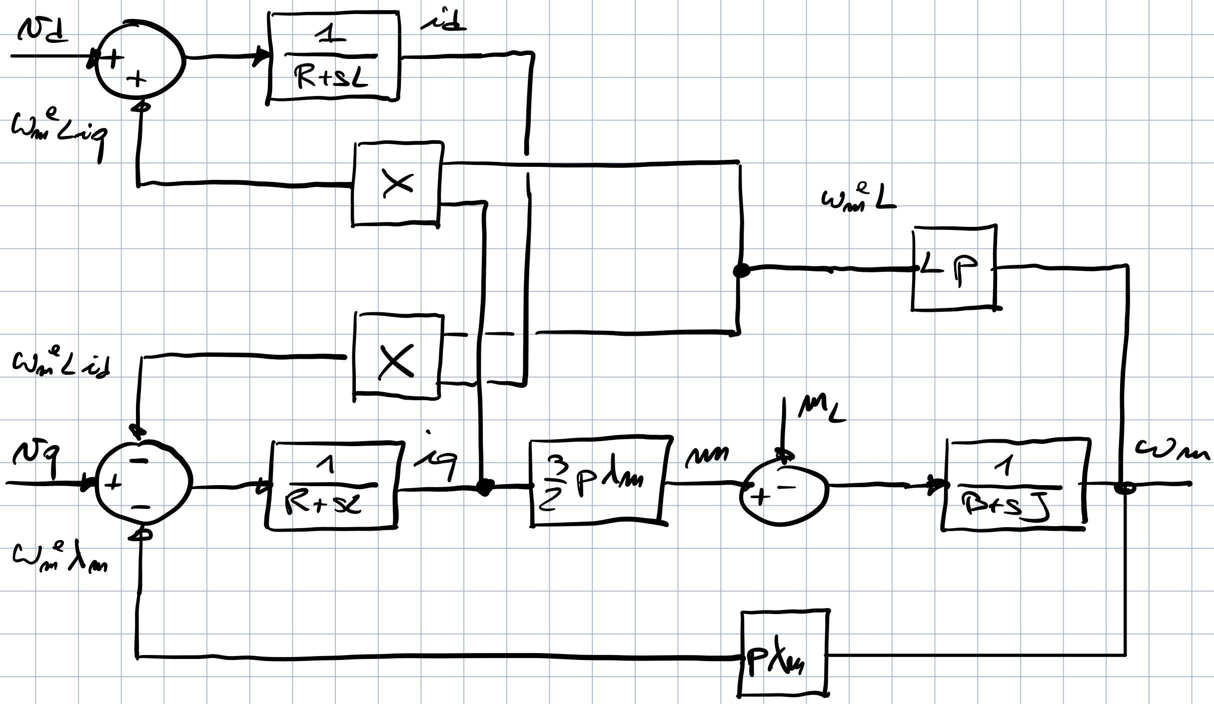
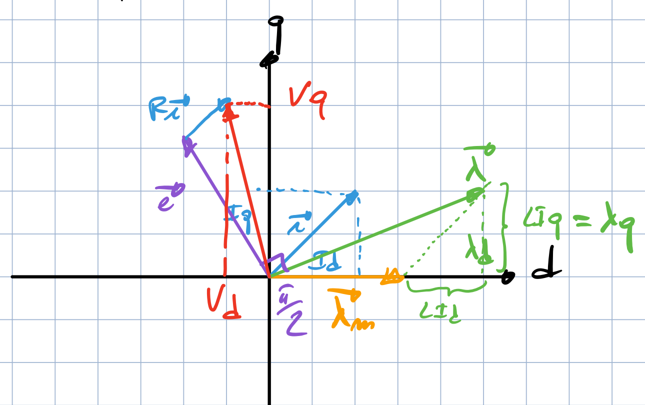
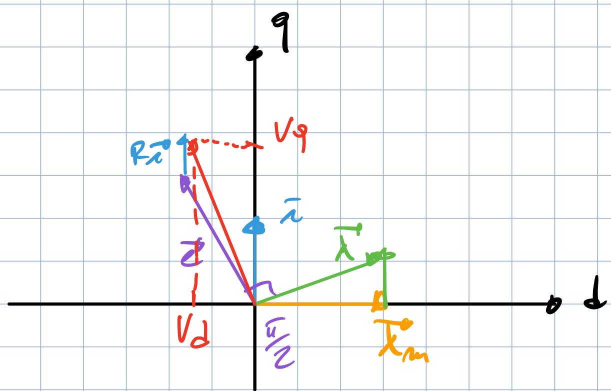


