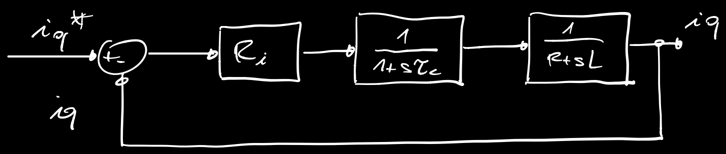
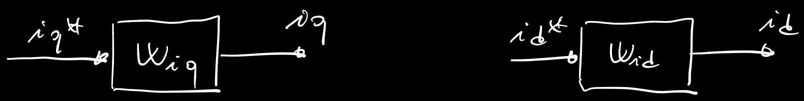
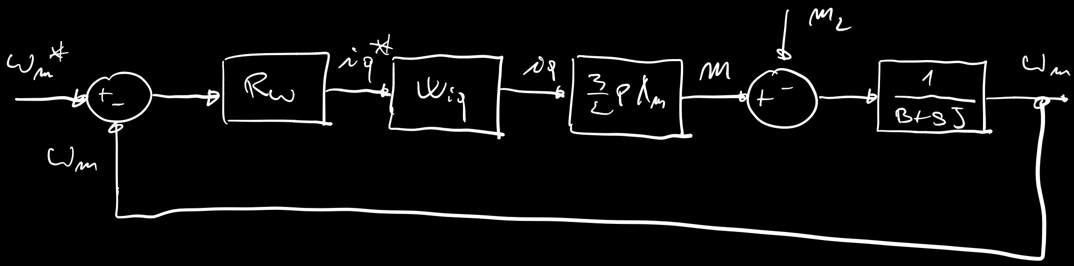
Esempio







Dati:

$R = 1{,}5\ \Omega$

$L = 5\ mH$ (SPM)

