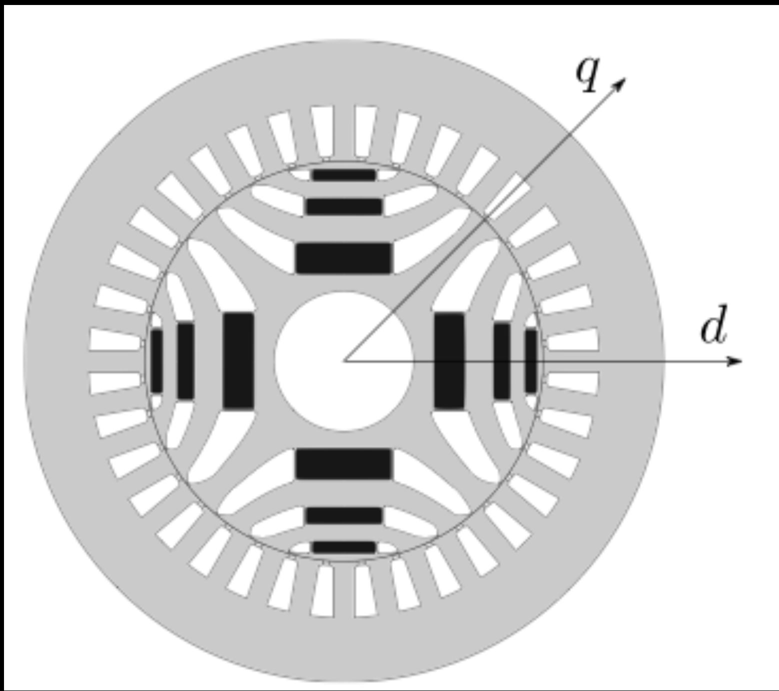
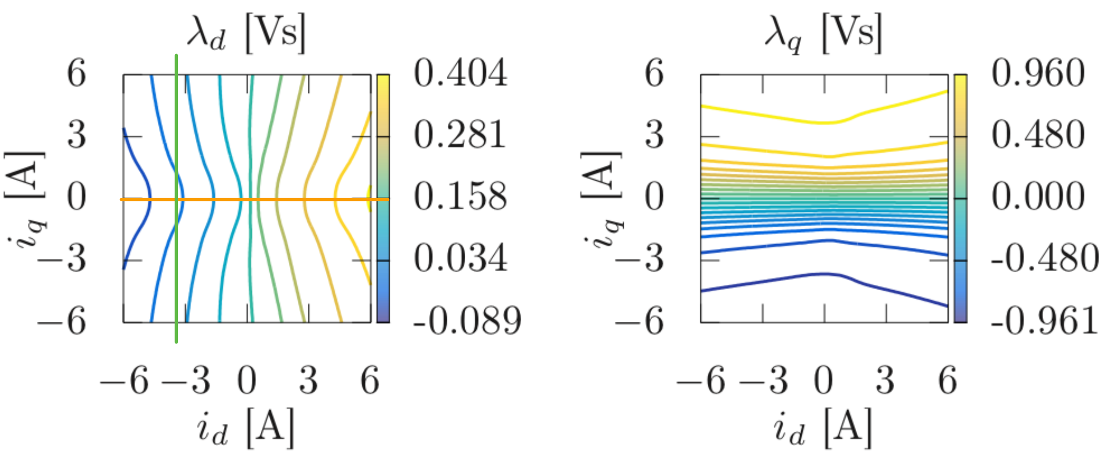
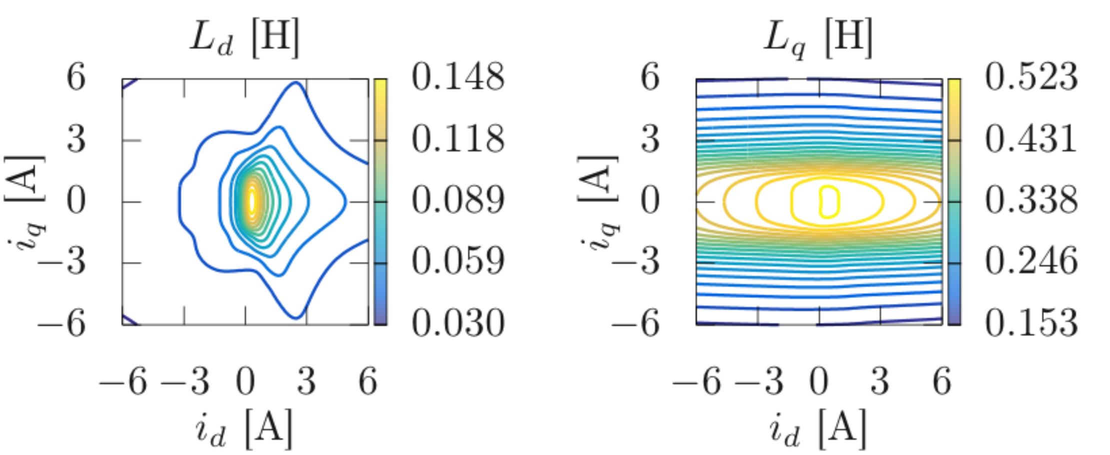




