

Università degli Studi di Padova – Dipartimento di Ingegneria Industriale

Corso di Laurea in Ingegneria dell'energia

Relazione per la prova finale

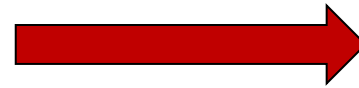
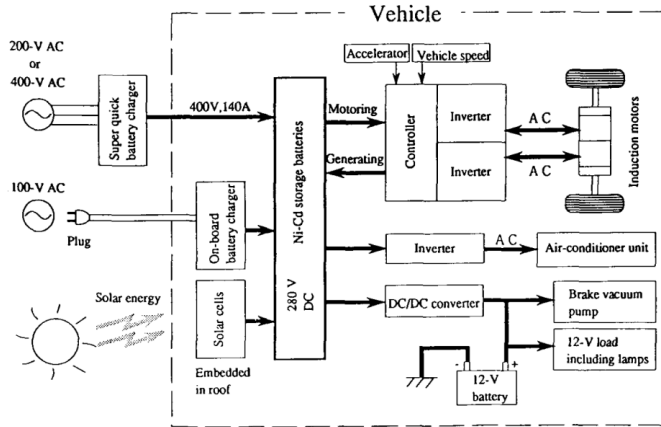
***«Utilizzo di motori elettrici nei trasporti, stima della
temperatura dei magneti nel motore sincrono a
magnet permanenti»***

