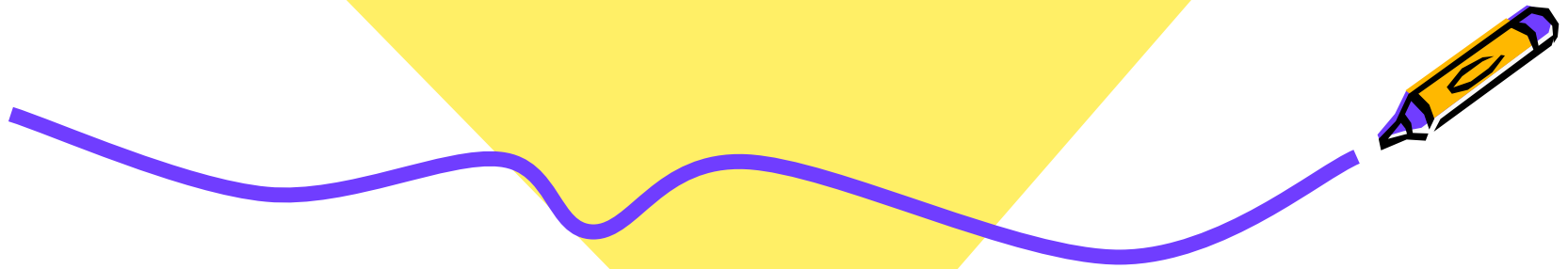
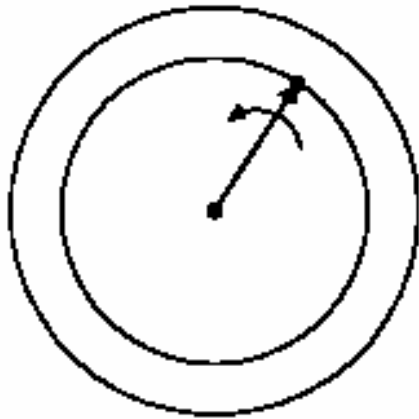


EXCENTRICITATI IN MASINI ELECTRICE

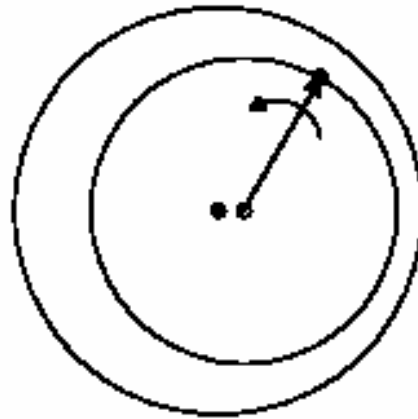


TIPURI DE EXCENTRICITATI

Masina sanatoasa



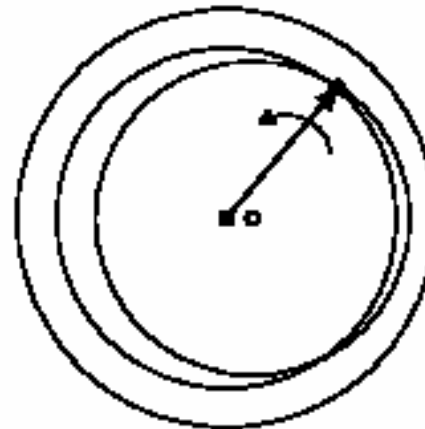
Excentricitate statica



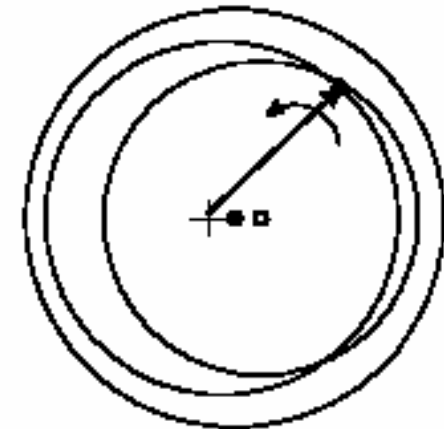
Rotorul se deplaseaza din pozitia normala, dar continua sa se roteasca in jurul propriului centru.