FUNZIONAMENTO A REGIME (SINUSOIDALE)

$$\begin{cases} V_d = R I_d - \omega_m^e \lambda_q \\ V_q = R I_q + \omega_m^e \lambda_d \end{cases} \qquad \begin{cases} \lambda_d = \lambda_m + L I_d \\ \lambda_q = L I_q \end{cases} \qquad m = \frac{3}{2} p \lambda_m I_q$$



$j\omega \vec{\lambda} = \vec{e}$



In MTPA

Esercizio

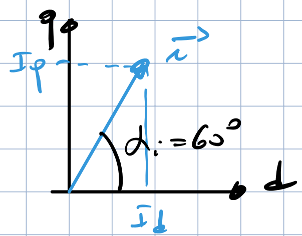
Dato un motore con:

$\lambda_m = 0,3\ Vs$
$R = 0,45\ \Omega$
$L = 18\ mH$
$p = 3 \quad (2p = 6)$

$I = 15\ A \quad \alpha_i = 60°$
$\omega_m = 1000\ rpm$
$\omega_m^e = 314\ \frac{rad}{s} \quad f = 50\ Hz$

a) Coppia sviluppata

$$m = \frac{3}{2} p \lambda_m I_q = \frac{3}{2} \cdot 3 \cdot 0,3 \cdot 15 \text{ sen} 60 = 17,55\ Nm$$



$|\vec{i}| = 15 \quad \begin{cases} I_d = 7,5 A \\ I_q = 13 A \end{cases}$

$$P_m = m \cdot \omega_m = 17,55 \cdot 1000 \frac{2\pi}{60} = 1837,8\ W$$

b) Tensione di alimentazione

$$\begin{cases} V_d = R I_d - \omega_m^e L I_q = 0,45 \cdot 7,5 - 314 \cdot 0,018 \cdot 13 = 3,375 - 73,51 = -70,13 V \\ V_q = R I_q + \omega_m^e (\lambda_m + L I_d) = 0,45 \cdot 13 + 314 (0,3 + 0,018 \cdot 7,5) = 5,85 + 136,7 = 142,5 V \end{cases}$$

$$V = \sqrt{V_d^2 + V_q^2} = \sqrt{70,13^2 + 142,5^2} = 158,8 V \quad (\text{di cui } RI \ 6,75 V)$$

$$V_{rms} = \frac{V}{\sqrt{2}} = 112,3 V$$

$$I_{rms} = \frac{15}{\sqrt{2}} = 10,6 A$$

$$S = 3 V_{rms} I_{rms} = 3571\ VA$$

$$\vec{V} = -70,13 + j 142,5 = 158,8\ e^{j 116,2°}$$

$$P = 3 \frac{VI}{2} \cos(116,2 - 60) = 1987,6\ W$$

$$P_J = 3 R \frac{I^2}{2} = 3 \cdot 0,45 \cdot \frac{15^2}{2} = 151,8\ W$$

$$P_{in} = P_m + P_J = 1837,8 + 151,8 = 1989 \simeq 1987,6$$

PROVARE A FARE DIAGRAMMA VETTORI DI SPAZIO

c) Quale sarebbe la massima coppia ottenibile con $I = 15\,A$

$$m_{max} = \frac{3}{2} p \lambda_m I \qquad \alpha_i = 90°$$

$$= \frac{3}{2} \cdot 3 \cdot 0{,}3 \cdot 15 = 20{,}25\ Nm$$

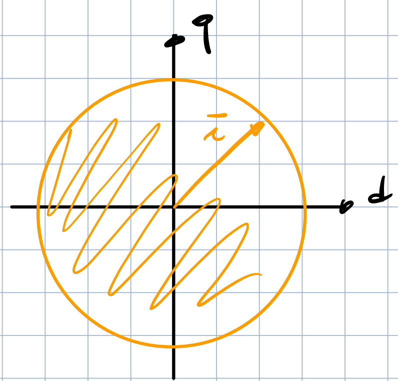
$$P_{m,max} = 2120{,}6\ W$$

Se voglio funzionare con $\omega_m' = 2000\,rpm$ $\qquad \omega_m^e = 628\ \frac{rad}{s}$