$T_c = 100\ \mu s$

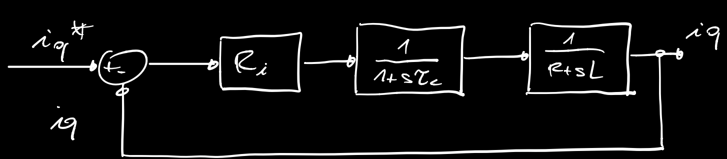
$\lambda_m = 0{,}067\ Vs$

$2p = 8$

$B = 0{,}00112\ \frac{Nm}{rad/s}$

$J = 929 \cdot 10^{-3}\ kg\, m^2$

Inizio dell'anello di corrente

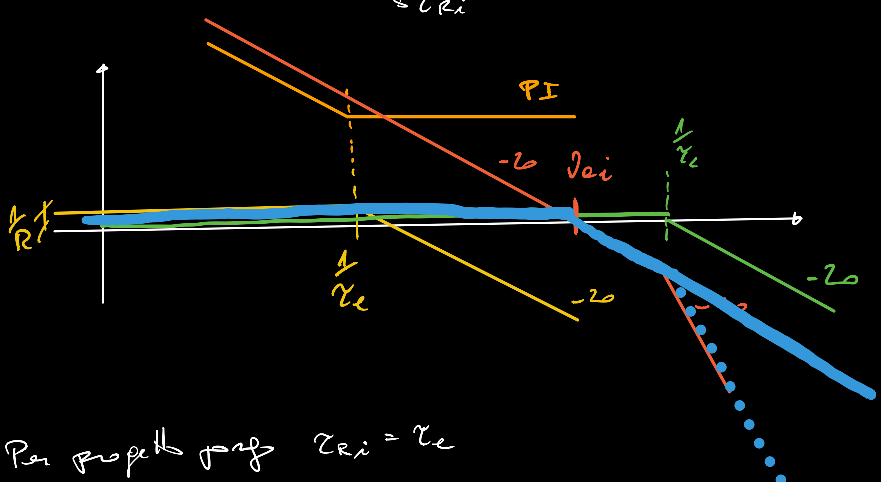


$\tau_c = \frac{3}{2} T_c = 150\ \mu s$

$$\frac{1}{R+sL} = \frac{1/R}{1+s\frac{L}{R}} = \frac{1/R}{1+s\tau_e}$$

$$\tau_e = \frac{L}{R} = \frac{5}{1{,}5} \cdot 10^{-3} = 3{,}3\ ms$$

R_i : PI $\quad R_i = k_{pi} \frac{1+s\tau_{Ri}}{s\tau_{Ri}}$



Per progetto pongo $\tau_{Ri} = \tau_e$

$$GH(s) = k_{pi} \frac{\cancel{1+s\tau_e}}{s\tau_e} \cdot \frac{1}{1+s\tau_c} \cdot \frac{1/R}{\cancel{1+s\tau_e}} = \frac{k_{pi}}{R} \frac{1}{s\tau_e} \frac{1}{1+s\tau_c}$$

$$GH(j\nu) = \frac{K_{pi}}{R}\,\frac{1}{j\nu\tau_e(1+j\nu\tau_c)}$$

$$\begin{cases} |GH| = \dfrac{K_{pi}/R\tau_e}{\nu\sqrt{1+(\nu\tau_c)^2}} \\[2ex] \arg[GH] = 0 - 90° - \arctan(\nu\tau_c) \end{cases}$$

Impongo $M\phi = 70° = 180° + \arg[GH(\nu_{ei})]$

$$70° = 180 - 90° - \arctan[\nu_{ei} \cdot 150 \cdot 10^{-6}]$$

$$\nu_{ei} = \frac{\tan 20°}{150 \cdot 10^{-6}} = 2426 \ \frac{rad}{s}$$

Posso ora calcolare K_{pi} imponendo $|GH(\nu_{ei})| = 1 = \dfrac{\frac{K_{pi}}{R\tau_e}}{\nu_{ei}\sqrt{1+(\nu_{ei}\cdot\tau_c)^2}}$

$$K_{pi} = \dots = 12{,}78 \ \frac{V}{A}$$

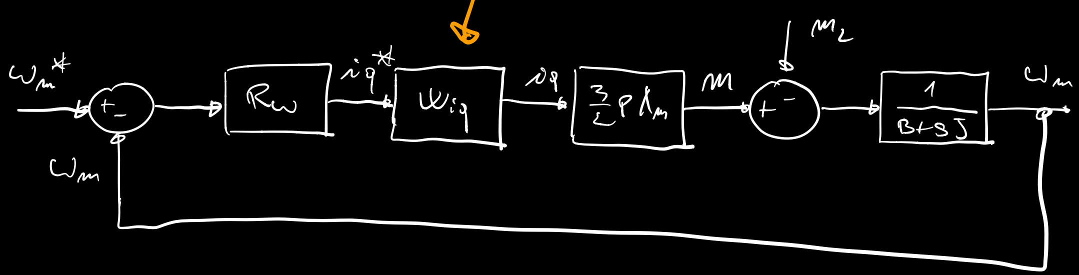
$$R_i = 12{,}78 \ \frac{1 + s \cdot 3{,}5 \cdot 10^{-3}}{s \cdot 3{,}5 \cdot 10^{-3}}$$

$$W_{iq} = \frac{GH}{1+GH} = \frac{1}{1 + s\frac{1}{\nu_{ei}}} = \frac{1}{1+s\tau_{ei}} \qquad \tau_{ei} = \frac{1}{\nu_{ei}}$$

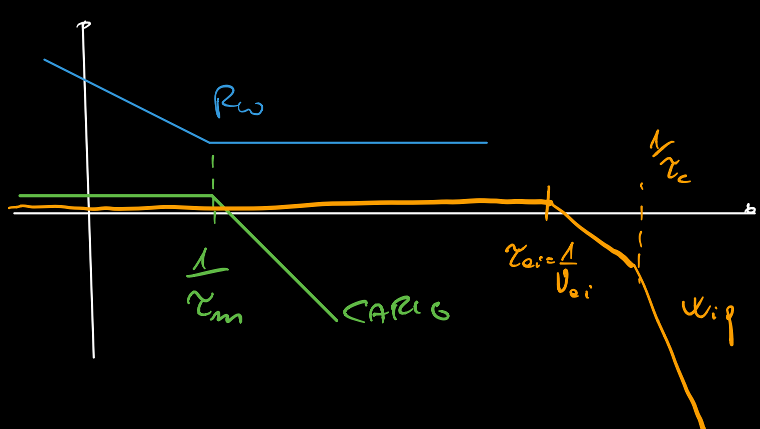
$$W_{iq} = \frac{1}{1+s\tau_{ei}}\,\frac{1}{1+s\tau_c}$$

USO QUESTA PER ESSERE PIÙ PRECISO!