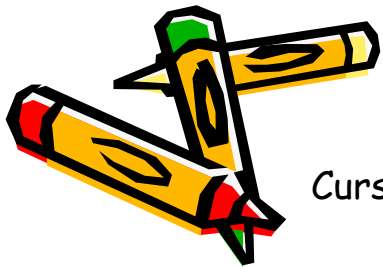
Excentricitate dinamica



Excentricitate mixta



Rotorul se deplaseaza din pozitia normala, dar continua sa se roteasca in jurul centrului statorului.



SURSE ALE EXCENTRICITATILOR

- ❑ Probleme legate de asamblare si productie a masinilor
- ❑ Probleme mecanice:
 - Dezechilibre
 - Alinieri defectuoase
 - Montare defectuoasa

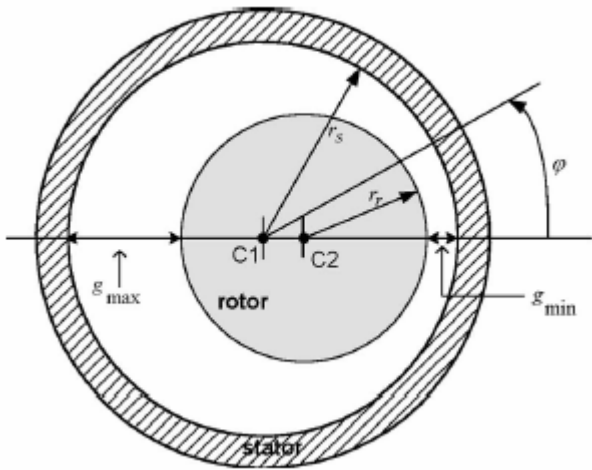
EFECTE ALE EXCENTRICITATILOR

- ❑ Ripluri de cuplu
- ❑ Pulsatii ale vitezei
- ❑ Vibratii
- ❑ Zgomote
- ❑ Distrugerea miezurilor static/rotoric



