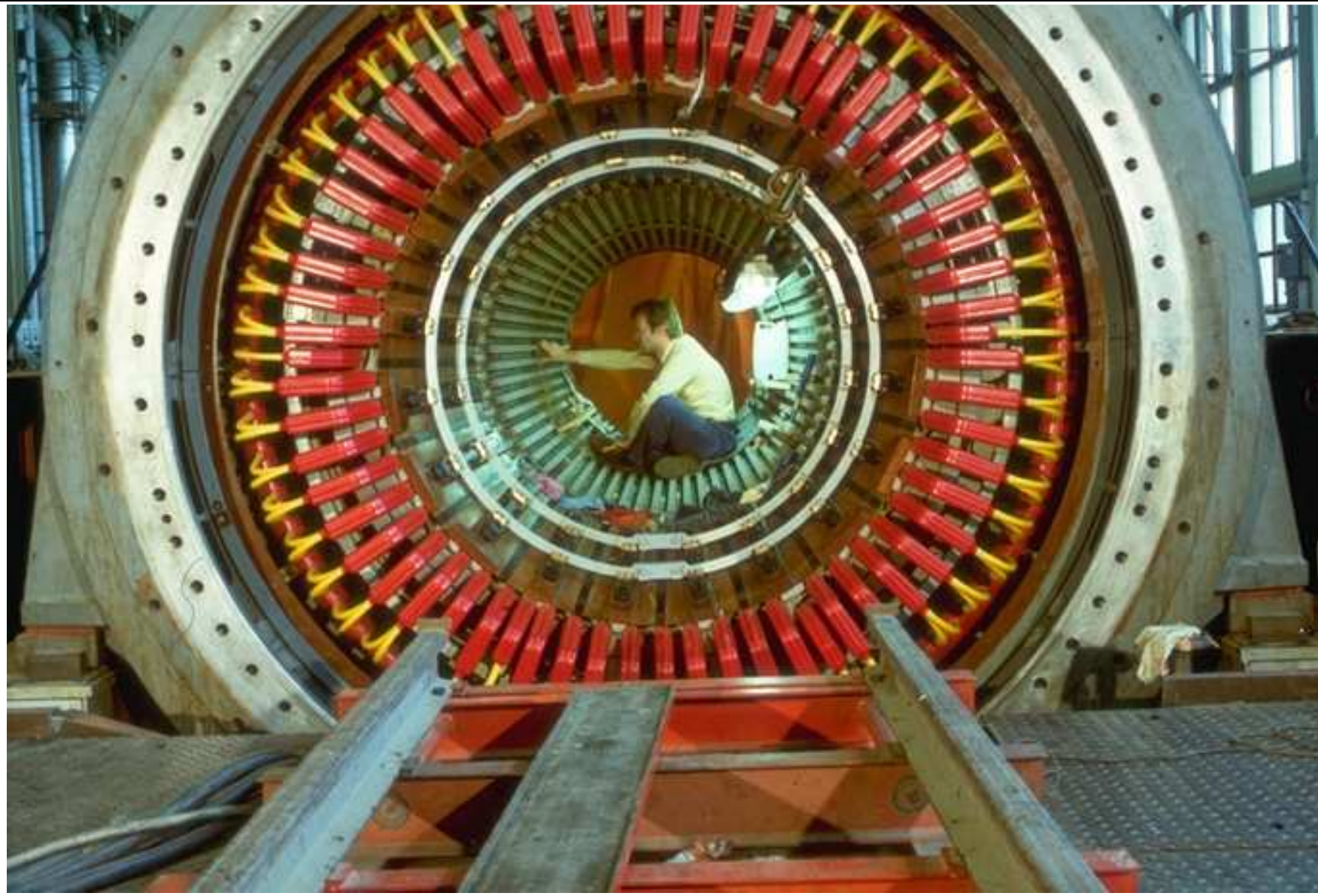


# **Motore sincrono a magneti permanenti**

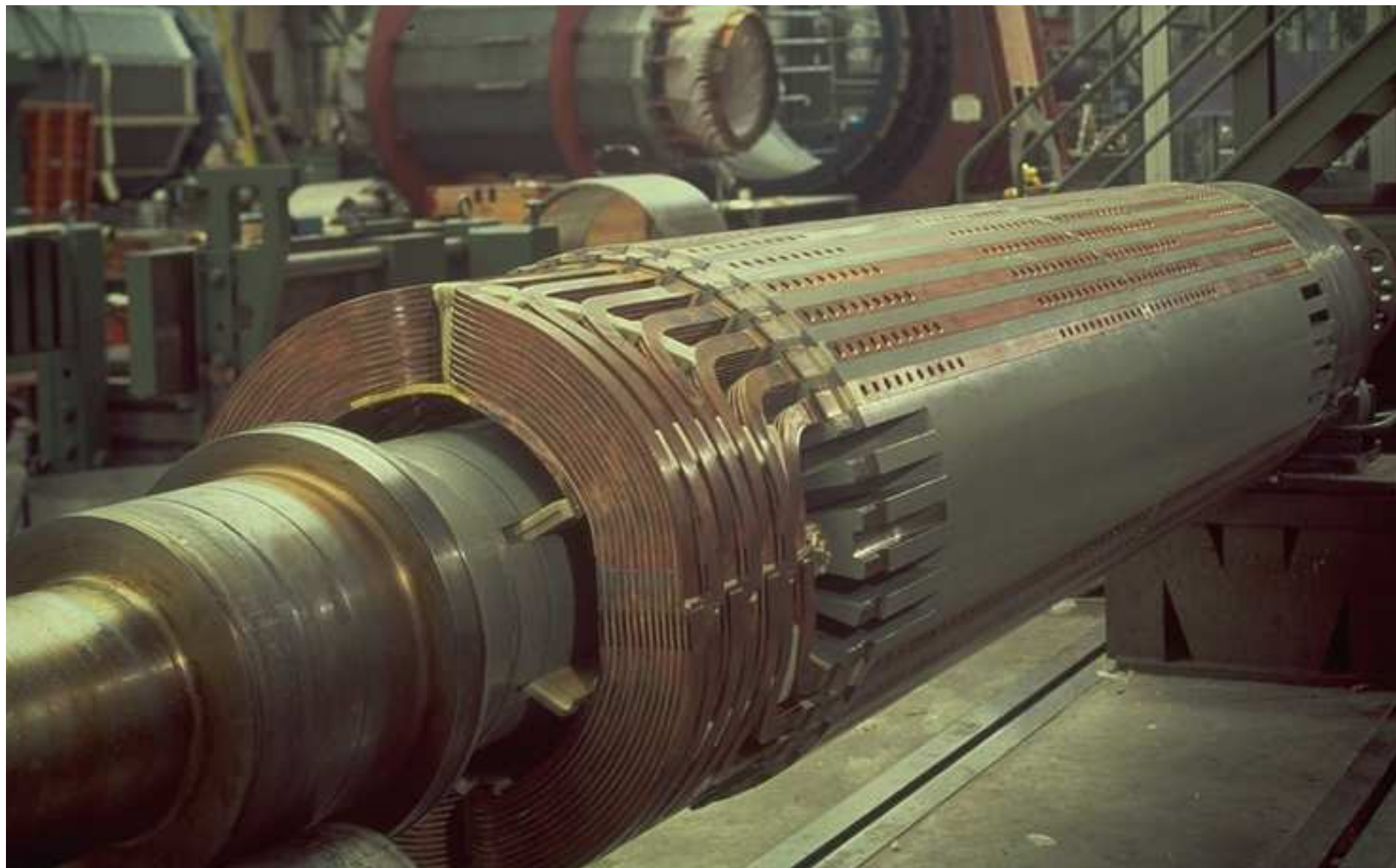
**brush-less sinusoidale**

**prof. Luigi Alberti**  
[luigi.alberti@unipd.it](mailto:luigi.alberti@unipd.it)

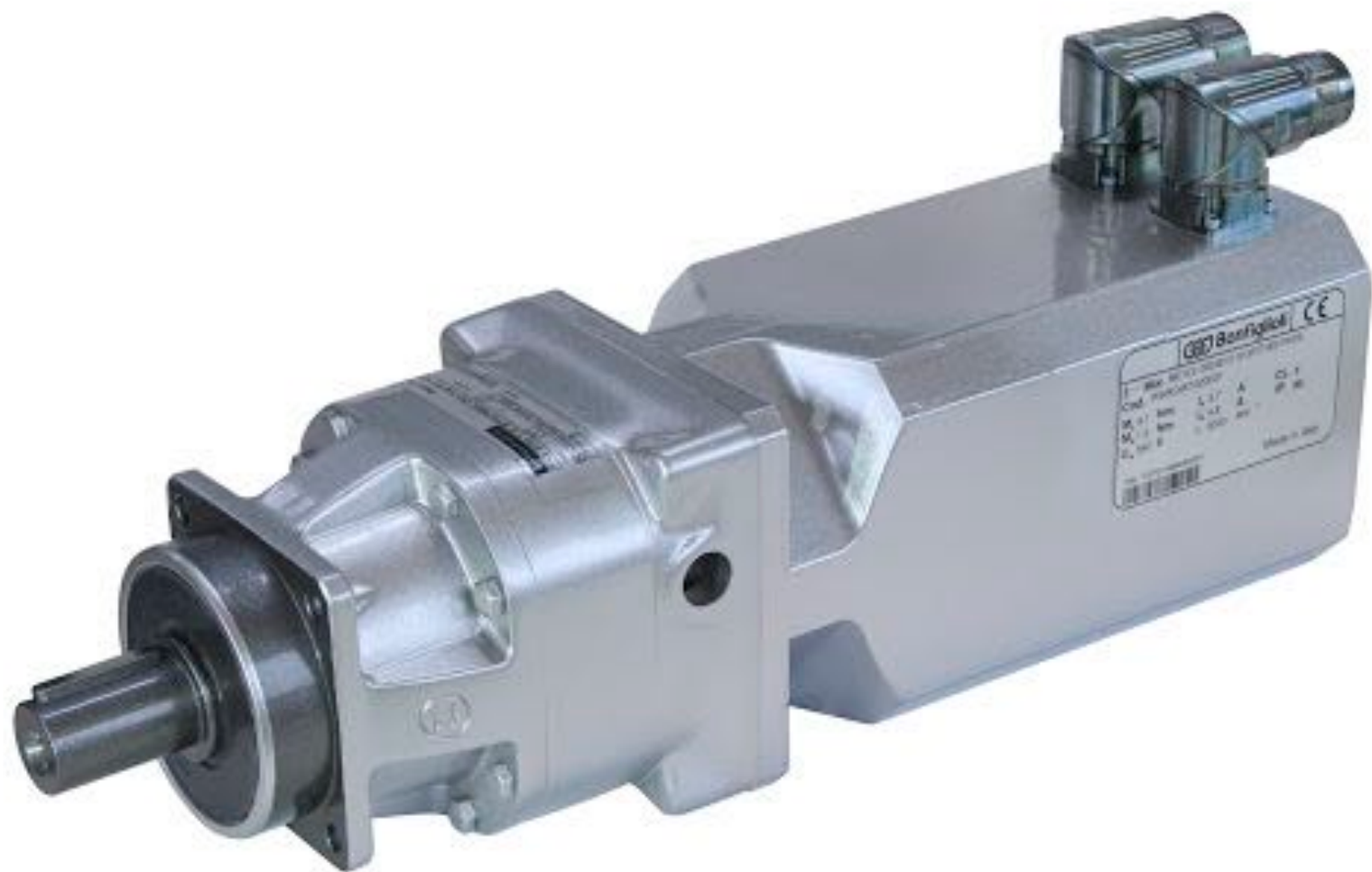










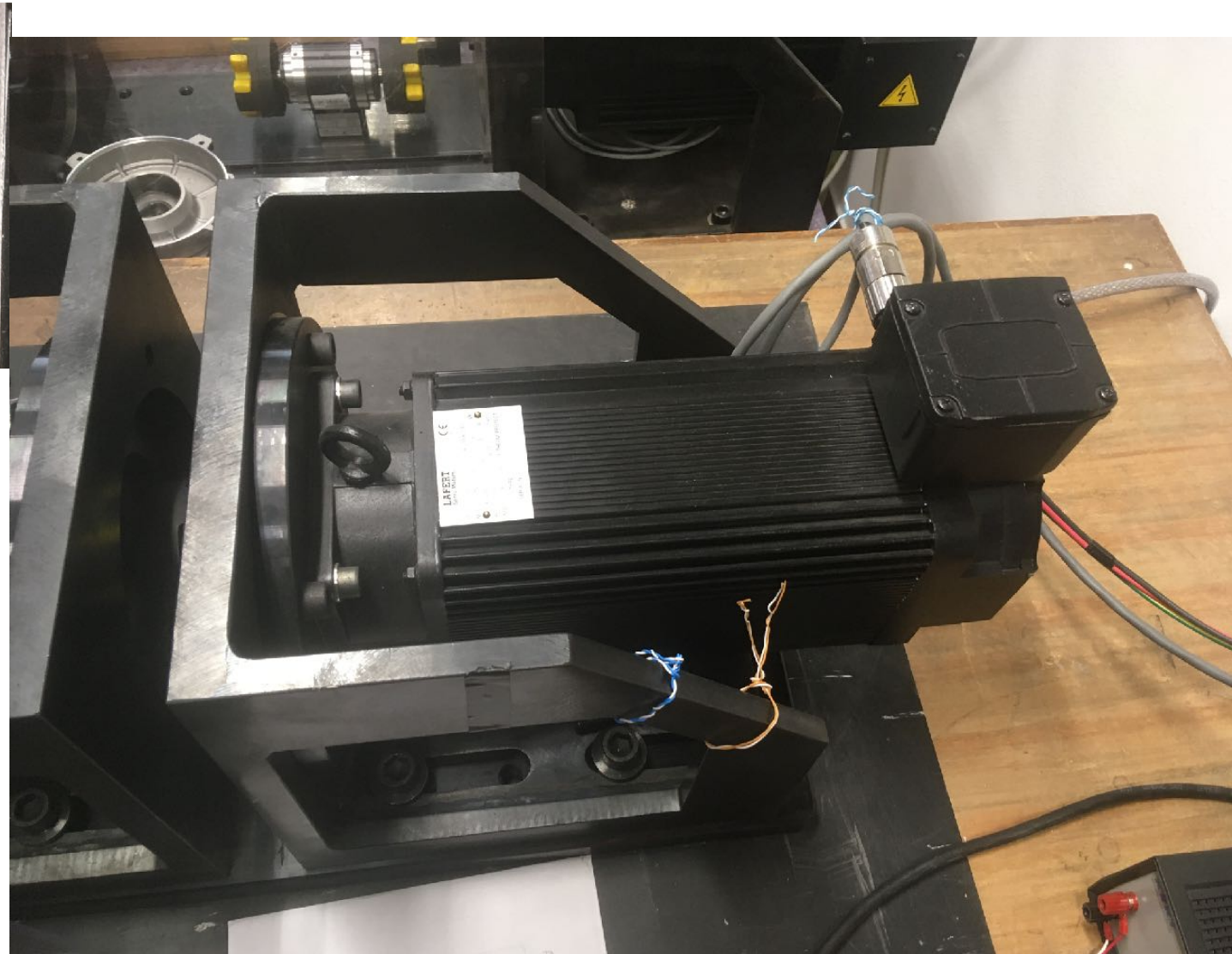


# LAFERT

Servo Motors



Mo 30.5 Nm    Io 33.7 A    100k 2P= 6  
Mn 25.6 Nm     $n_n$  4000 /min    Vi 365 VV  
Brake:VDC    V    I    A  
Resolver 2P=2    Tacho 3~G.T:    mVmin  
IMB5    IP 65    Iso Cl.F THERM. PROTECT.  
TYPE B7132Z-00151  
SERIAL N. 207797





**magnetic**Via del Lavoro, 7  
MONTEBELLO (VI) ITALYPERMANENT MAGNET  
BRUSHLESS SERVOMOTOR

No.	182776	Type BLQ 104 P 19 2010			
Nmax	1900	RPM	BEMF	148	V/kRPM
Tn	139	Nm	In	28	Arms
Tp	177	Nm	Ip	97	Arms
Transd.	D2PA	Brake Nm - 24Vdc - A			