Dimensiono ora R_ω



$$\frac{1}{B+sJ} = \frac{1/B}{1+s\tau_m} \qquad \tau_m = \frac{J}{B} = 0{,}15\,s$$



$$\tau_{R\omega} = \tau_m = 0{,}15\,s$$

$$GH(s) = k_{pw}\,\frac{1+\cancel{s\tau_m}}{s\tau_m}\cdot\frac{1}{1+s\tau_{ei}}\;\frac{1}{1+s\tau_c}\;\frac{\frac{3}{2}p\lambda_m\frac{1}{B}}{\cancel{1+s\tau_m}}$$

$$= \frac{k_{pw}}{\tau_m}\;\frac{3p\lambda_m}{2B}\;\frac{1}{s}\;\frac{1}{1+s\tau_{ei}}\;\frac{1}{1+s\tau_c}$$

$\tau_{ei} = 512\cdot10^{-6}\,s$

$\tau_c = 150\cdot10^{-6}\,s$

$\tau_m = 0{,}15\,s$

Impongo $M\phi = 70° = 180 + \arg[GH(j\omega_{cw})]$

$$20° = \arctan(\omega_{cw}\,512\cdot10^{-6}) + \arctan(\omega_{cw}\cdot150\cdot10^{-6})$$

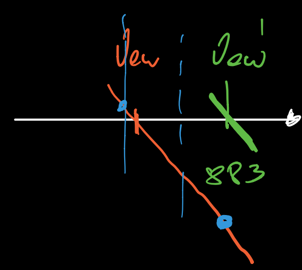
è trascendente!

Se trascuro polo $\frac{1}{\tau_c}$: $20° = \arctan(\omega'_{cw}\,512\cdot10^{-6})$

$$\omega'_{cw} = \frac{\tan 20}{512\cdot10^{-6}} = 883\ \frac{rad}{s}$$

SICURAMENTE È MAGGIORE DI ω_{cw} VERA!

$$f(\omega) = 20° - \arctan(\omega\,512\cdot10^{-6}) - \arctan(\omega\cdot150\cdot10^{-6})$$



ω	$f\,\omega$
883	-0,13
800	-0,088
700	-0,036
600	0,017
650	-0,0098
625	0,0036
630	$1\cdot10^{-3}\approx 0$ ok!

$$\omega_{cw} = 630\ \frac{rad}{s}$$

Numericamente $\omega_{cw} = 631\ \frac{rad}{s}$

$$|GH(\omega_{cw})| = 1 = \frac{k_{pw}\,3p\lambda_m}{2B\tau_m}\;\frac{1}{\omega_{cw}}\;\frac{1}{\sqrt{1+(\omega_{cw}\tau_{ei})^2}}\;\frac{1}{\sqrt{1+(\omega_{cw}\tau_c)^2}}$$

$$k_{pw} = \dots = 0{,}586\ \frac{A}{rad/s}$$

$$R_w = k_{pw}\,\frac{1+s\tau_{rw}}{s\tau_{rw}} = 0{,}586\ \frac{1+s\cdot0{,}15}{s\cdot0{,}15}$$

1 Block diagrams

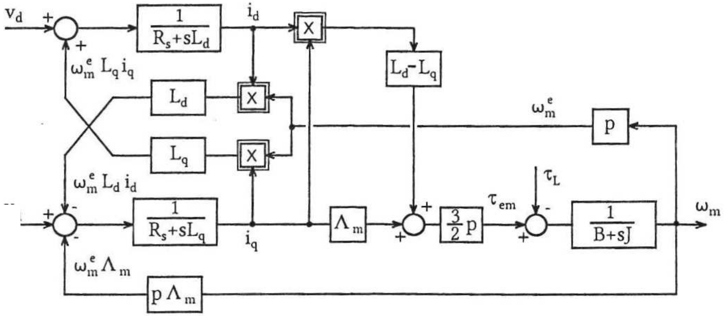


Figura 1: Scheme of the IPM motor vector control.