Tutor universitario: Prof. Torchio Riccardo

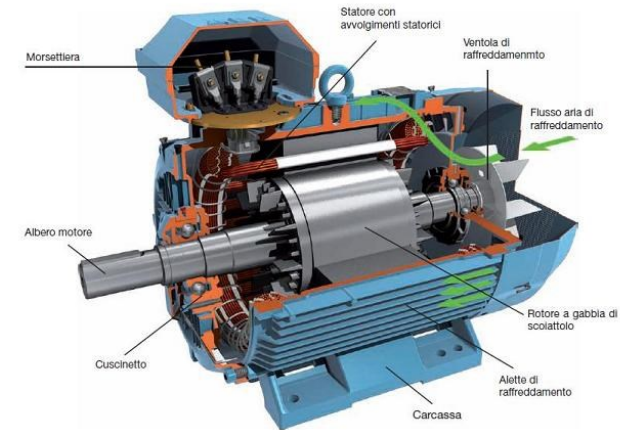
Laureando: *Bracchi Gabriele*

Padova, 21/11/2022

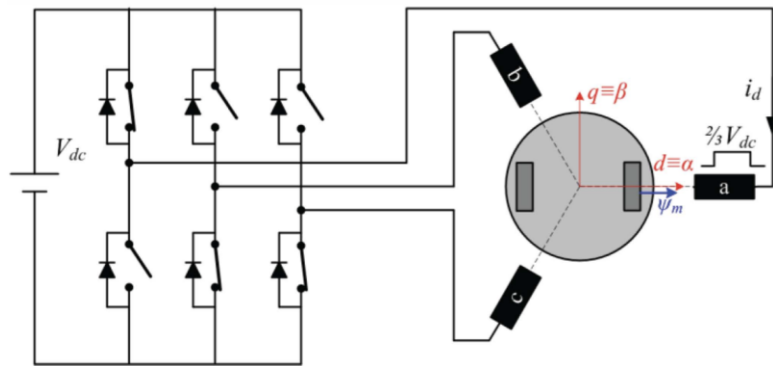
MOBILITÀ ELETTRICA



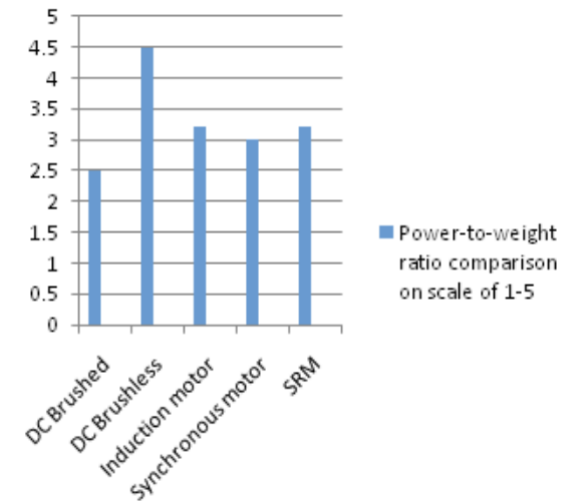
MOTORI ELETTRICI

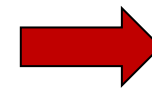
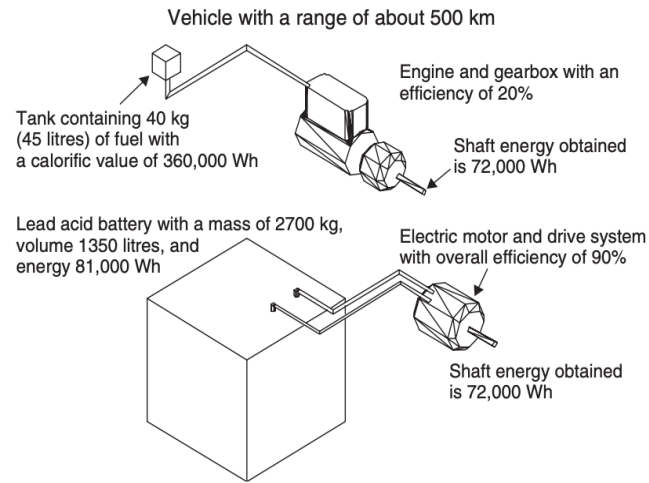


STIMA DI TEMPERATURA

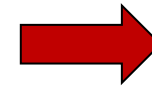


CONFRONTO



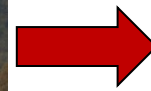


Energia specifica batteria al piombo 30Wh/kg (di cui 27 utili)

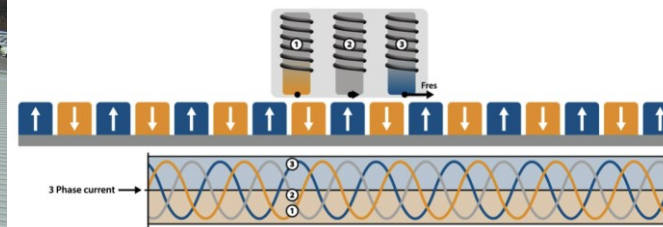


Energia specifica carburante petrolifero 9000 W/kg (di cui 1800 utili)

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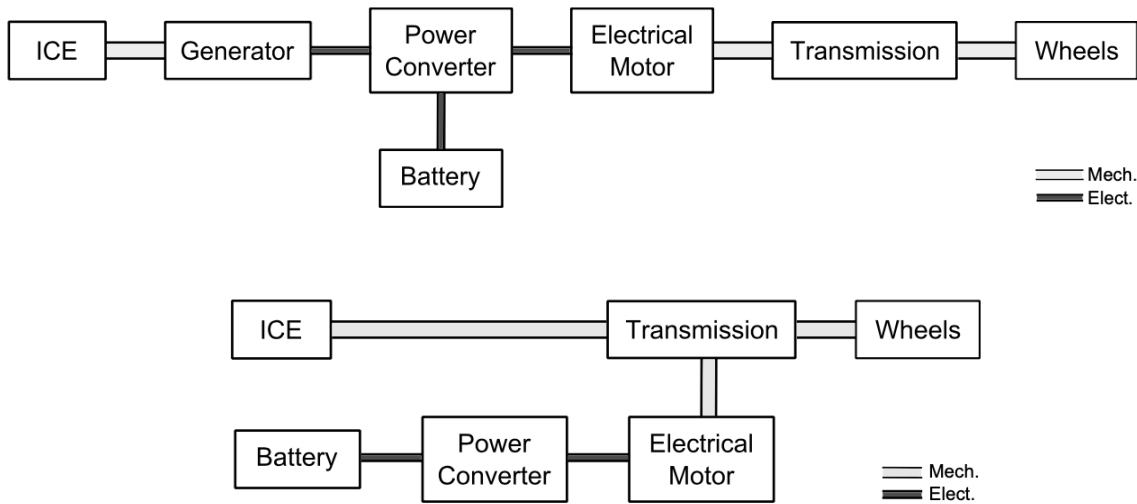
Treno sperimentale JR-Maglev (581 km/h)