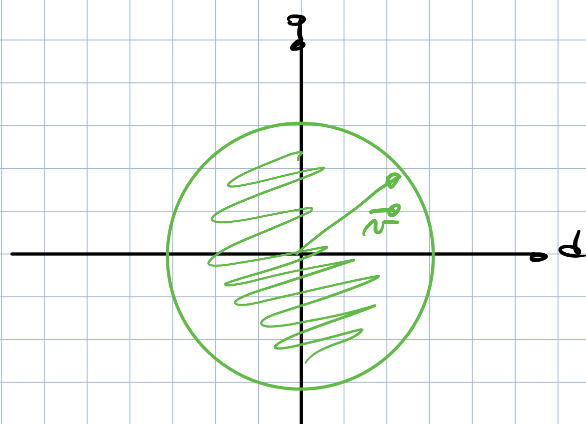
$$\left.\begin{aligned} V_d' &\cong 2V_d = -150\,V \\ V_q' &\cong 2V_q = 285\,V \end{aligned}\right\} \quad V' \cong 2V = 317\,V$$

DIAGRAMMI LIMITE

Limite di corrente



Limite di tensione



$$\bar{v} = R\bar{i} + L\frac{d\bar{i}}{dt} + j\omega_m^e \bar{\lambda}$$

Regioni di funzionamento

$$\begin{cases} V_d = \cancel{R I_d} - \omega_m^e L I_q \\ V_q = \cancel{R I_q} + \omega_m^e (\lambda_m + L I_d) \end{cases}$$

$R \cong 0$

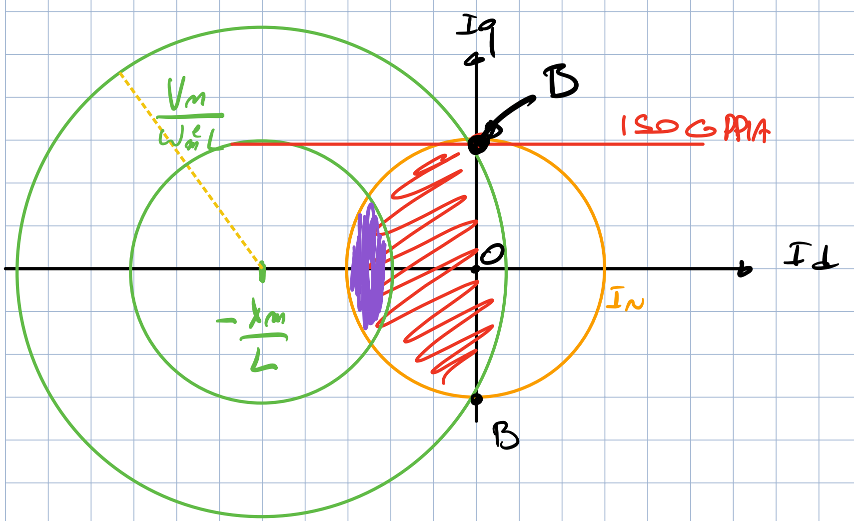
ω_m^e come parametro

$I_d^2 + I_q^2 \leq I_M^2$ limite corrente

$V_d^2 + V_q^2 \leq V_M^2$ limite tensione

$$(\omega_m^e L I_q)^2 + \left[\omega_m^e(\lambda_m + L I_d)\right]^2 \le V_m^2$$

$$I_q^2 + \left(\frac{\lambda_m}{L} + I_d\right)^2 \le \left(\frac{V_m}{\omega_m^e L}\right)^2 \qquad \left(I_d + \frac{\lambda_m}{L}\right)^2 + I_q^2 \le \left(\frac{V_m}{\omega_m^e L}\right)^2$$