CEI EN 60034-1		Tamb. max 40° C / Ir. cl. F			



# LUST

ANTRIEBSTECHNIK

TYP: PSM-21-20G52-410 Nr.7060368



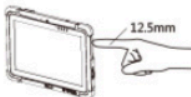





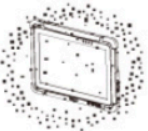





$U_N$	330 V	$M_{dN}$	7.00 Nm	$n_N$	2000 min <sup>-1</sup>
$I_{dN}$	3.10 A	$M_{d0}$	8.40 Nm	$f_N$	100 Hz
iso.-Kl.	F	IP	65		10.2 kg



Made in Germany





Solids		Waters	
1	 <p>Protected against a solid object greater than 50 mm such as a hand</p>	1	 <p>Protected against vertically falling drops of water. Limited ingress permitted</p>
2	 <p>Protected against a solid object greater than 12.5 mm such as a finger</p>	2	 <p>Protected against vertically falling drops of water with enclosure tilted up to 15 degrees from the vertical. Limited ingress permitted</p>
3	 <p>Protected against a solid object greater than 2.5 mm such as a screwdriver</p>	3	 <p>Protected against sprays of water up to 60 degrees from the vertical. Limited ingress permitted for three minutes.</p>
4	 <p>Protected against a solid object greater than 1 mm such as a wire</p>	4	 <p>Protected against water splashed from all directions. Limited ingress permitted.</p>
5	 <p>Dust Protected, Limited ingress of dust permitted. Will not interfere with operation of the equipment. 2-8 hours</p>	5	 <p>Protected against jets of water. Limited ingress permitted.</p>
6	 <p>Dust tight. No ingress of dust. 2-8 hours</p>	6	 <p>Waters from heavy seas of water projected in powerful jets shall not enter the enclosure in harmful quantities</p>
Rating Example:		7	 <p>Protection against the effects of immersion in water between 15 cm and 1 m for 30 minutes</p>
		8	 <p>Protection against the effects of immersion in water under pressure for long periods</p>

Rating Example:

**IP65**

INGRESS PROTECTION

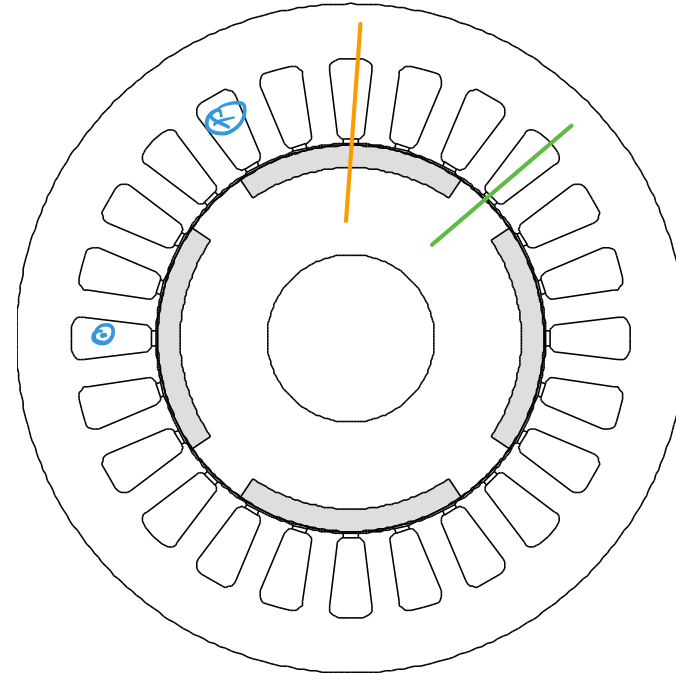
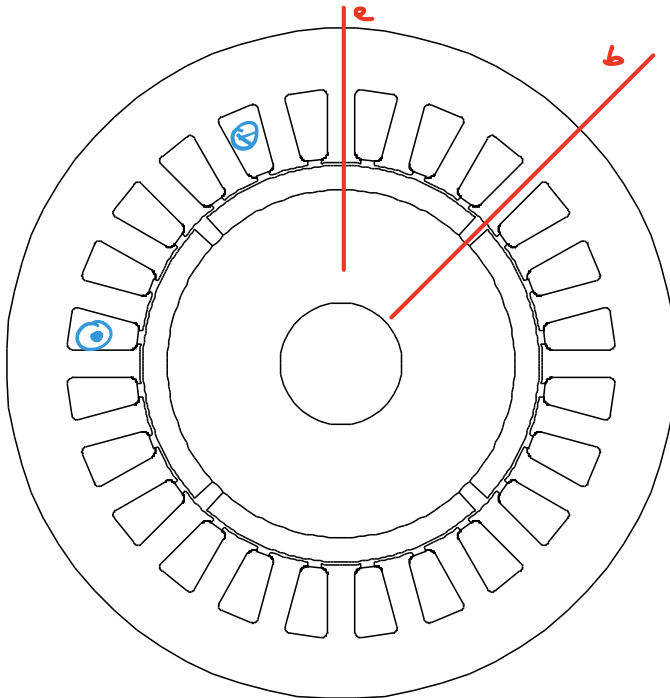




## The rotor configurations

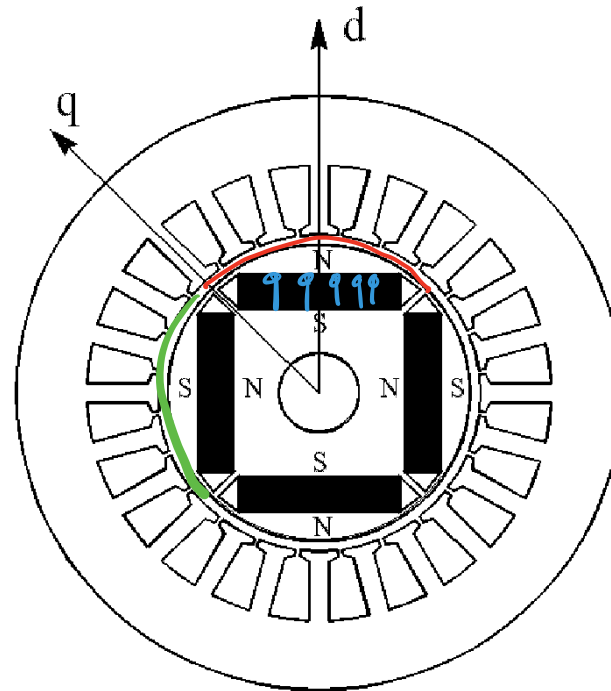
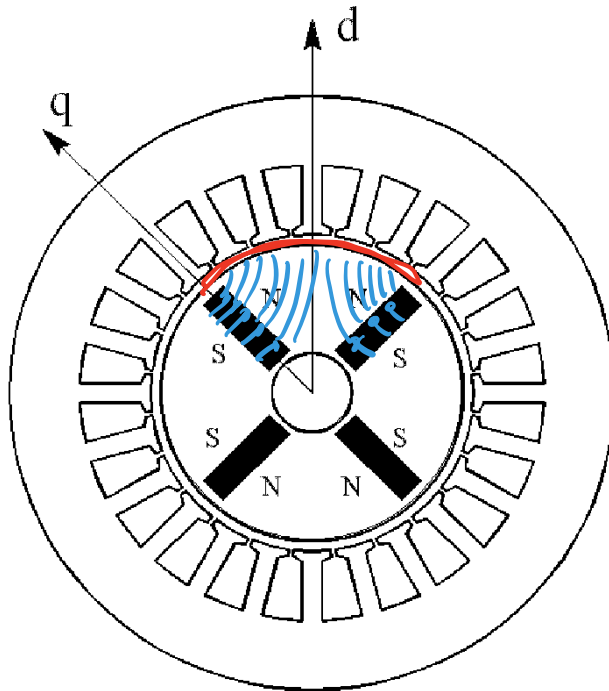
- SPM rotor
- inset rotor

4-pole 24-slot motors.



## The rotor configurations

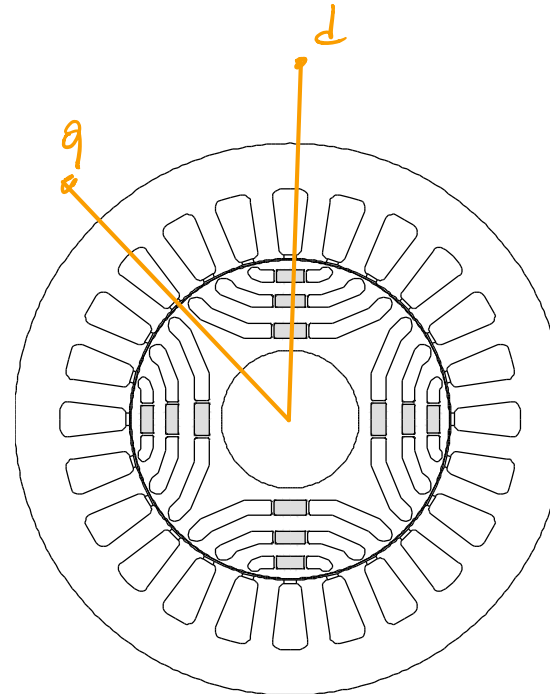
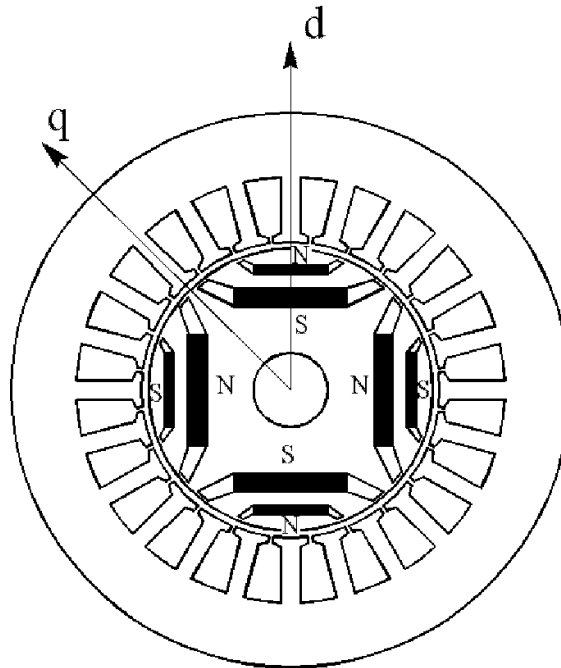
- tangentially magnetized PMs
- radially magnetized PMs

