ESEMPIO NUMERICO

$V_{m,rms} = 250\,V$ CONCATENATA RMS

$I_{m,rms} = 200\,A$ RMS

$L = 0{,}15\,mH$

$2p = 8$

$K_E = 0{,}6 \; \dfrac{V_{RMS}}{rad/s}$ SU TENSIONE CONCATENATA

VALORI LIMITE AZIONAMENTO

$$V_m = \frac{250 \cdot \sqrt{2}}{\sqrt{3}} = 204\,V$$

$$I_m = 200 \cdot \sqrt{2} = 282{,}8\,A$$

} VALORI DI PICCO "DI FASE"

$K_E \quad \dfrac{V_{rms}}{\frac{rad}{s}}$ efficaci

BEMF DI PICCO

$$K_E \cdot \omega_m = V_{rms} = \frac{\sqrt{3}E}{\sqrt{2}} = \sqrt{\frac{3}{2}}\,\omega_m^e \lambda_m = \sqrt{\frac{3}{2}}\,\omega_m \cdot p\,\lambda_m$$

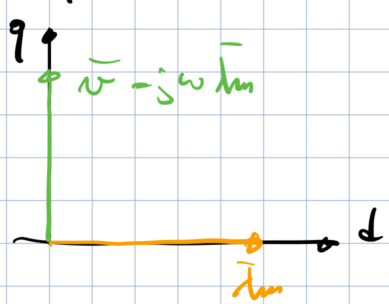
$$K_E = \sqrt{\frac{3}{2}}\,p\,\lambda_m \Rightarrow \lambda_m = \sqrt{\frac{2}{3}}\,\frac{K_E}{p} = \sqrt{\frac{2}{3}}\,\frac{0{,}6}{4} = 0{,}122\;Vs$$

① Velocità a vuoto

Trascuro perdite

$$\begin{cases} I_d = 0 \\ I_q = 0 \end{cases} \quad \begin{cases} \lambda_d = \lambda_m \\ \lambda_q = 0 \end{cases} \quad \begin{cases} V_d = R I_d - \omega \lambda_q \\ V_q = R I_q + \omega \lambda_d \end{cases}$$

$$R \cong 0 \quad \begin{cases} V_d = 0 \\ V_q = \omega \lambda_m \end{cases}$$



Se alimento con V_m

$$\omega_0^e = \frac{V_m}{\lambda_m} = \frac{204}{0,122} = 1672 \ \frac{rad}{s}$$

$$\omega_0 = \frac{\omega_0^e}{p} = \frac{1672}{4} = 418 \ \frac{rad}{s} = 4000 \ rpm$$

2) Calcolare velocità base

$$\begin{cases} I_d = 0 \\ I_q = I_m \end{cases} \qquad m = \frac{3}{2} p \lambda_m I_q = \frac{3}{2} \cdot 4 \cdot 0{,}122 \cdot 282{,}8 = 207 \ Nm$$

$$\begin{cases} \lambda_d = \lambda_m \\ \lambda_q = L I_m = 0{,}15 \cdot 10^{-3} \cdot 282{,}8 = 42{,}42 \ mVs \end{cases}$$

$$\begin{cases} V_d = -\omega_m^e L I_m \\ V_q = \omega_m^e \lambda_m \end{cases}$$

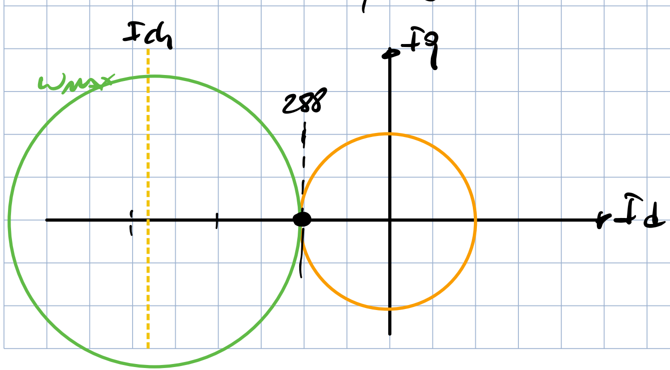
$$\omega_B^e = \frac{V_m}{\sqrt{(L I_m)^2 + \lambda_m^2}} = \frac{204}{\sqrt{(0{,}15 \cdot 10^{-3} \cdot 282{,}8)^2 + 0{,}122^2}} = 1579{,}4 \ \frac{rad}{s}$$