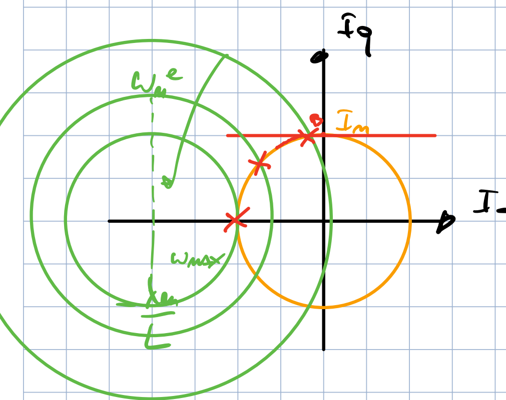


Note :
$$\begin{cases} 0 = \omega_m^e L I_q & I_q = 0 \\ 0 = \omega_m^e(\lambda_m + L I_d) = 0 & I_d = -\dfrac{\lambda_m}{L} \end{cases}$$

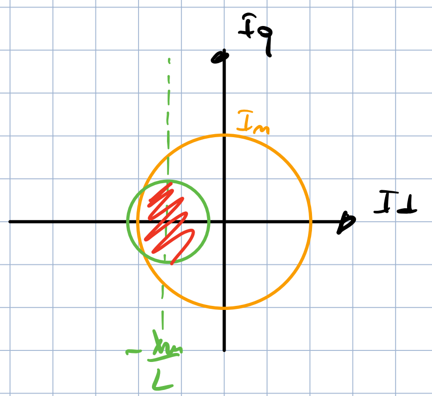
$$I_{ch} = -\frac{\lambda_m}{L}$$

$$m = \frac{3}{2} p \lambda_m I_q$$

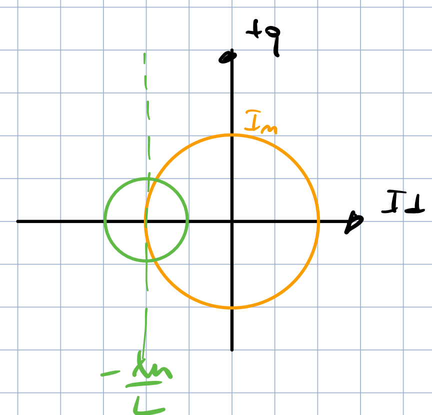
In funzione del valore di I_{ch} si possono avere 3 casi



$|I_{ch}| > I_m$



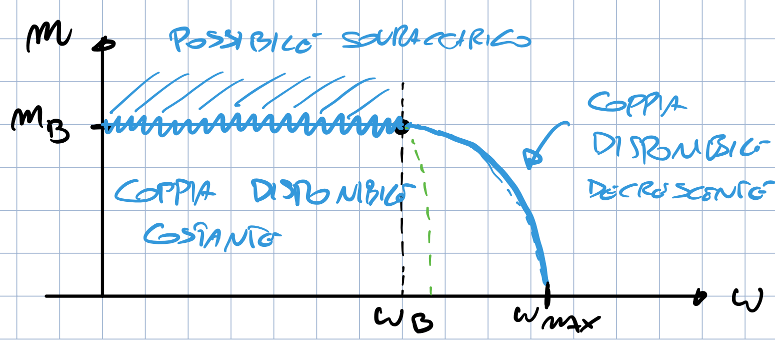
$|I_{ch}| < I_m$



$|I_{ch}| = I_m$

B Punto Base

$\overline{OB}$ MTPA



Quanto vale $\omega_B = \omega_m^e$?