(a) (b)

Fig. 4: PMA-SynRM flux-linkages maps (finite element analysis). (a) $\lambda_d(i_d, i_q)$ (b) $\lambda_q(i_d, i_q)$



(a) (b)

Fig. 6: PMA-SynRM apparent inductances maps (finite element analysis). (a) $L_d(i_d, i_q)$ (b) $L_q(i_d, i_q)$

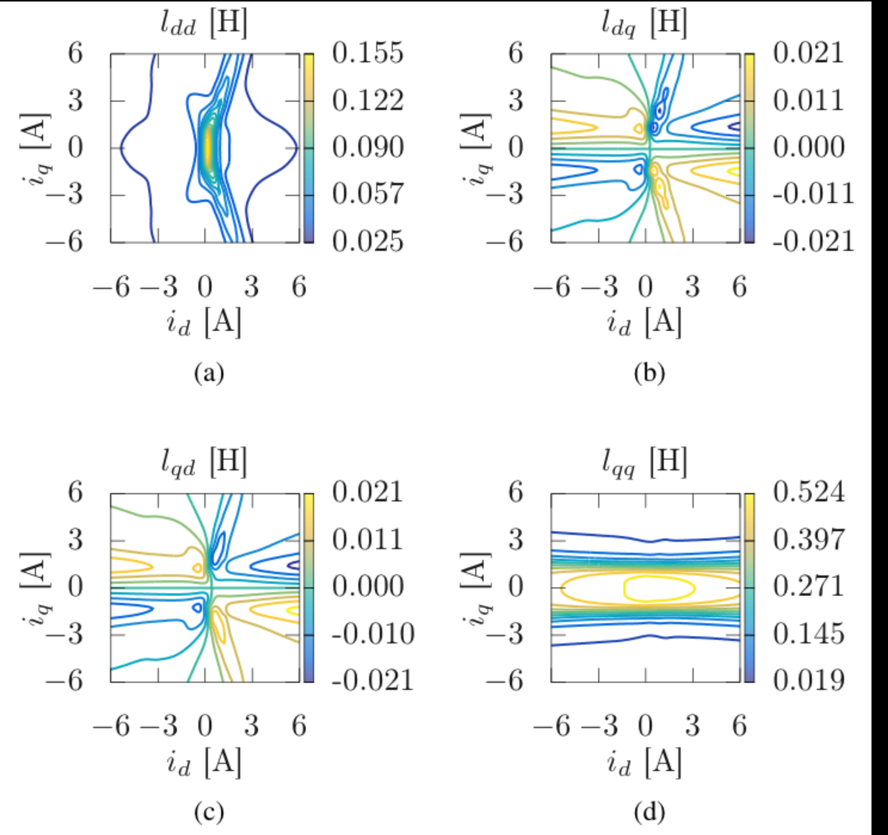


Fig. 7: PMA-SynRM incremental inductances maps (finite element analysis). (a) $l_{dd}(i_d, i_q)$ (b) $l_{dq}(i_d, i_q)$ (c) $l_{qd}(i_d, i_q)$ (d) $l_{qq}(i_d, i_q)$

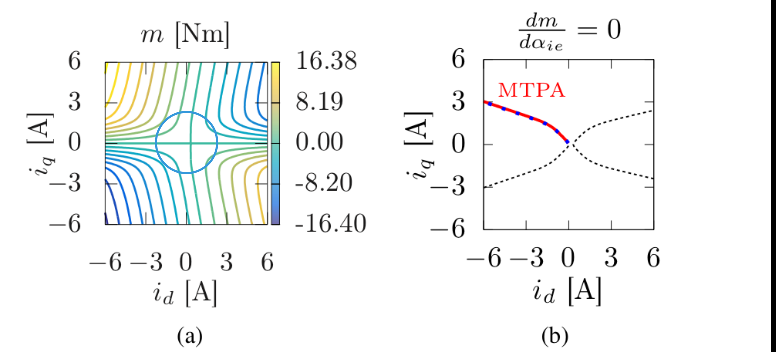


Fig. 8: PMA-SynRM torque map and MTPA trajectory (finite element analysis). (a) $m(i_d, i_q)$ (b) $\frac{\partial m(i_d,i_q)}{\partial \alpha_{ie}} = 0$. In red, MTPA trajectory computed with (8). In blue, MTPA trajectory computed with (10).