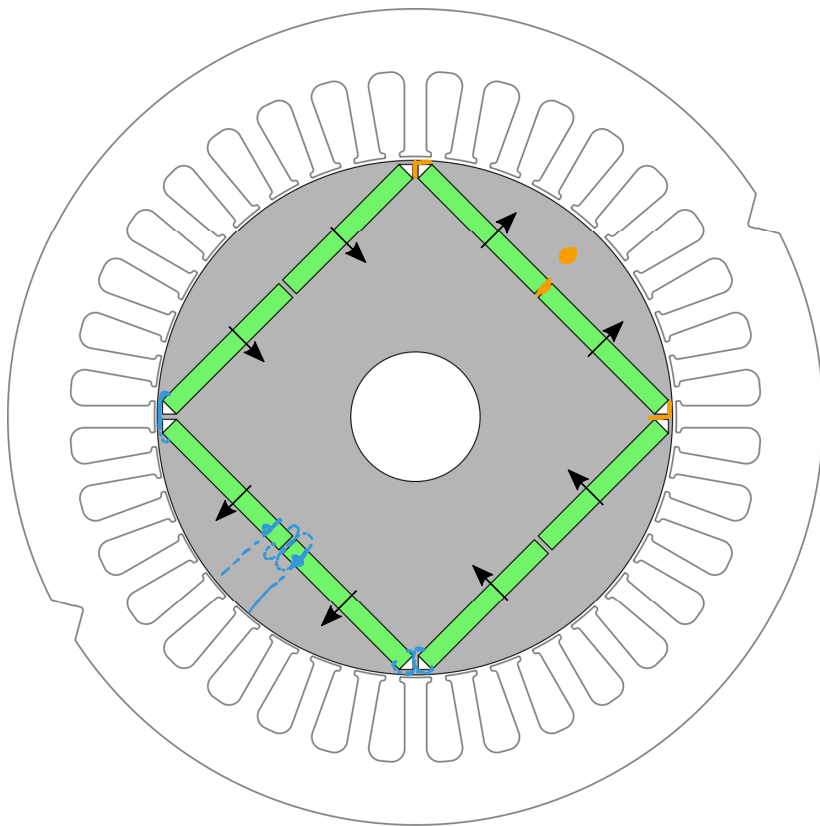




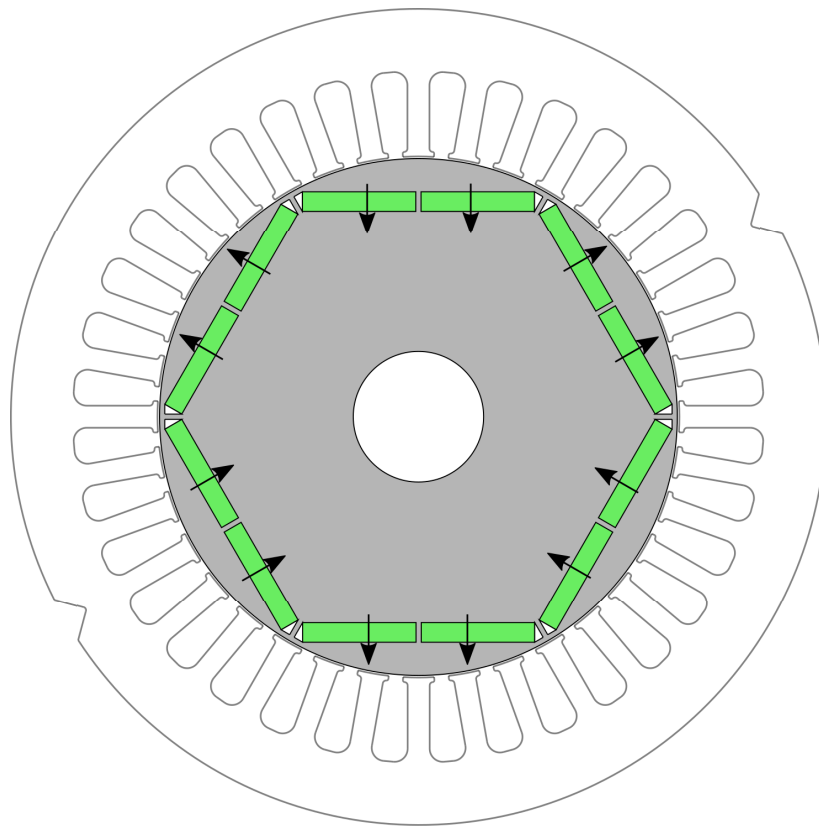
## The rotor configurations

- two flux-barriers per pole
- more flux-barriers per pole
- axially laminated rotor.