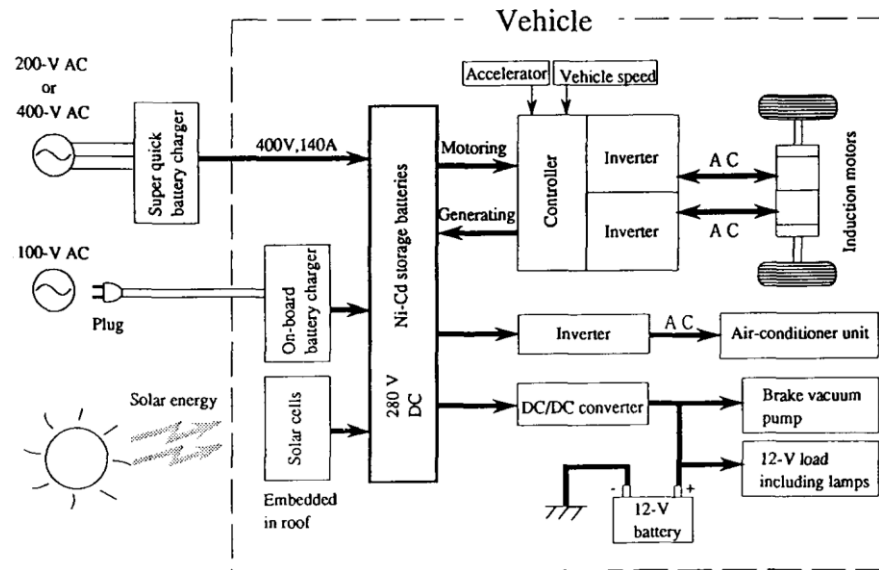
PARIS GREENMENT

- ➔ Industria automobilistica = emissione di gas serra
- ➔ Decarbonizzazione settore dei trasporti

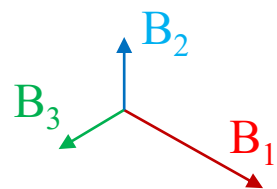
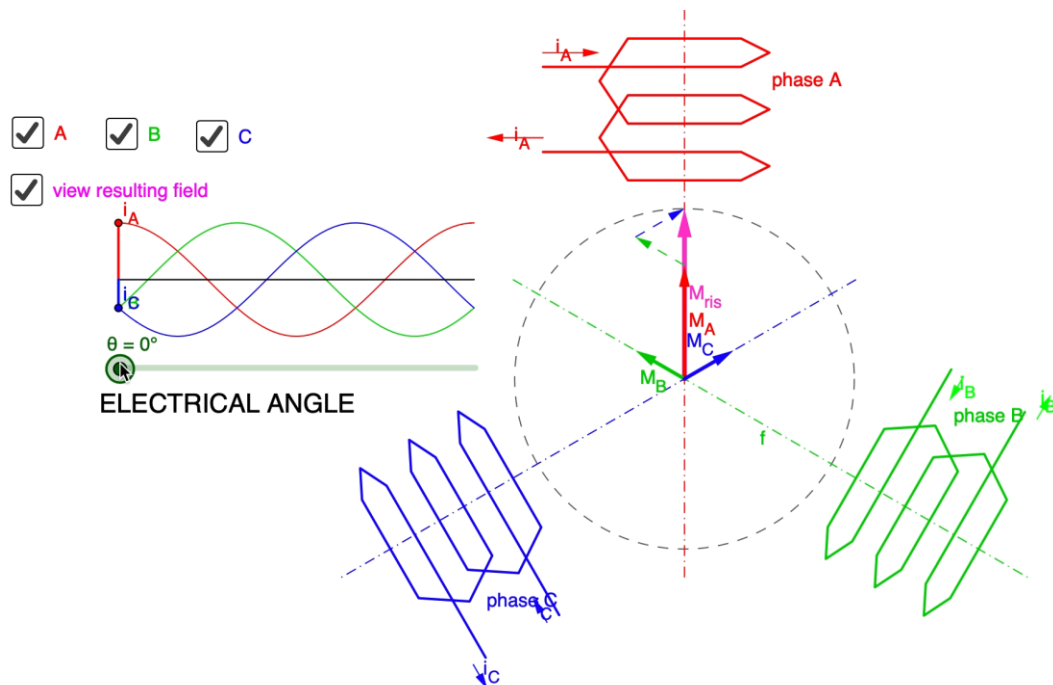
Mobilità ibrida