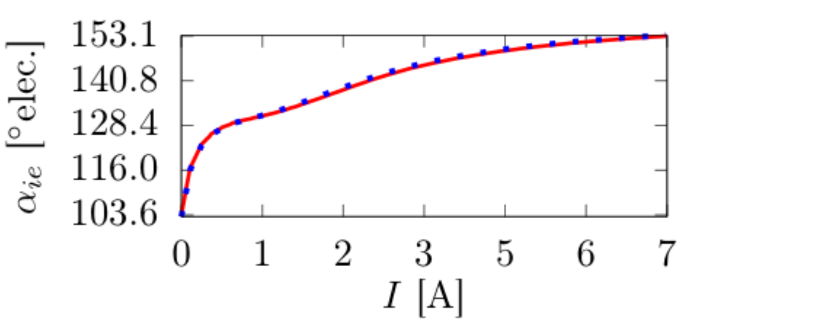


Fig. 9: PMA-SynRM MTPA trajectory in polar coordinates (finite element analysis). In red, MTPA trajectory computed with (8). In blue, MTPA trajectory computed with (10).

$$m = \frac{3}{2} p \left(\lambda d \, iq - \lambda q \, id \right) \qquad MTPA: \ \frac{\partial m}{\partial \alpha_i} = 0$$

$$id = i \cos \alpha_i$$

$$iq = i \operatorname{sen} \alpha_i$$

$$\overbrace{\frac{\partial \lambda d}{\partial id} \frac{d\, id}{\partial \alpha_i} iq + \frac{\partial \lambda d}{\partial iq} \frac{d\, iq}{\partial \alpha_i} iq}^{\frac{d\lambda d}{d\alpha_i} iq} + \lambda d \frac{d\, iq}{d\alpha_i} - \Bigg[\overbrace{\frac{\partial \lambda q}{\partial id} \frac{d\, id}{\partial \alpha_i} id + \frac{\partial \lambda q}{\partial iq} \frac{d\, iq}{\partial \alpha_i} id}^{\frac{d\lambda q}{d\alpha_i} id} + \lambda q \frac{\partial id}{\partial \alpha_i} \Bigg] = 0$$

$$\frac{\partial \lambda d}{\partial id} = ldd \qquad \frac{\partial \lambda q}{\partial iq} = lqq \qquad \frac{\partial \lambda d}{\partial iq} = \frac{\partial \lambda q}{\partial id} = ldq = lqd$$

$$\frac{d\, id}{d\alpha_i} = -i \operatorname{sen} \alpha_i \qquad \frac{d\, iq}{d\alpha_i} = i \cos \alpha_i$$

$$\underline{ldd(-i \operatorname{sen} \alpha_i)\, i \operatorname{sen} \alpha_i} + ldq\, i \cos \alpha_i\, i \operatorname{sen} \alpha_i + \lambda d\, i \cos \alpha_i \ -$$

$$\left[ldq(-i \operatorname{sen} \alpha_i)\, i \cos \alpha_i + \underline{lqq\, i \cos \alpha_i\, i \cos \alpha_i} + \lambda q(-i \operatorname{sen} \alpha_i) \right] = 0$$

$$-ldd \underbrace{i^2 \operatorname{sen}^2 \alpha_i}_{iq^2} - lqq \underbrace{i^2 \cos^2 \alpha_i}_{id^2} + ldq \underbrace{i^2 \cos \alpha_i \operatorname{sen} \alpha_i}_{id\, iq} \cdot 2 + \lambda d \underbrace{i \cos \alpha_i}_{id} + \lambda q \underbrace{i \operatorname{sen} \alpha_i}_{iq} = 0$$

$$2\, ldq\, id\, iq - \left(ldd\, iq^2 + lqq\, id^2 \right) + \lambda d\, id + \lambda q\, iq = 0$$

$$2\, ldq\, id\, iq - \left(ldd\, iq^2 + lqq\, id^2 \right) + Ld\, id^2 + Lq\, iq^2 = 0 \qquad \text{LUOGO MTPA}$$

l_{xx} e L_x sono funzioni (id, iq)