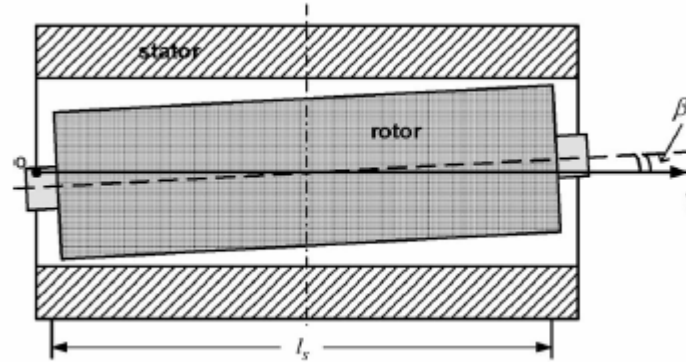
Curs 9





$$g(\varphi) = g_o(1 - a \cos \varphi)$$

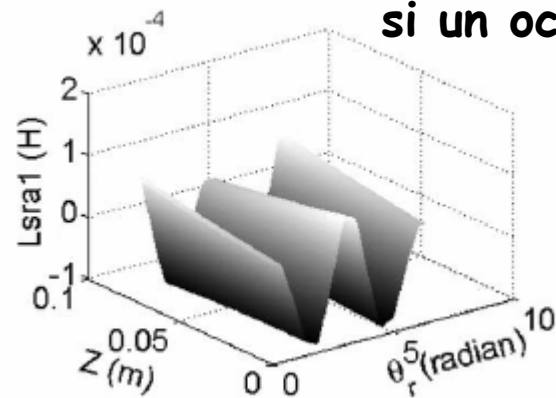
$$a = (g_{\max} - g_{\min}) / (2g_o)$$



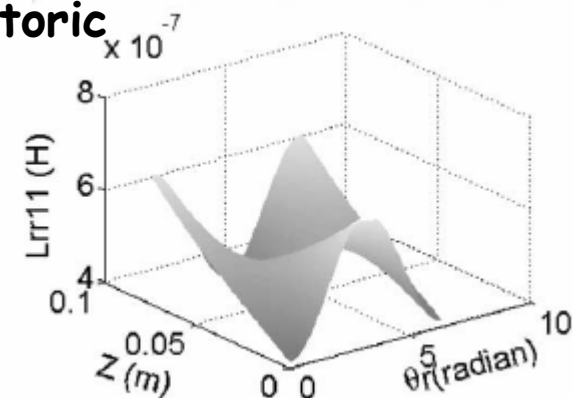
$$g(\varphi, y) = g_o [1 - a(y) \cos \varphi]$$

$$a(y) = (2a_0 - l_s \sin \beta / g_o) / 2 + y \tan \beta / g_o$$

Inductivitatea mutuala intre o faza statorica si un ochi rotorice



Masina fara probleme



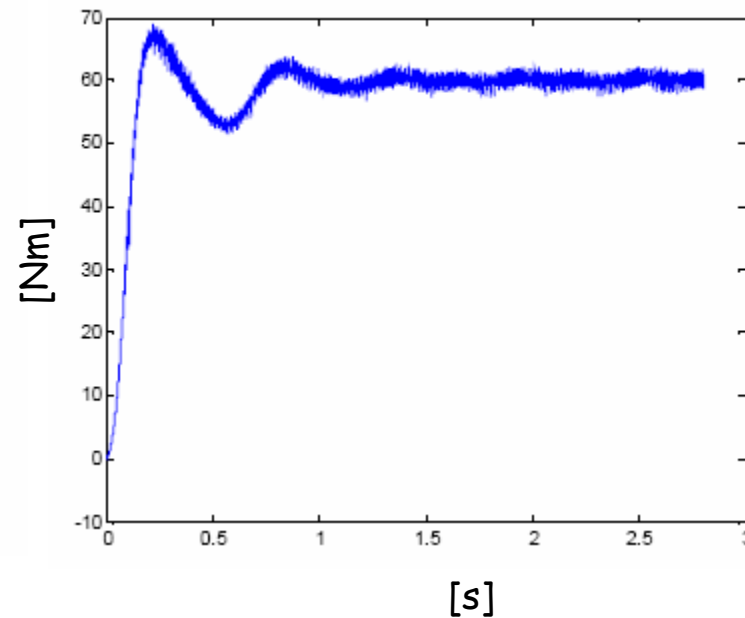
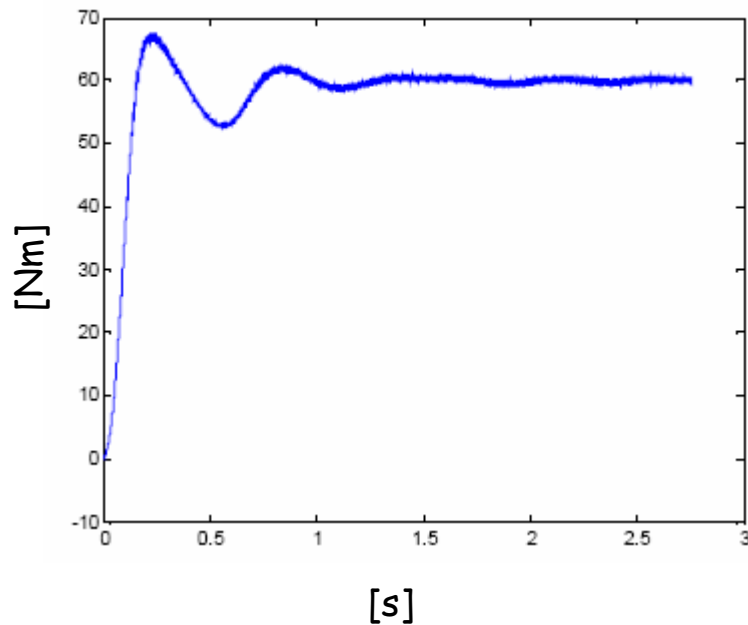
Masina cu excentricitate 50% la ambele capete