Mobilità elettrica



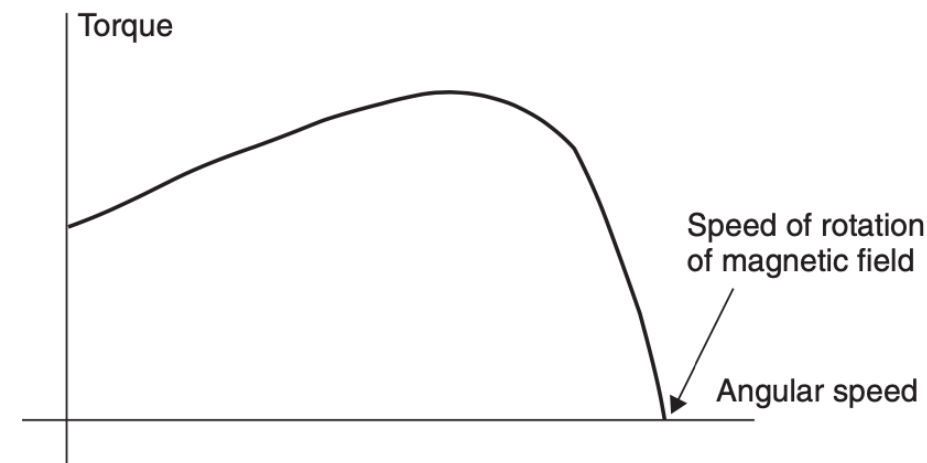
Motore asincrono trifase



$$B = B_1 + B_2 \cos\left(\frac{\pi}{3}\right) + B_3 \cos\left(\frac{\pi}{3}\right) =$$

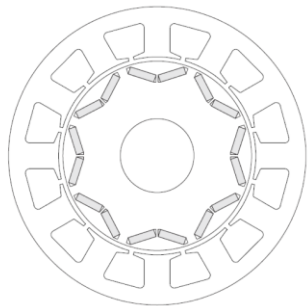
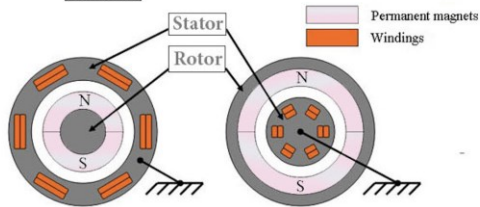
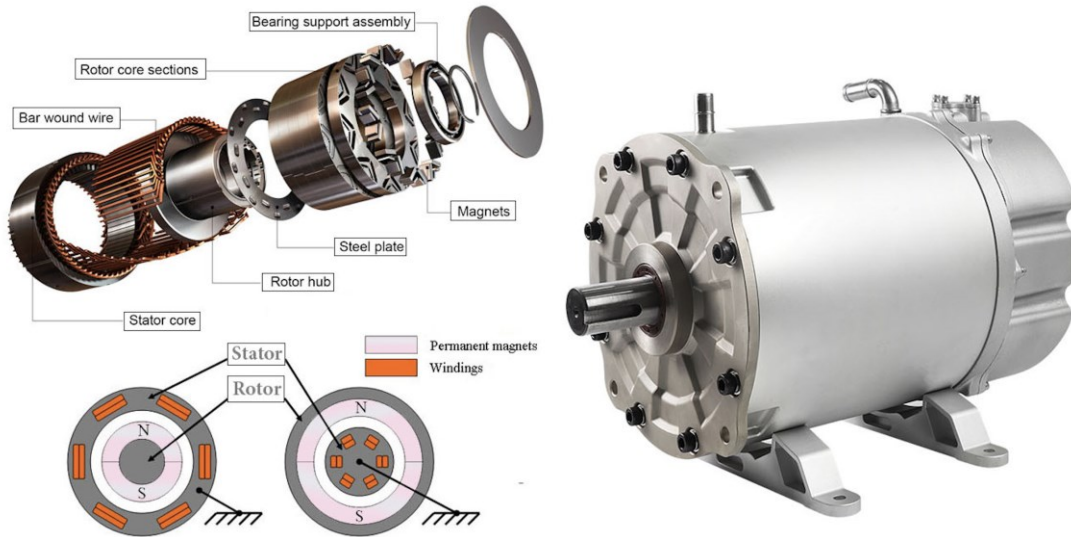
$$= B_1 + B_2 \frac{1}{2} + B_3 \frac{1}{2} = \frac{3}{2} B_m$$