MISURA DELLE CARATTERISTICHE $\lambda - i$

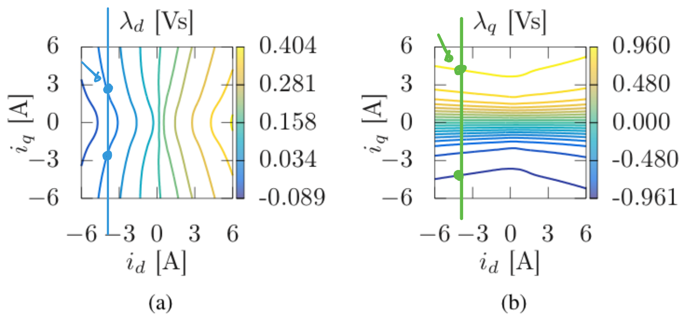
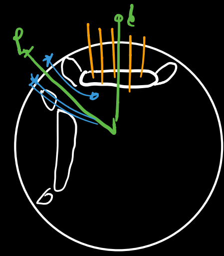


Fig. 4: PMA-SynRM flux-linkages maps (finite element analysis). (a) $\lambda_d(i_d, i_q)$ (b) $\lambda_q(i_d, i_q)$

$$\lambda_d(I_d, I_q^+) = \lambda_d(I_d, I_q^-)$$

$$\lambda_q(I_d, I_q^+) = -\lambda_q(I_d, I_q^-)$$



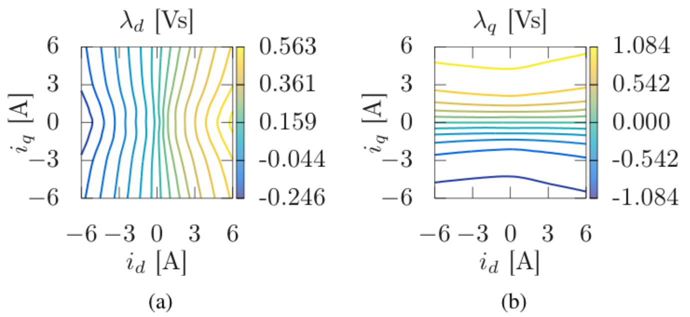
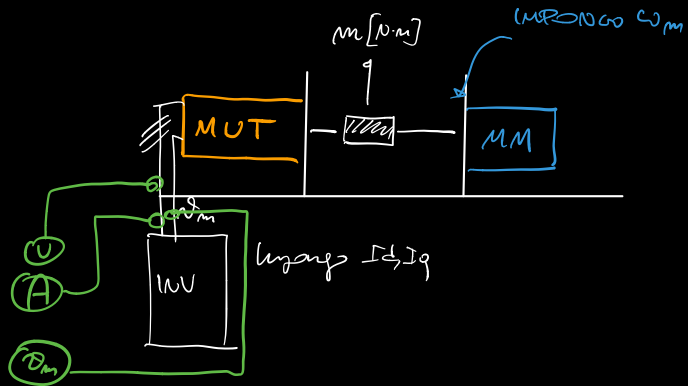


Fig. 5: PMA-SynRM flux-linkages maps (measurements). (a) $\lambda_d(i_d, i_q)$ (b) $\lambda_q(i_d, i_q)$