$$\omega_B = \frac{\omega_B^e}{p} = 394{,}8 \ \frac{rad}{s} = 3770 \ rpm$$

3) MASSIMA VELOCITÀ DI FUNZIONAMENTO

$$I_{ch} = -\frac{\lambda_m}{L} = -\frac{0{,}122}{0{,}15 \cdot 10^{-3}} = -813{,}3 \ A$$

$$\begin{cases} V_d = 0 = -\omega_m^e L I_q \\ V_q = 0 = \omega_m^e (\lambda_m + L I_d) \end{cases} \qquad I_d = -\frac{\lambda_m}{L} = I_{ch}$$

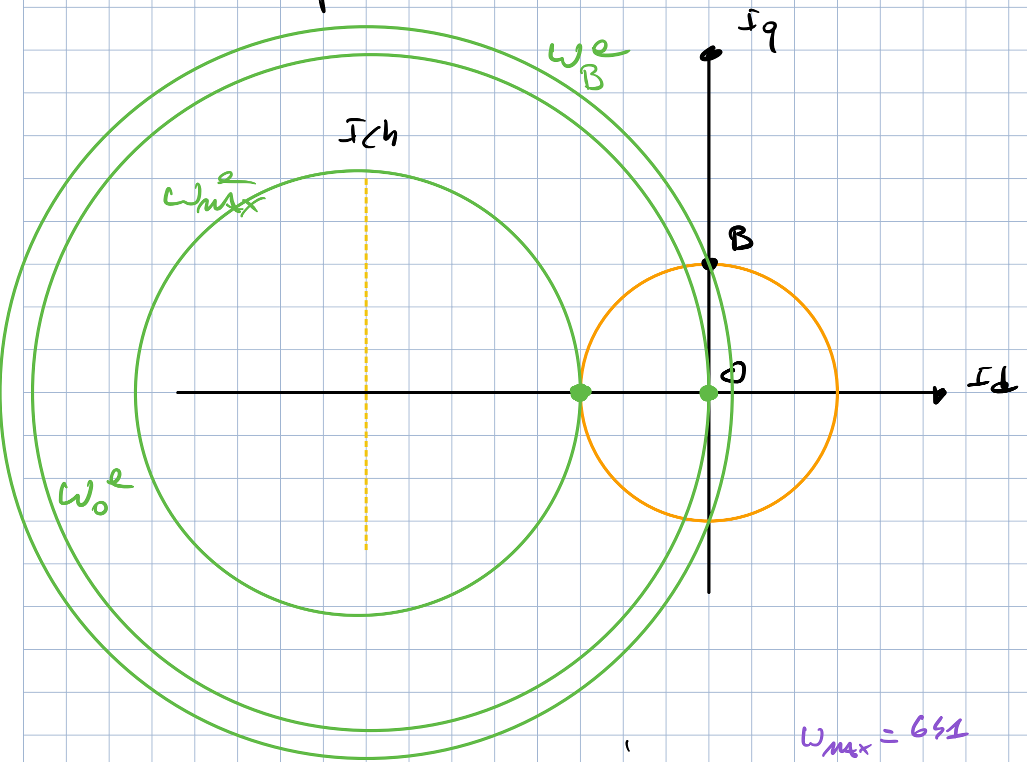


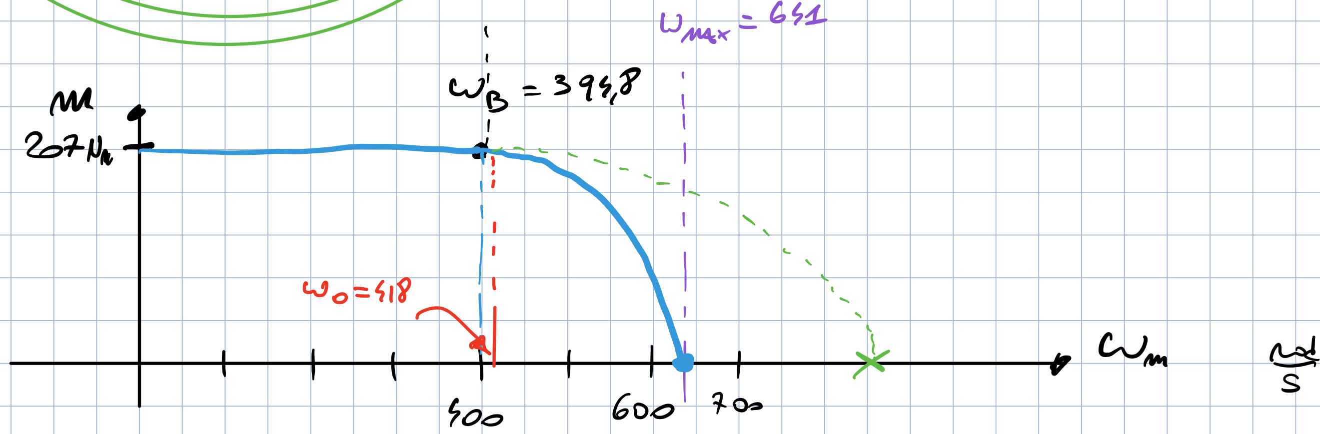
Per $\omega_m^e = \omega_{max}$

$$\begin{cases} V_d = -\omega_{max} L I_q \\ V_q = \omega_{max} (\lambda_m + L I_d) \end{cases} \qquad \begin{cases} I_d = -I_m \\ I_q = 0 \end{cases}$$

$$\omega^{e}_{MAX} = \frac{V_n}{\lambda_m - L I_n} = \frac{204}{0{,}122 - 0{,}15 \cdot 10^{-3} \cdot 282{,}8} = 2563 \ \frac{rad}{s}$$

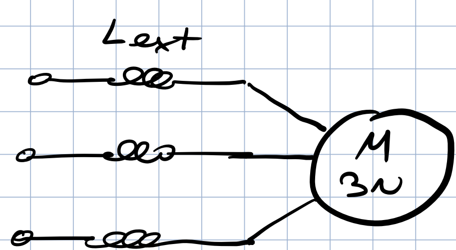
$$\omega_{MAX} = \frac{\omega^{e}_{MAX}}{P} = 6598 \ \frac{rad}{s} = 6120 \ rpm$$