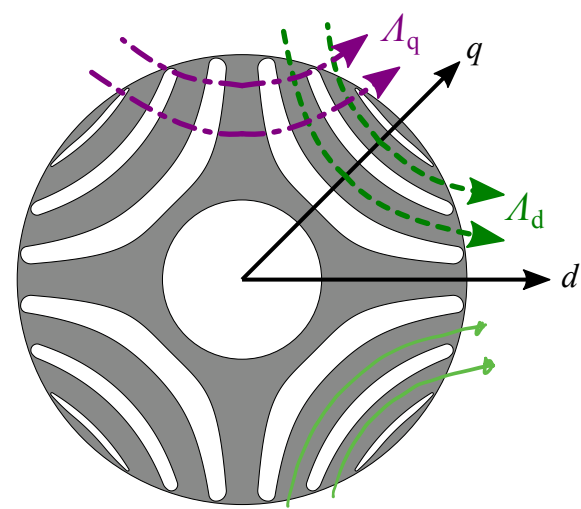
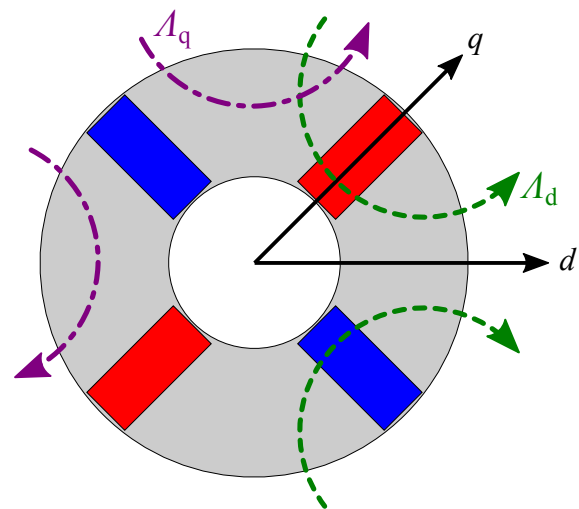
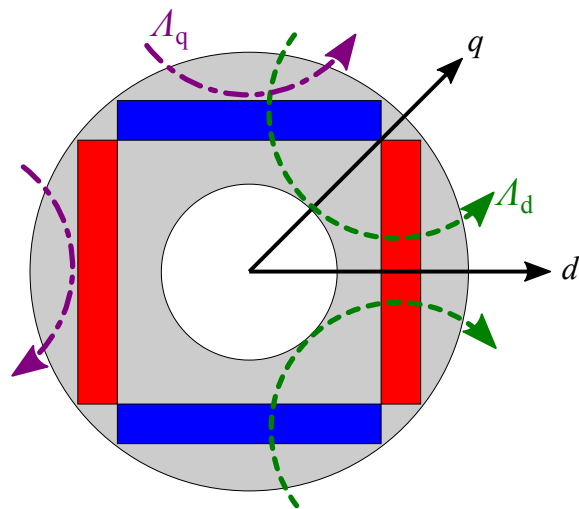
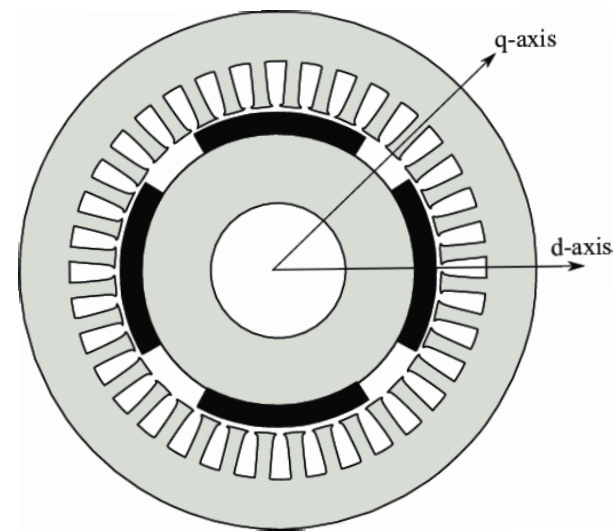




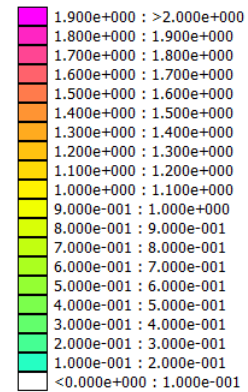
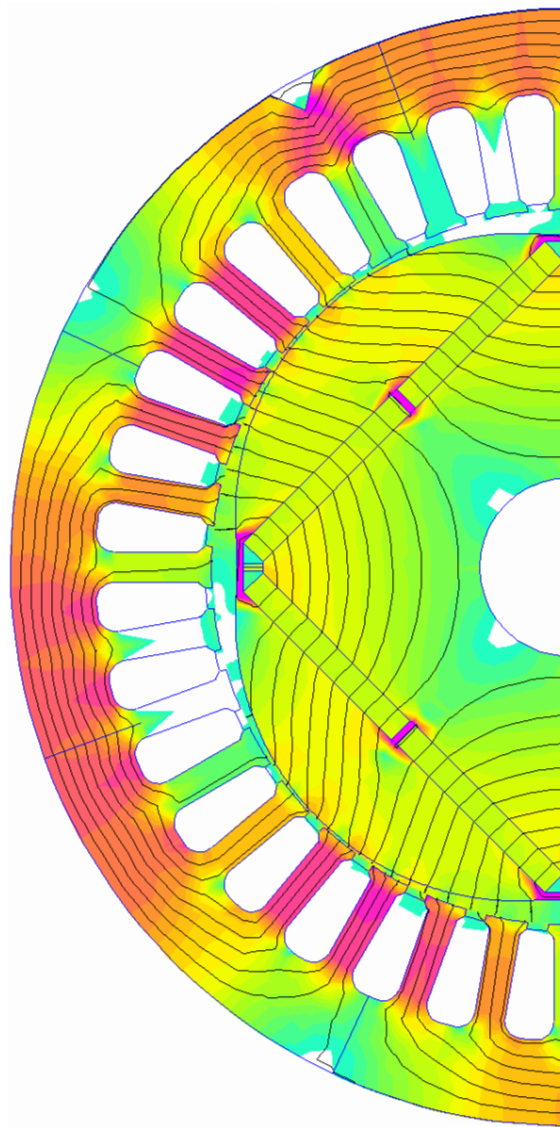
(a) 4 poli



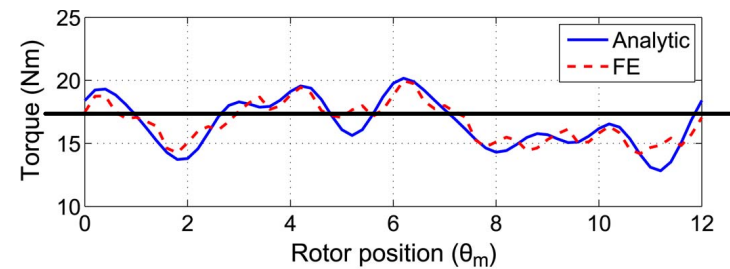
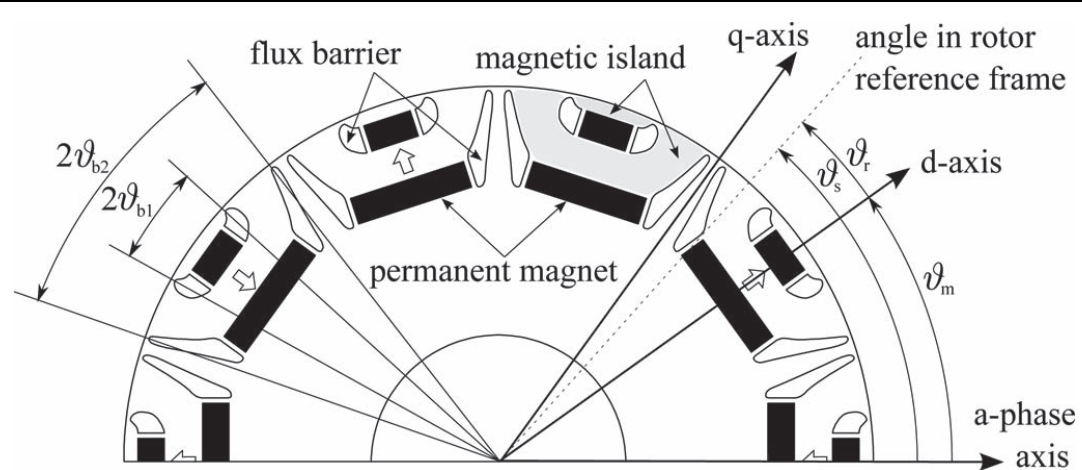
(b) 6 poli