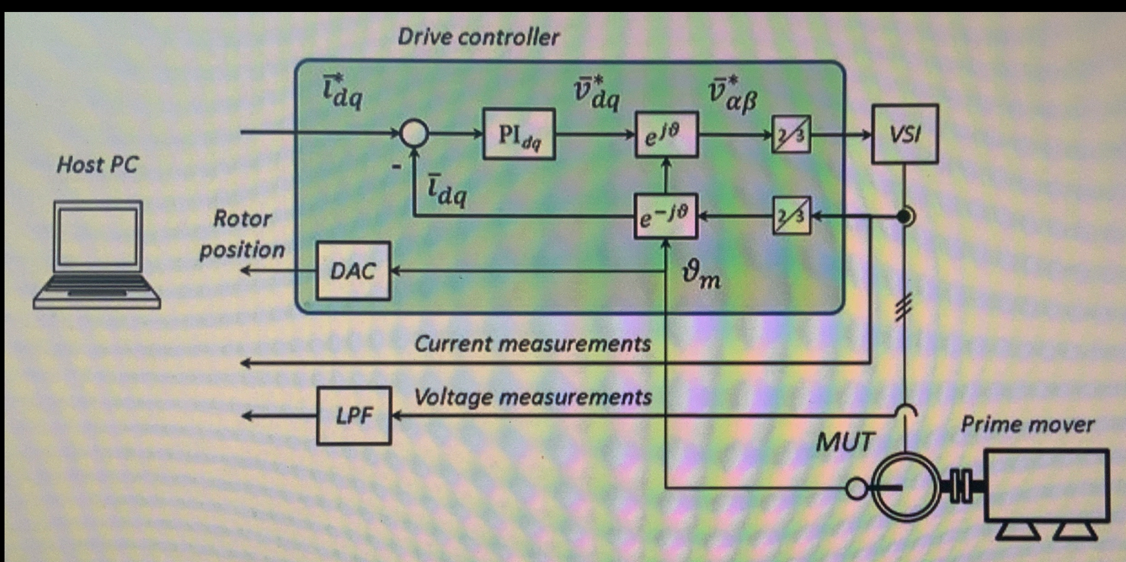


$$\begin{cases} V_d = R I_d - \omega_m^e \lambda_q \\ V_q = R I_q + \omega_m^e \lambda_d \end{cases}$$

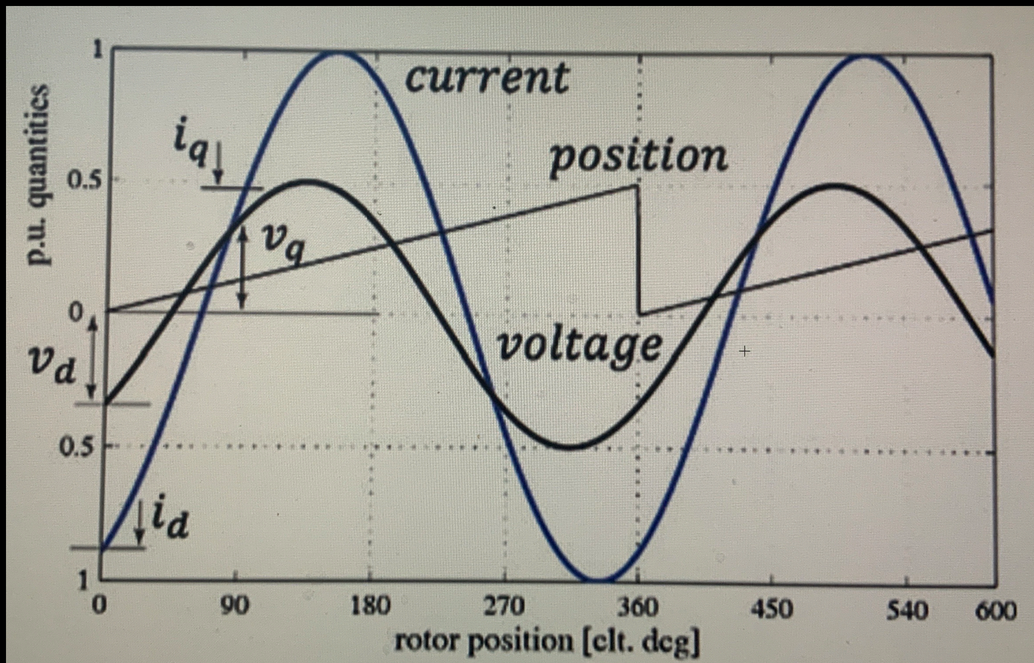
Misuro $\underbrace{v_{abc},\ i_{abc}}_{V_d, V_q,\ I_d, I_q}$, ϑ_m $\Rightarrow$ Post elaborazione off-line