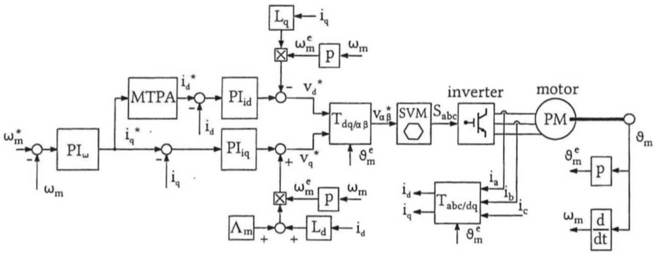


Figura 3: Scheme of the IPM motor vector control with $d-q$ axis decoupling and compensation of the EMF induced by the PM flux linkage.

SPM
$I_d=0$

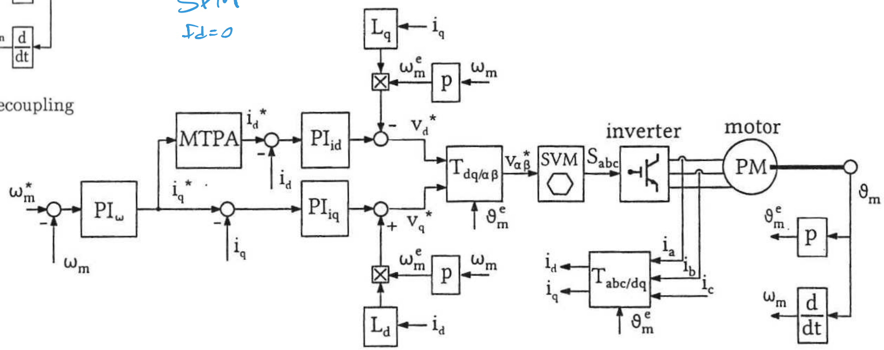
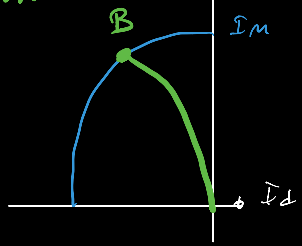
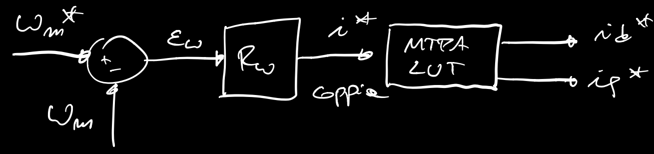
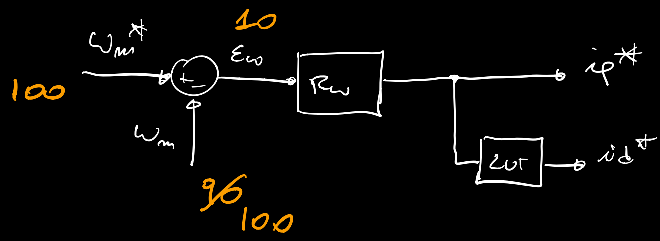


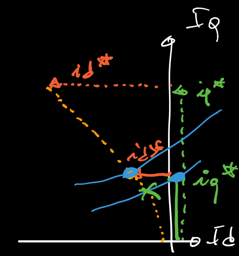
Figura 2: Scheme of the IPM motor vector control with decoupling between the two axes.

MTPA



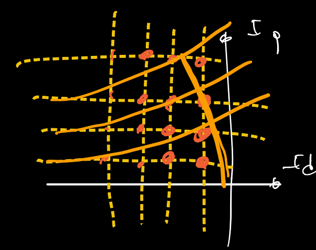






MTPA OFF-LINE

PREDETERMINO MTPA
- CALCOLO
- STIMA
- MISURE



MTPA – ON LINE

STIMO DURANTE IL FUNZIONAMENTO SE MI TROVO O NO NEL PUNTO / TRAIETTORIA DI MTPA

SI OTTIENE CON TECNICHE DI PERTURBAZIONE