METODE DE DETECTIE ALE EXCENTRICITATILOR

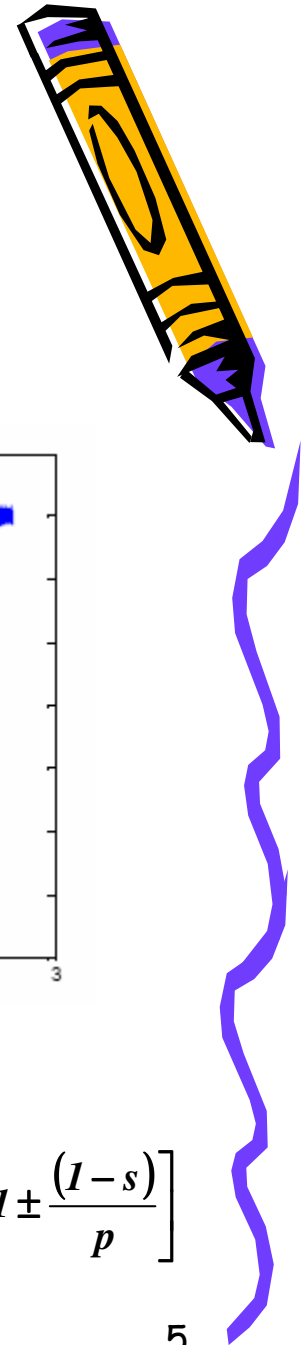
Monitorizarea zgomotului

Monitorizarea cuplului



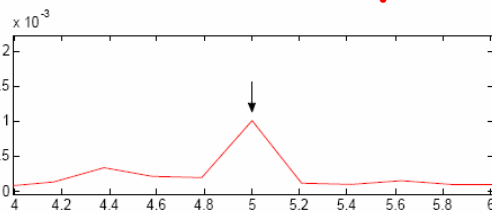
Monitorizarea fluxului in intrefier

$$f_{statica / dinamica} = f_s \left[\frac{(kZ_R \pm n_d)(1-s)}{p} \pm n_s \right] \quad f_{mixta} = f_s \pm f_m = f_s \left[1 \pm \frac{(1-s)}{p} \right]$$

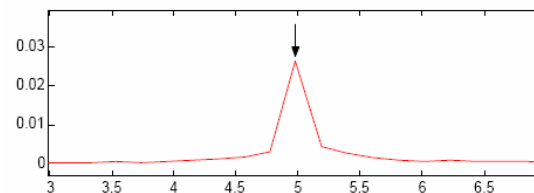
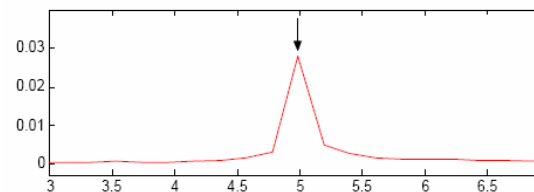
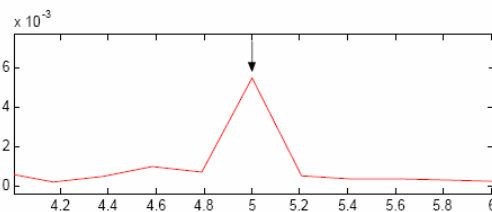


□ Monitorizarea componentelor pe d si pe q ale curenților, respectiv tensiunilor statorice

Spectrul curenților, i_d și i_q (normalizat)