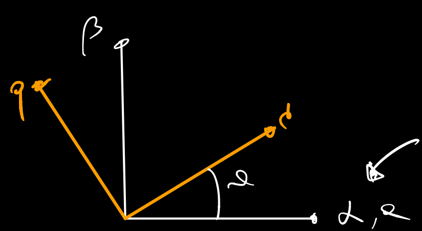
$$\lambda_q = \frac{-V_d + R I_d}{\omega_m^e}$$

$$\lambda_d = \frac{V_q - R i_q}{\omega_m^e}$$



$\vartheta_m^e = \omega_m^e t$





Provo ad eliminare le resistenze nel calcolo del λ_x

I_q^+ $\quad I_q^- = -I_q^+$ $\quad |I_q^+| = |I_q^-|$ $\quad$ Motore / generatore

$$\begin{cases} V_d = RI_d - \omega_m^e \lambda_q \\ V_q = RI_q + \omega_m^e \lambda_d \end{cases}$$

$$\begin{cases} V_d^+ = RI_d - \omega_m^e \lambda_q^+ \\ V_q^+ = RI_q^+ + \omega_m^e \lambda_d^+ \end{cases} \qquad I_d, I_q^+$$

$$\begin{cases} V_d^- = RI_d - \omega_m^e \lambda_q^- \\ V_q^- = RI_q^- + \omega_m^e \lambda_d^- \end{cases} \qquad I_d, I_q^-$$

Valgono le simmetrie: $\lambda_d^+ = \lambda_d^-$

$\lambda_q^+ = -\lambda_q^-$

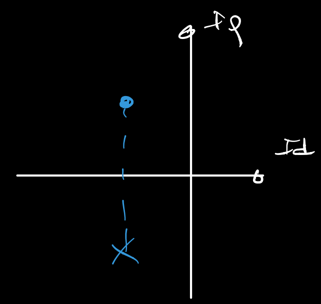
$$V_d^- - V_d^+ = \cancel{RI_d} - \omega_m^e(-\lambda_q^+) - \cancel{RI_d} + \omega_m^e \lambda_q^+ = 2\omega_m^e \lambda_q^+$$

$$V_q^+ + V_q^- = \cancel{RI_q^+} + \omega_m^e \lambda_d^+ + \cancel{R(-I_q^+)} + \omega_m^e \lambda_d^+ = 2\omega_m^e \lambda_d^+$$

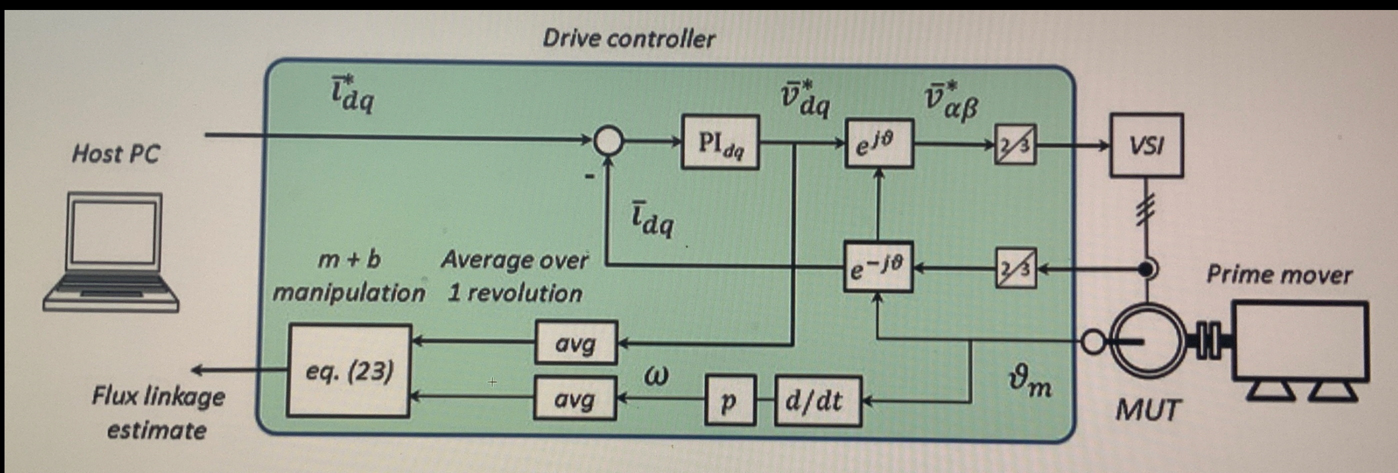
Da cui:

$$\lambda_d^+(I_d, I_q^+) = \frac{V_q^+ + V_q^-}{2\,\omega_m^e}$$

$$\lambda_q^+(I_d, I_q^+) = \frac{V_d^- - V_d^+}{2\,\omega_m^e}$$



Posso anche rimuovere le misure delle tensione e il filtro LPF



ALTRE TECNICHE PER CARATTERIZZARE / IDENTIFICARE I PARAMETRI

SELF-COMMISSIONING DELL'AZIONAMENTO