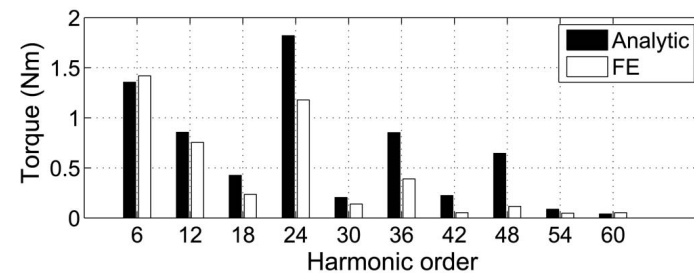




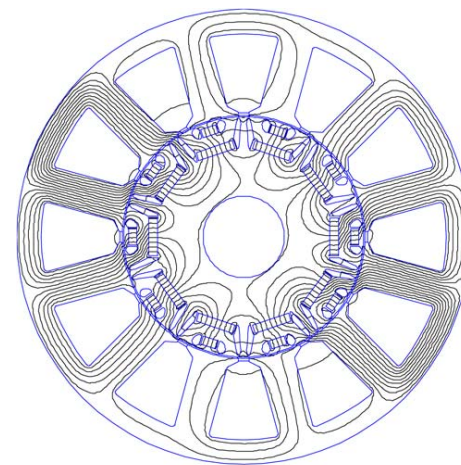
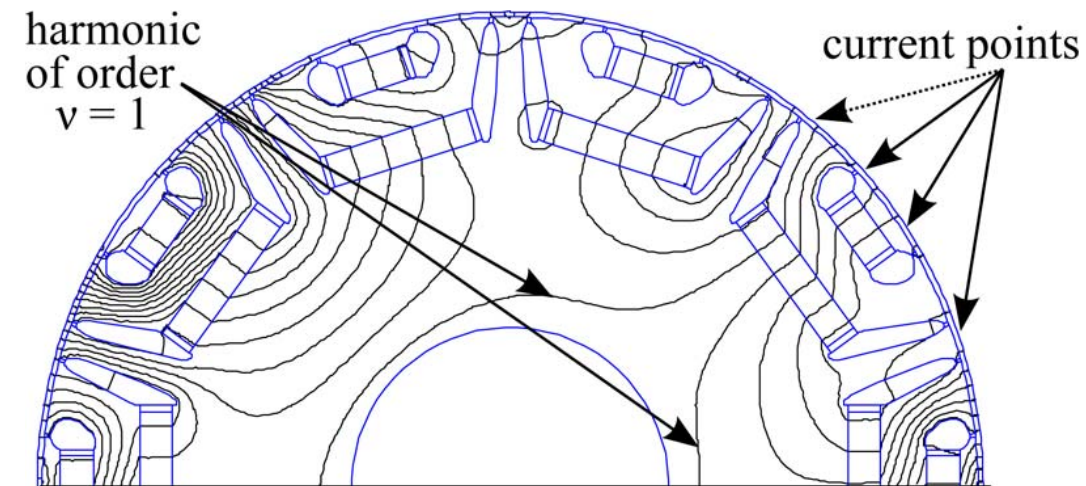
Density Plot:  $|B|$ , Tesla