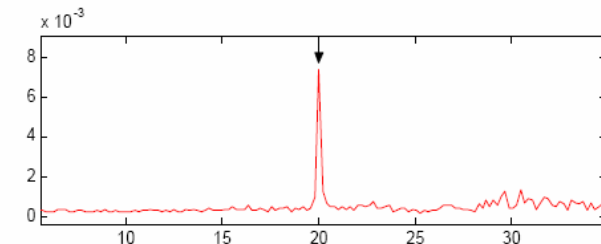
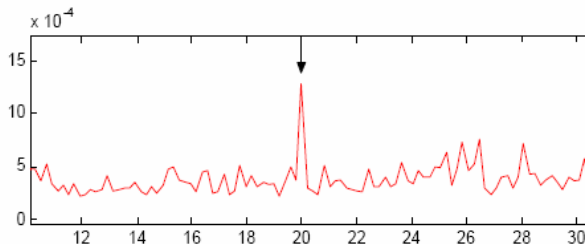
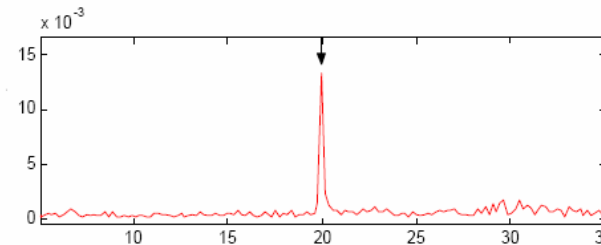
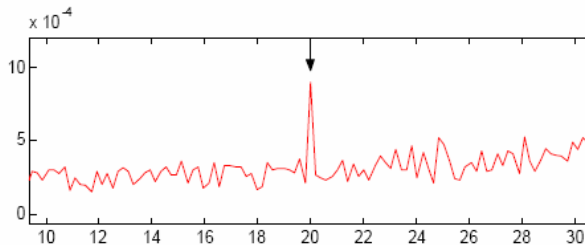


Spectrul tensiunilor, u_d și u_q (normalizat)



[Hz]
Mers in gol, 300rpm

[Hz]
Mers in sarcina, 300rpm



[Hz]
Mers in gol, 1200rpm

[Hz]
Mers in sarcina, 1200rpm



□ Monitorizarea curentilor statorici

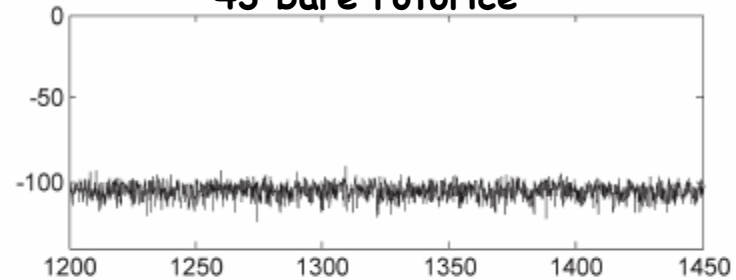
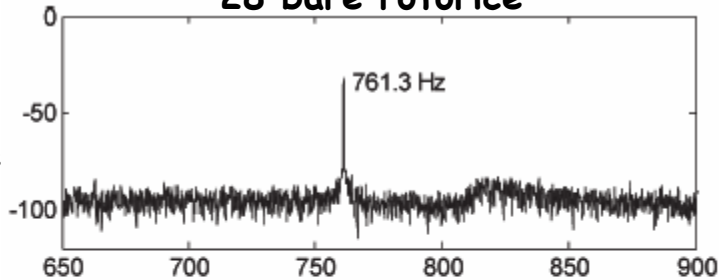
$$f_{statica / dinamica} = f_s \left[\frac{(kZ_R \pm n_d)(1-s)}{p} \pm n_s \right]$$