③ COME POSSO AUMENTARE ω_{MAX}

$$\omega_{MAX} = \frac{V_n}{\lambda_m - L I_n}$$



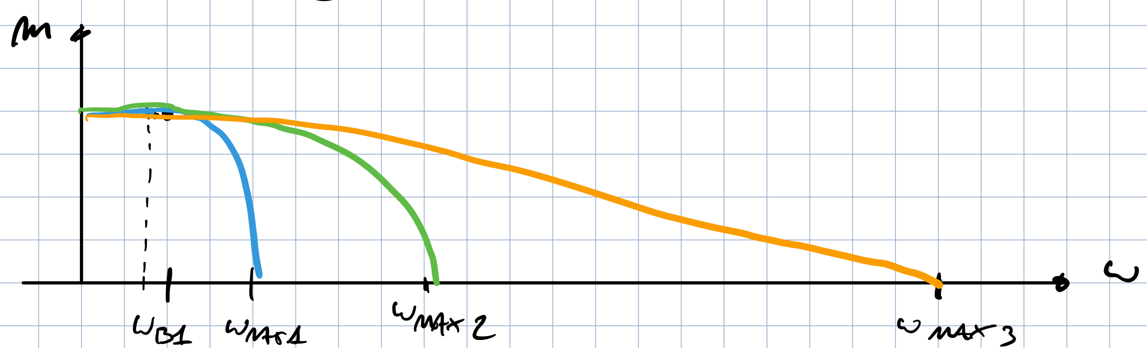
Fissati $\lambda_m = 0{,}122 \ Vs$

$V_n = 204 V$ $\quad I_n = 282{,}8 \ A$

Ricalcolo ω_{max} $L_{tot} = L + L_{est}$

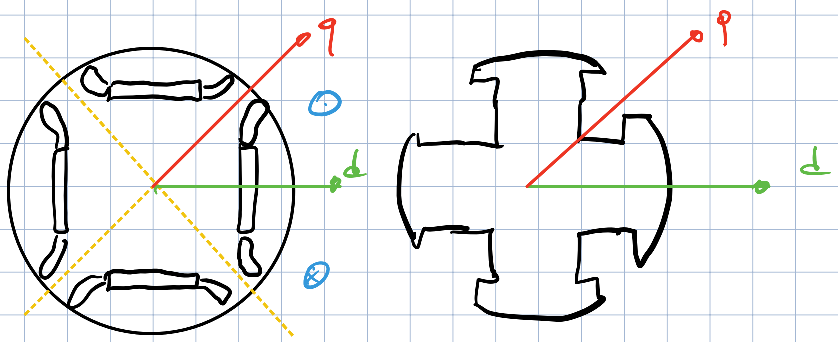
Cambiare anche $\longrightarrow$ $\omega_B = \dfrac{V_M}{\sqrt{\lambda_m^2 + (L_{tot} I_M)^2}}$

L_{est}	0	0,15	0,25	mH
L_{tot}	0,15	0,30	0,40	mH
ω_B meccanica	394	343	306	rad/s
	3770	3277	2927	rpm
ω_{max}	640	1372	5743	rad/s
meccanica	6120	13105	54 844	rpm
	①	②	③	

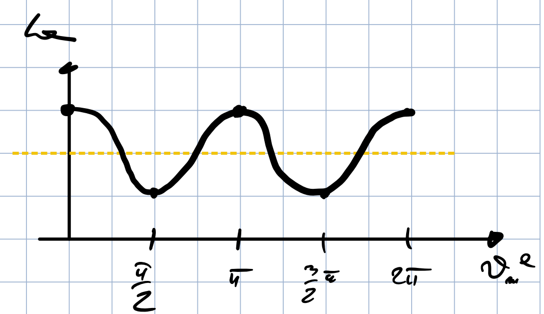


MACCHINA ANISOTROPA

$$\begin{cases} v_a = R i_a + \dfrac{d\lambda_a}{dt} \\ v_b = R i_b + \dfrac{d\lambda_b}{dt} \\ v_c = R i_c + \dfrac{d\lambda_c}{dt} \end{cases} \qquad \begin{cases} \lambda_a = \lambda_{am} + \lambda_{ai} \\ \lambda_b = \lambda_{bm} + \lambda_{bi} \\ \lambda_c = \lambda_{cm} + \lambda_{ci} \end{cases}$$



$$\begin{cases} \lambda_{ai} = L_a(\vartheta_m) i_a + M_{ab}(\vartheta_m) i_b + M_{ac}(\vartheta_m) i_c \\ \lambda_{bi} = M_{ba}(\vartheta_m) i_a + L_b(\vartheta_m) i_b + M_{bc}(\vartheta_m) i_c \\ \lambda_{ci} = M_{ca}(\vartheta_m) i_a + M_{cb}(\vartheta_m) i_b + L_c(\vartheta_m) i_c \end{cases}$$



$$\vec{v} = R\vec{i} + \frac{d\vec{\lambda}}{dt}$$ in $\alpha\beta$ o Rif. STAZIONARIO

$$\vec{v}^R = R\vec{i}^R + \frac{d\vec{\lambda}^R}{dt} + j\omega\vec{\lambda}^R$$ in dq o Rif. ROTANTE

$$\begin{cases} v_d = R i_d + \dfrac{d\lambda_d}{dt} - \omega \lambda_q \\ v_q = R i_q + \dfrac{d\lambda_q}{dt} + \omega \lambda_d \end{cases} \qquad \begin{cases} \lambda_d = \lambda_m + L_d i_d \\ \lambda_q = L_q i_q \end{cases}$$