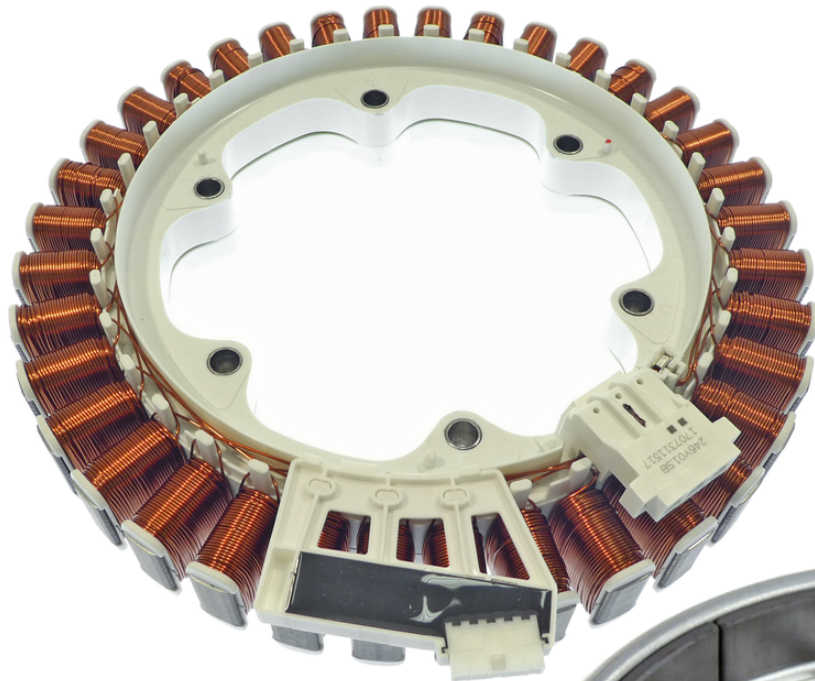


(a) Torque



(b) Harmonic content

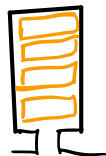




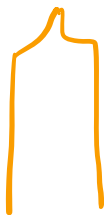




$$\frac{\sigma_{cr}}{\sigma_{slt}} = 0,4$$



$$\frac{\sigma_{cr}}{\sigma_{slt}} = 0,8$$



$$\frac{d\sigma}{dt}$$

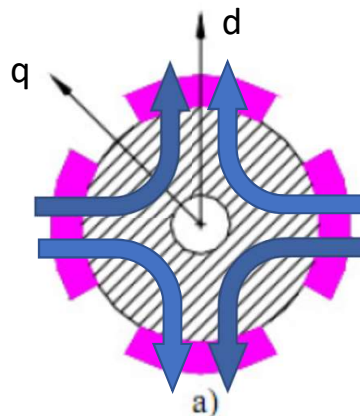




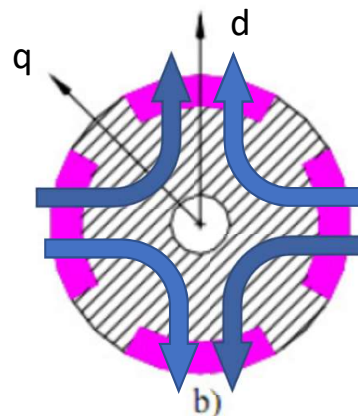


## *Strutture di principio motore con rotore anisotropo (IPM)*

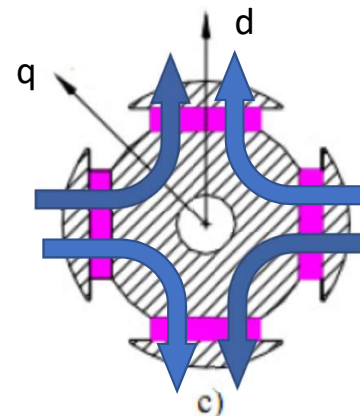
a) SPM (isotropo)



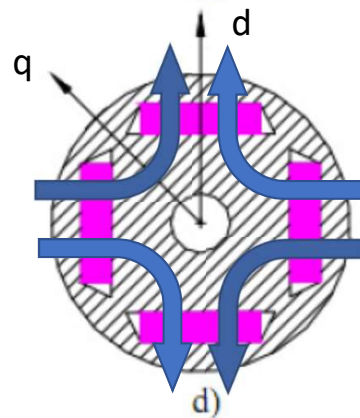
b) Inset PM (anisotropo)



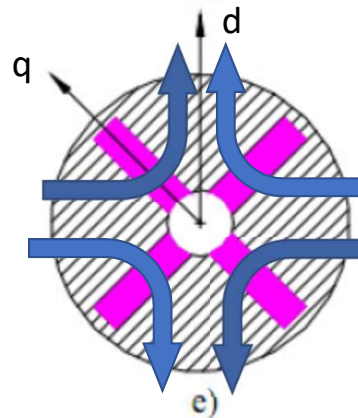
c) Salient pole  
(isotropo | anisotropo)



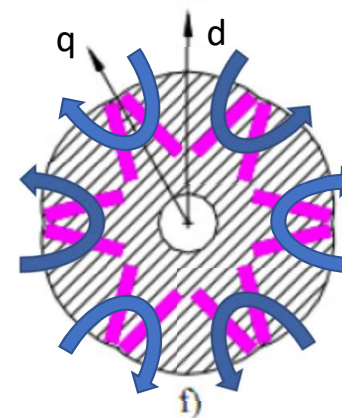
d) IPM (Interior PM)  
(anisotropo)



e) Spoke PM (anisotropo)

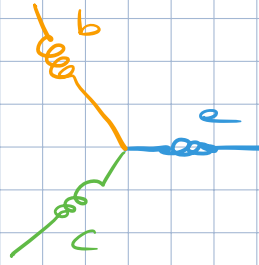
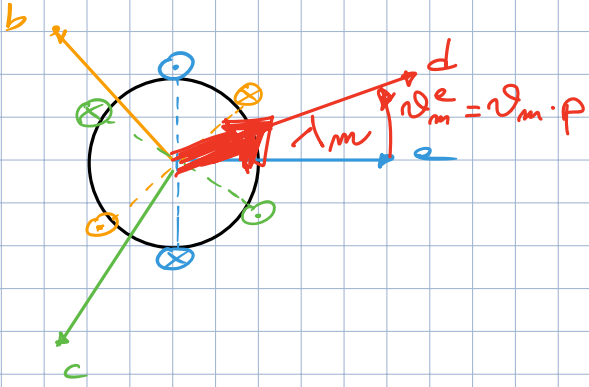


f) IPM (anisotropo)





## Macchine sincrone trifase



3 avvolgimenti  
sfasati di  $120^\circ$

$$\begin{bmatrix} \phi : \text{Wb} & [\text{B} \cdot \text{m}] \\ \lambda : \text{V} \cdot \text{s} \end{bmatrix}$$

$$\begin{cases} v_a = R i_a + \frac{d\lambda_a}{dt} \\ v_b = R i_b + \frac{d\lambda_b}{dt} \\ v_c = R i_c + \frac{d\lambda_c}{dt} \end{cases}$$

Equazioni del tubo generale:

$R$ : Resistenze  $[\Omega]$  di ciascuna fase

Sono valide anche se l' saturazione

$\lambda_x$  dipende da  $i_a, i_b, i_c$ , per cui  $\lambda_m$

$H_p$ : TRASCURO SATURAZIONE

$$\begin{cases} \lambda_a = \lambda_{am} + \lambda_{ai} \\ \lambda_b = \lambda_{bm} + \lambda_{bi} \\ \lambda_c = \lambda_{cm} + \lambda_{ci} \end{cases}$$

Flusso del  
Rotoe

Contributo di ente mutua induttanza

$H_p$ : CONSIDERO MACCHINA ISOTROPA

ente e mutua induttanza ( $\lambda_{xi}$ ) non dipende dalla posizione

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

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

$H_p$ :  $i_a + i_b + i_c = 0$

$$i_a = -i_b - i_c$$

$$\begin{cases} \lambda_{ai} = (L - M) i_a = L i_a \\ \lambda_{bi} = (L - M) i_b = L i_b \\ \lambda_{ci} = (L - M) i_c = L i_c \end{cases}$$

$$L = L_0 - M \quad \text{INDUTANZA SINCRONA}$$

$$\text{Poiché } M \cong -\frac{1}{2}L_0 \quad L \cong \frac{3}{2}L_0$$

$$\begin{cases} \lambda_{em} = \lambda_m \cos \vartheta_m^e \\ \lambda_{bm} = \lambda_m \cos(\vartheta_m^e - \frac{2}{3}\pi) \\ \lambda_{cm} = \lambda_m \cos(\vartheta_m^e - \frac{4}{3}\pi) \end{cases}$$

$$\vartheta_m^e = p \vartheta_m$$

$2p$  # pol. del motore

Induttanze sincrone

$$\begin{cases} \lambda_e = \lambda_m \cos \vartheta_m^e + L i_e \\ \lambda_b = \lambda_m \cos(\vartheta_m^e - \frac{2}{3}\pi) + L i_b \\ \lambda_c = \lambda_m \cos(\vartheta_m^e - \frac{4}{3}\pi) + L i_c \end{cases}$$