Masina de inductie trifazata, cu patru poli

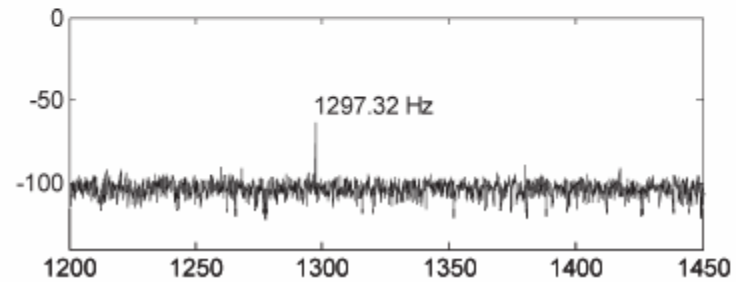
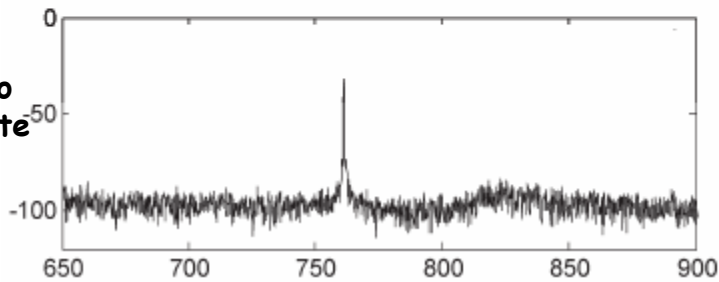
28 bare rotorice

43 bare rotorice

Masina fara probleme



Masina cu o excentricitate de 50%



[Hz]

[Hz]