← QUESTO SI PUÒ DIMOSTRARE

$$\begin{cases} v_d = R i_d + L_d \dfrac{di_d}{dt} - \omega_m^e L_q i_q \\ v_q = R i_q + L_q \dfrac{di_q}{dt} + \omega_m^e (\lambda_m + L_d i_d) \end{cases}$$

$$\begin{bmatrix} v_d \\ v_q \end{bmatrix} = R \begin{bmatrix} i_d \\ i_q \end{bmatrix} + \begin{bmatrix} L_d \\ L_q \end{bmatrix}^T \frac{d}{dt} \begin{bmatrix} i_d \\ i_q \end{bmatrix} + \begin{bmatrix} 0 & -\omega_m^e L_q \\ \omega_m^e L_d & 0 \end{bmatrix} \begin{bmatrix} i_d \\ i_q \end{bmatrix} + \begin{bmatrix} 0 \\ \omega_m^e \lambda_m \end{bmatrix}$$

$$v_d i_d = R i_d^2 + L_d i_d \frac{di_d}{dt} - \omega_m^e L_q i_q i_d$$

$$v_q i_q = R i_q^2 + L_q i_q \frac{di_q}{dt} + \omega_m^e i_q (\lambda_m + L_d i_d)$$

$\frac{3}{2}$ ⊕ ―――――――――――

P_{in} | P_J | $\frac{dW_m}{dt}$ | P_{out}

$$P_m = \frac{3}{2} p \omega_m \left[\lambda_m i_q + L_d i_d i_q - L_q i_d i_q \right]$$

$$= \frac{3}{2} p \omega_m \left[\lambda_m i_q + (L_d - L_q) i_d i_q \right]$$

$$m = \frac{3}{2} p \left[\lambda_m i_q + (L_d - L_q) i_d i_q \right]$$

Coppia dalle PM — Coppia di Riluttanza

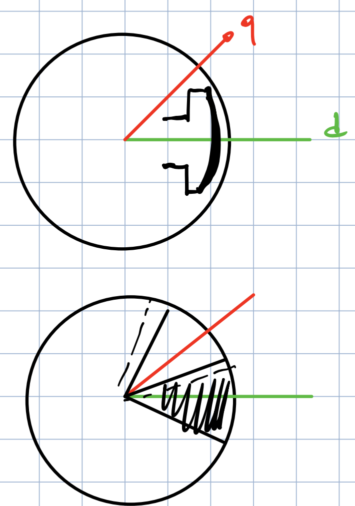
$L_d = L_q = L \Rightarrow$ MACCHINA ISOTROPA

Se $L_d < L_q \Rightarrow i_d < 0$ per avere $m \nearrow$

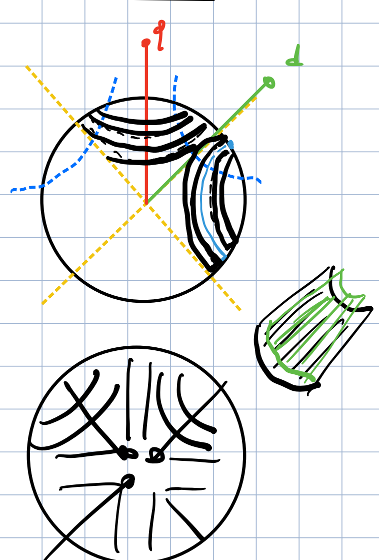
$\lambda_m = 0 \Rightarrow$ MACCHINA A RILUTTANZA "PURA"

SALIENZA $\xi = \frac{L_q}{L_d} > 1$

$\xi' = \frac{L_d}{L_q}$



$\underline{L_d - L_q}$



L_d L_q

ASSE "d"

ASSE "q"