Caratteristica meccanica

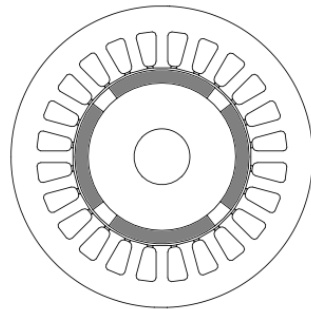


- Alta coppia avviamento
- Robusti, affidabili economici
- Manutenzione minima
- Frenata rigenerativa efficiente
- Regolazione velocità variando la frequenza

Motore sincrono

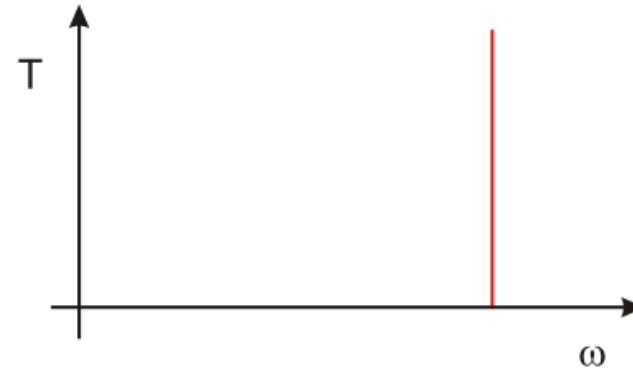


IPM



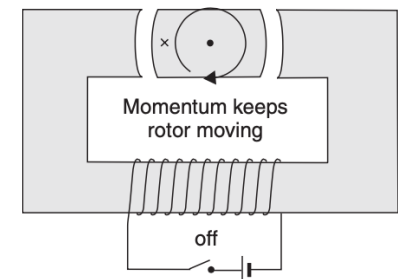
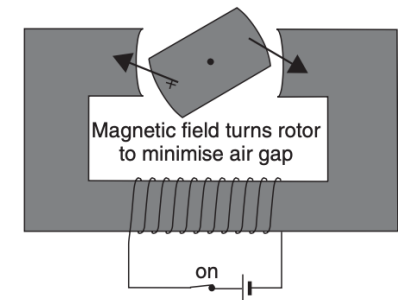
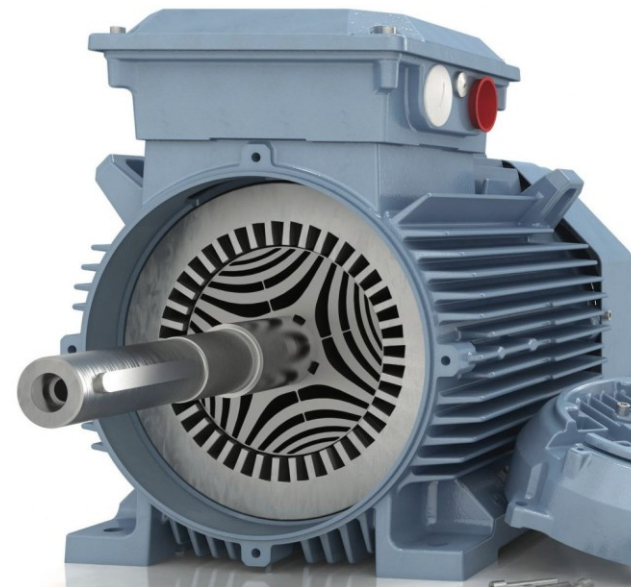
SPM