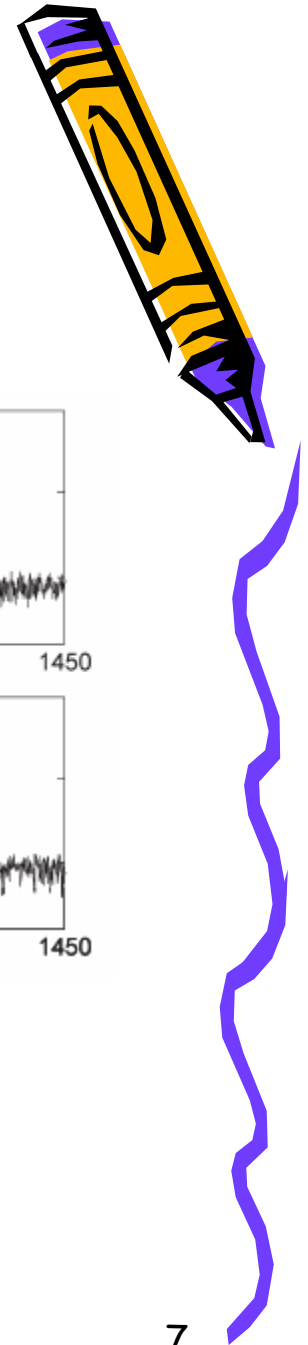
$$Z_R = 2p[3(m \pm q) \pm r] \pm k$$

$$m \pm q = 0, 1, 2, 3, \dots \quad r = 0 \quad \text{sau} \quad 1$$

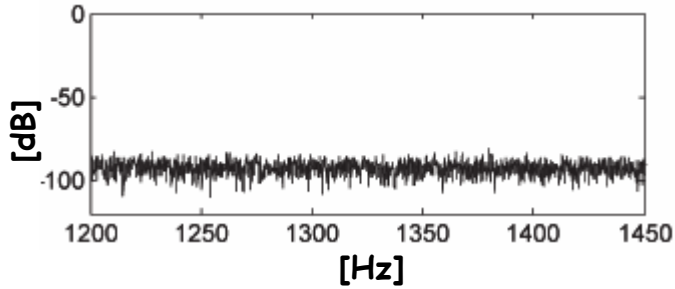
$$k = 1 \quad \text{sau} \quad 2$$



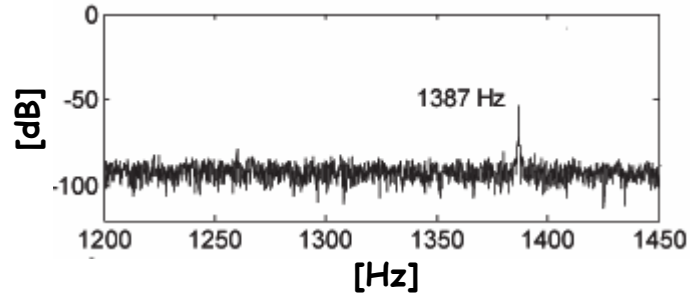
Curs 9



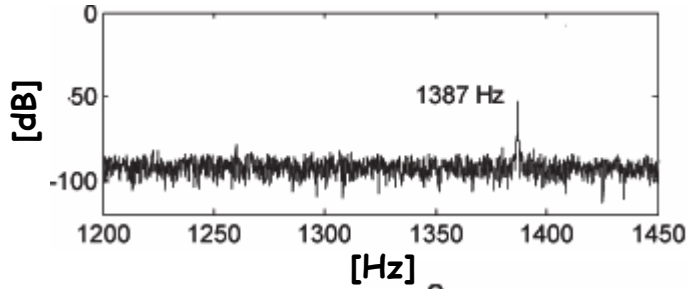
Masina fara probleme



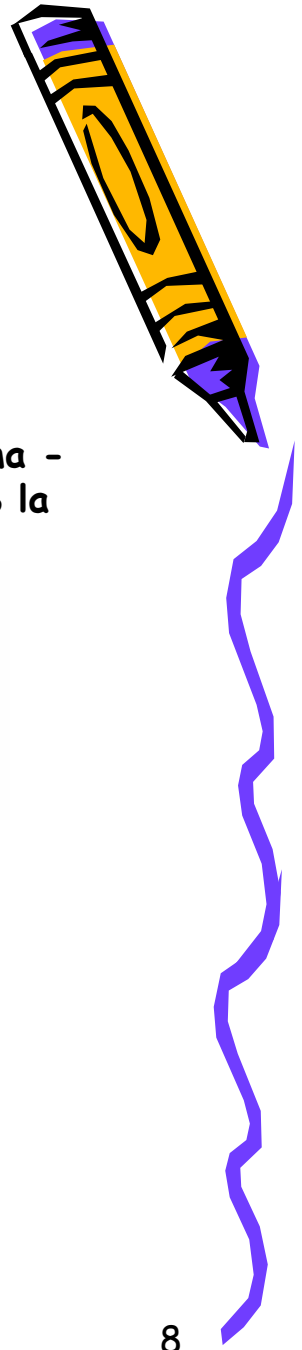
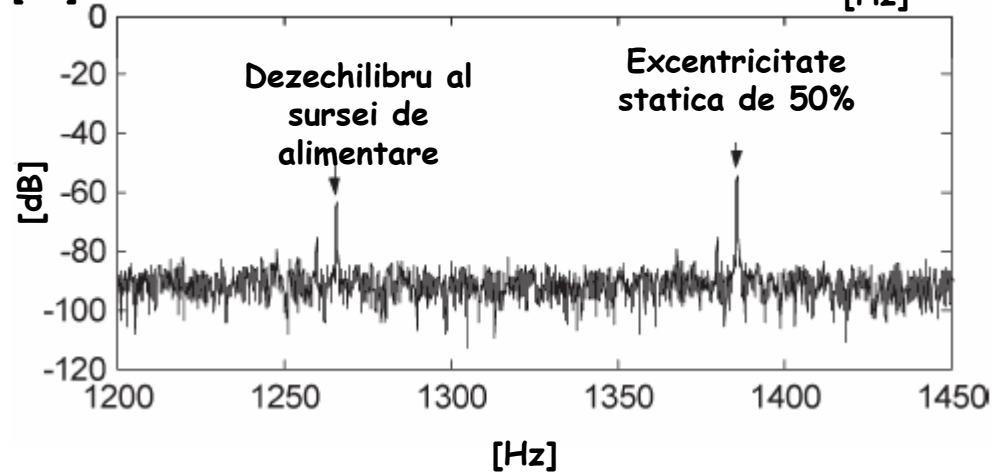
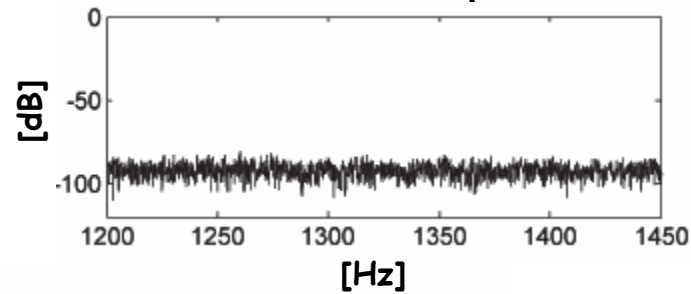
Masina cu 50% excentricitate