$$(\omega_B L I_q)^2 + \omega_B^2(\lambda_m + \cancel{L I_d})^2 = V_m^2$$

$I_p = I_m \qquad I_d = 0$

$$(\omega_B \lambda_m)^2 + (\omega_B L I_m)^2 = V_m^2$$

$$\omega_B = \frac{V_m}{\sqrt{\lambda_m^2 + (L I_m)^2}}$$

$$V_d^2 + V_q^2 = V_m^2$$

$$I_d = -I_m \qquad I_q = 0 \qquad \omega_m^e = \omega_{max}$$

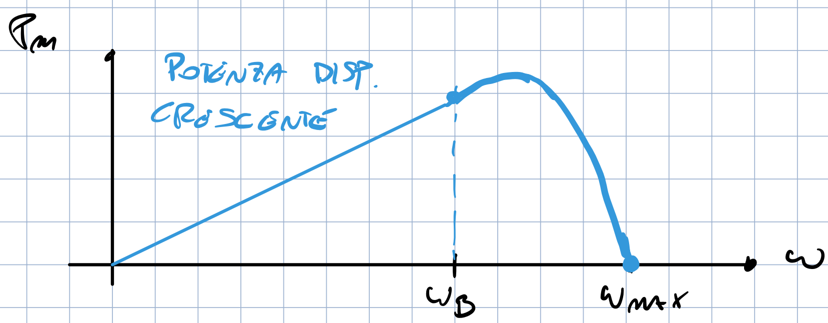
$$(\omega_{max} \cdot 0)^2 + \omega_{max}^2 (\lambda_m + L I_d)^2 = V_m^2$$

Note: se $L I_m \ll \lambda_m$

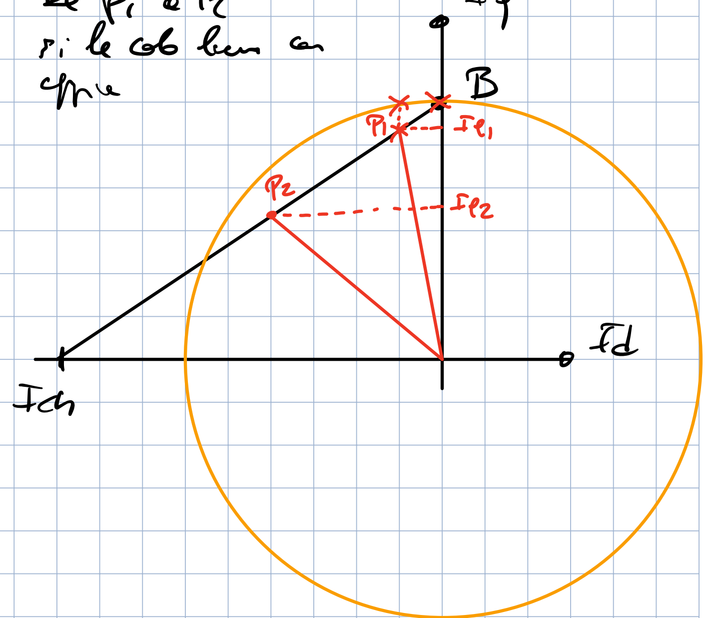
$$\omega_{max} \cong \omega_B$$

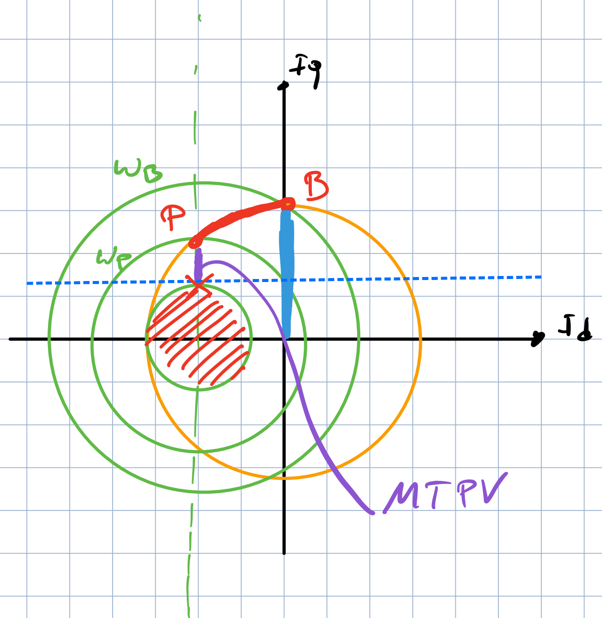
$$\omega_{max}^2 (\lambda_m - L I_m)^2 = V_m^2$$

$$\omega_{max} = \frac{V_m}{\lambda_m - L I_m}$$



De P_1 e P_2 si le cob ben con cerchio





Note: $I_d < 0 \qquad \omega_m^e > \omega_B$

DEFLUSSAGGIO

INDEBOLISCO λ_m

$$\begin{cases} \lambda_d = \lambda_m + L I_d \\ \lambda_q = L I_q \end{cases}$$

$$V_m = \omega \lambda$$