Caratteristica meccanica

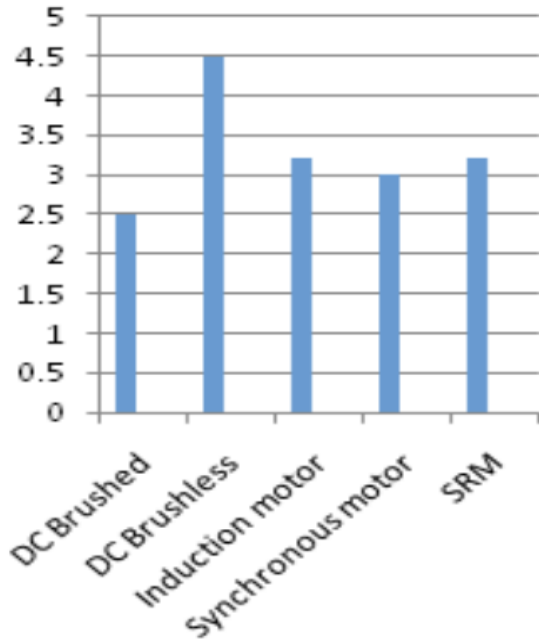


$$n = \frac{60f}{p}$$

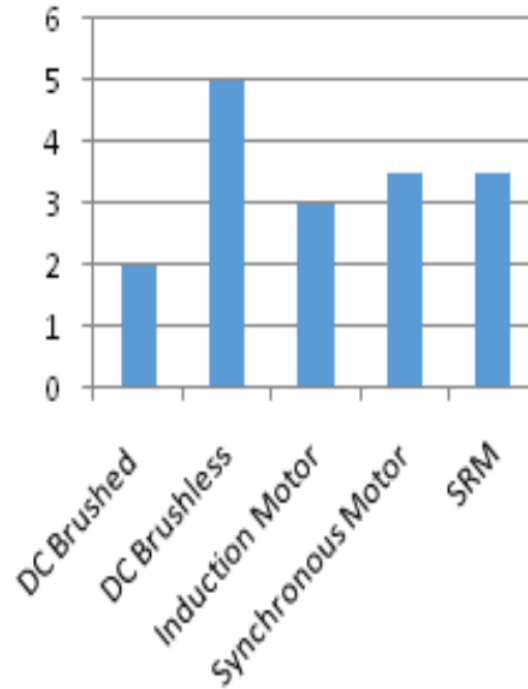
Motore a riluttanza



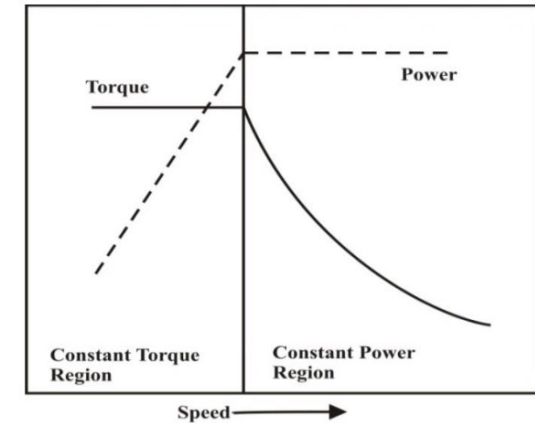
Rapporto peso-potenza



Costo unità di controllo

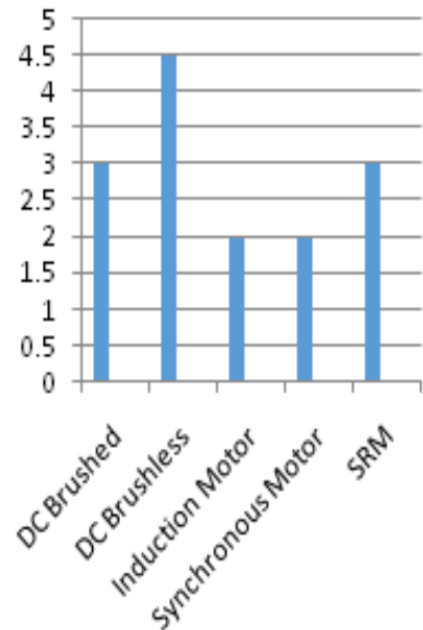


Caratteristica meccanica ideale



Tipo di motore	Massima efficienza (percentuale)	Efficienza al 10%del carico
CC con spazzole	>85-90	80-85
CC senza spazzole	>95	70-80
Ad induzione	>90	>90
Sincrono	>92	80-85
Riluttanza	>95	>90

