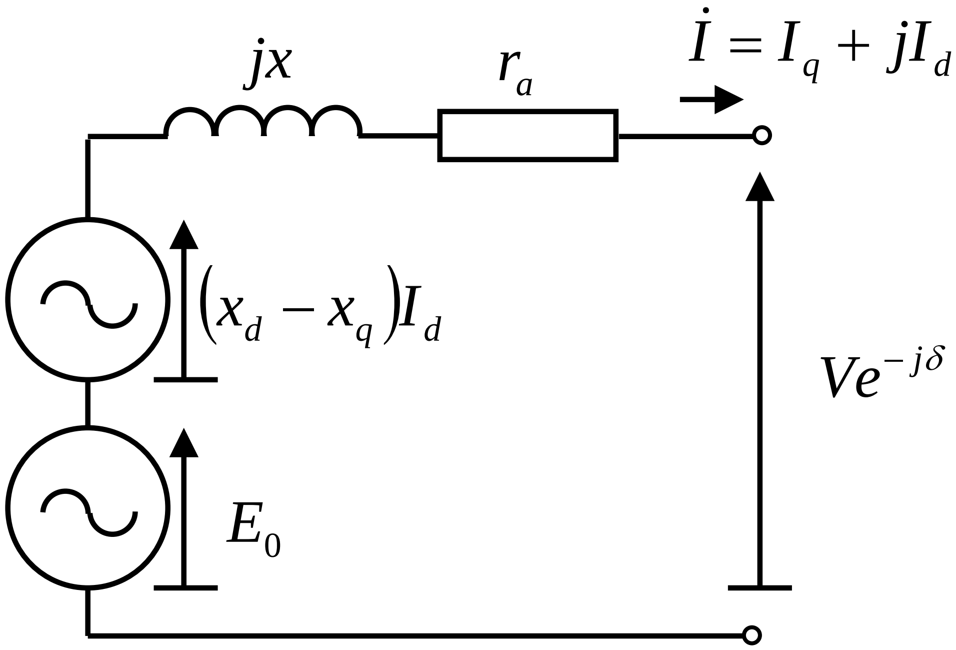

U
N
S
ω_m
W
V
−U





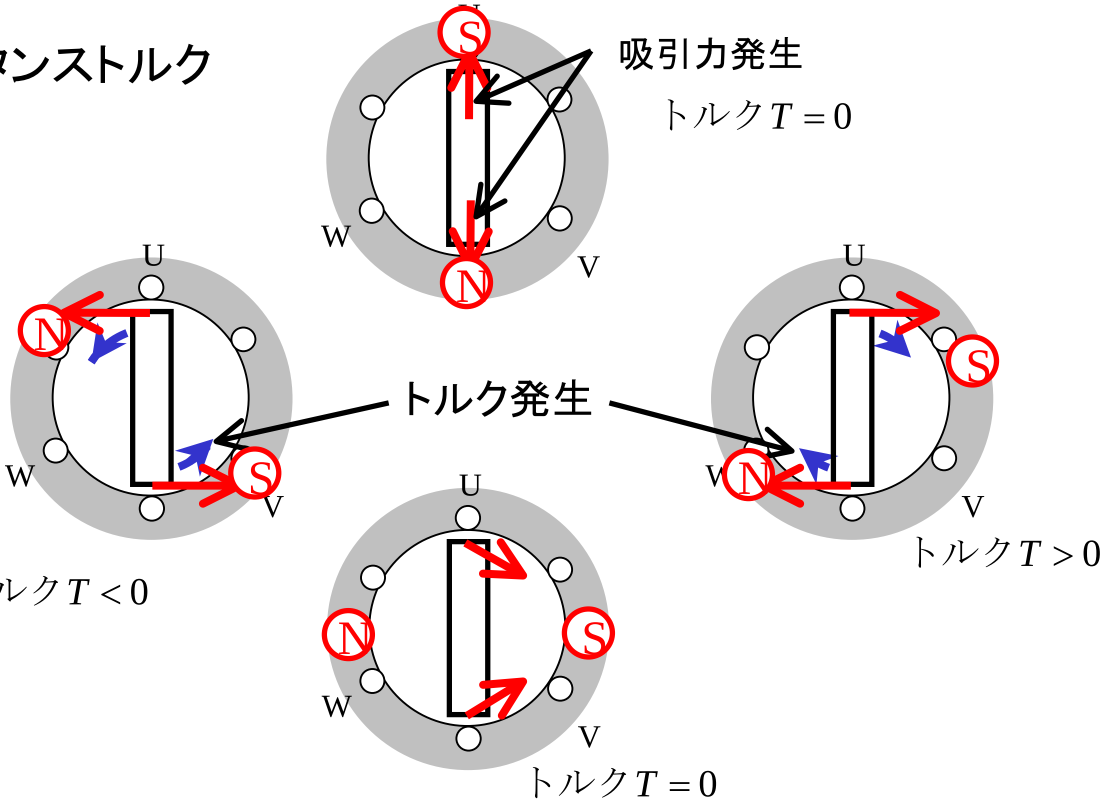






jx
r_a
$\dot{I} = I_q + jI_d$
$(x_d - x_q)I_d$
$Ve^{-j\delta}$
E_0

リラクタンストルク



突極機トルク

全トルク $T = Ts + Tr$