Costo del motore



Motore asincrono con elevata coppia a basse velocità ma efficienza contenuta

Tesla model S 2018



Tesla model 3

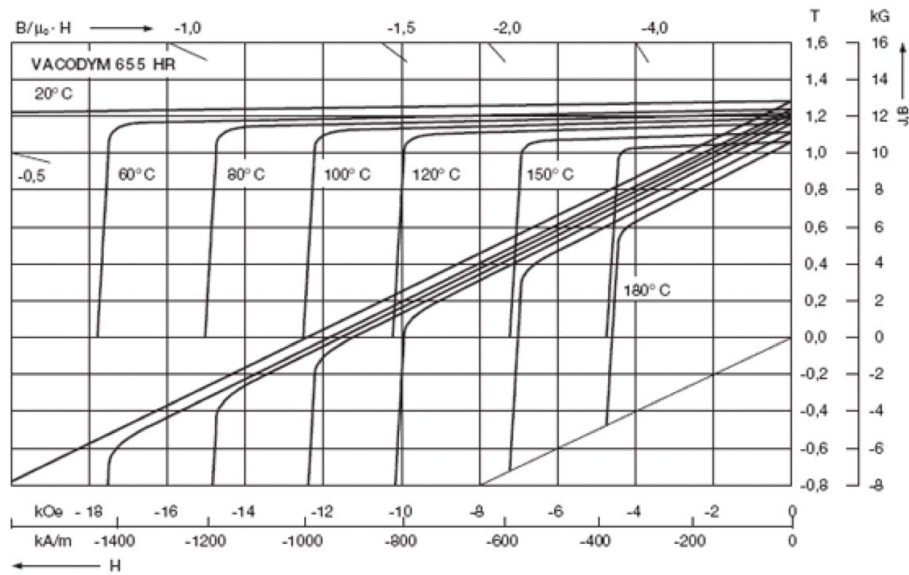


Motore IPM-SynRM con caratteristiche più idonee all'applicazione EV e maggiore efficienza

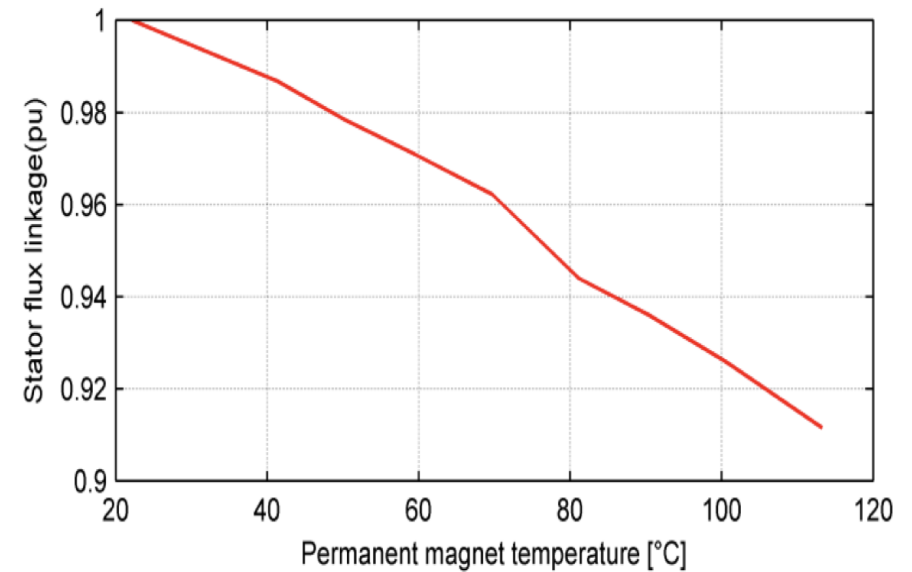
Problema



Curve di smagnetizzazione



Andamento flusso-temperatura



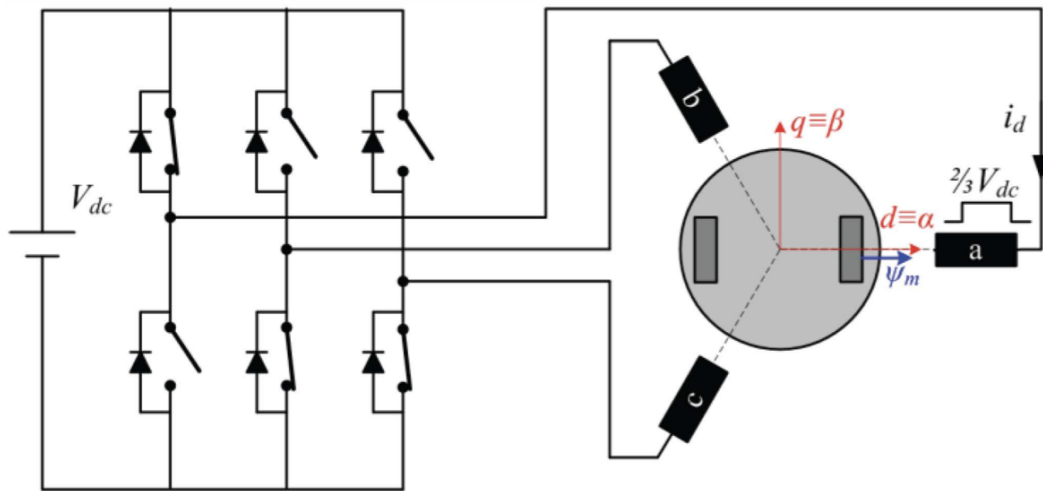
Metodo di stima



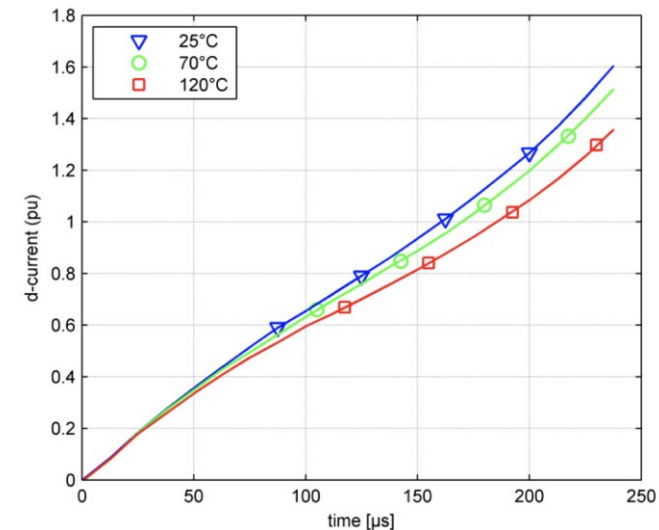
$$u_d = R_s(i_d + ji_q) + j\omega_r\psi_m + \frac{d}{dt}(L_d i_d + jL_q i_q)$$

$$\frac{di_d}{dt} = f(i_d, T_m)$$

Impulso di tensione

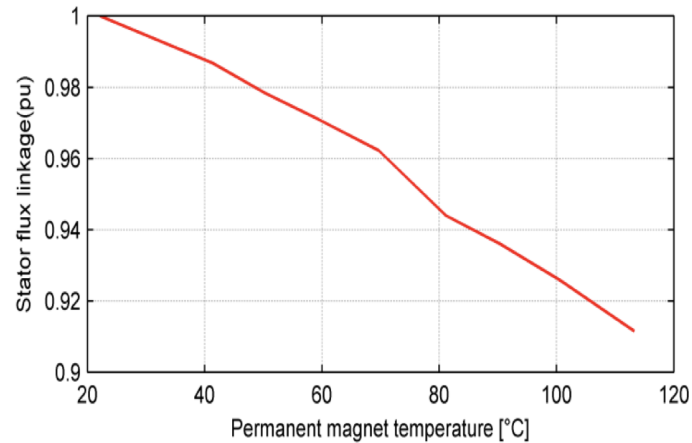





Risposta in corrente



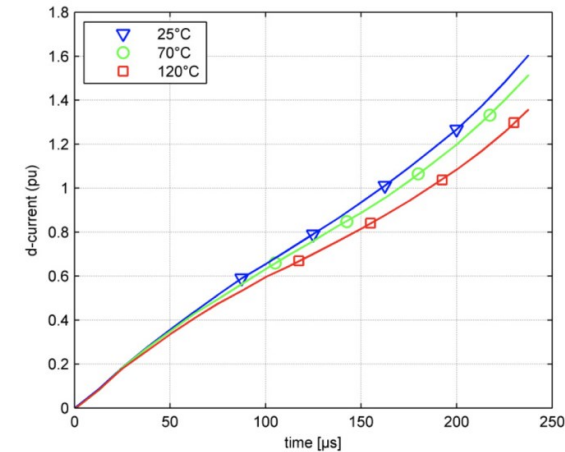
Risultati




Andamento flusso-temperatura



-  Diminuzione prestazioni
-  Smagnetizzazione irreversibile
-  Evitare sovradimensionamento della macchina

Risposta in corrente



-  Termocoppia
-  Sensore ad infrarossi
-  Precisione segnali di temperatura di $\pm 1,5$ °C

[1] J. Larminie, J. Lowry, Electric vehicle technology explained, a John Wiley e Sons, Ltd., publication, 2012, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, United Kingdom.

[2] S. Jape, A. Thosar, "COMPARISON OF ELECTRIC MOTORS FOR ELECTRIC VEHICLE APPLICATION", Settembre 2017

[3] M. Ganchev, C. Kral, H. Oberguggenberger and T. Wolbank, "Sensorless rotor temperature estimation of permanent magnet synchronous motor," IECON 2011 - 37th Annual Conference of the IEEE Industrial Electronics Society, 2011, pp. 2018-2023,