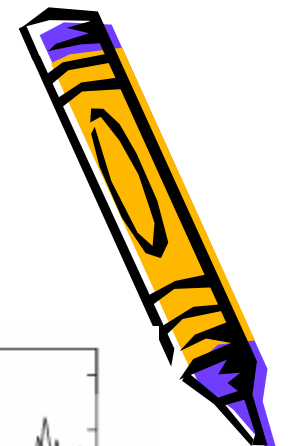
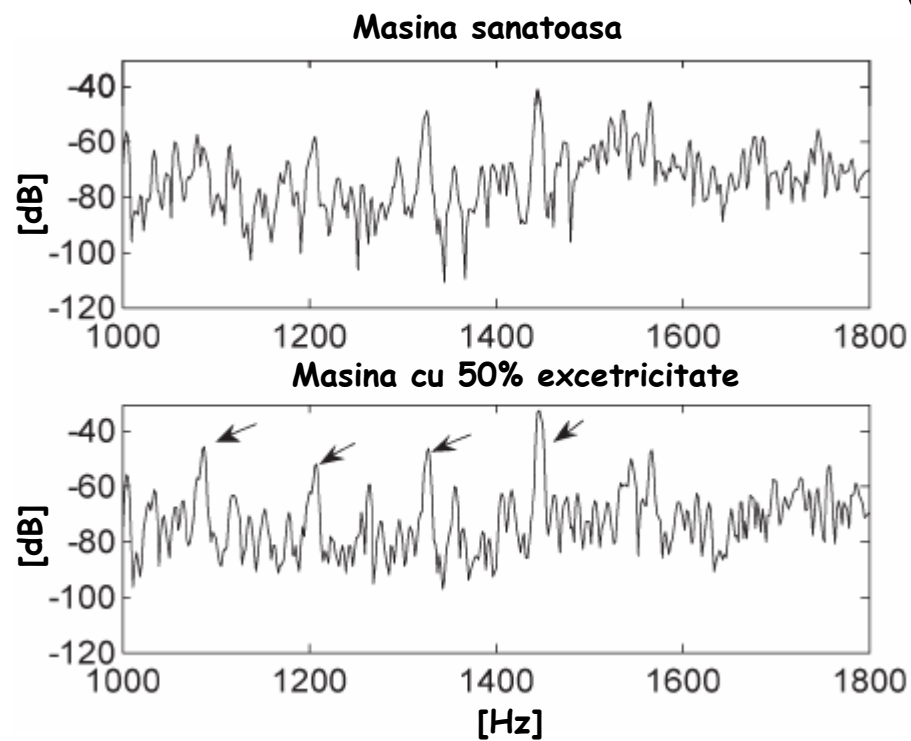
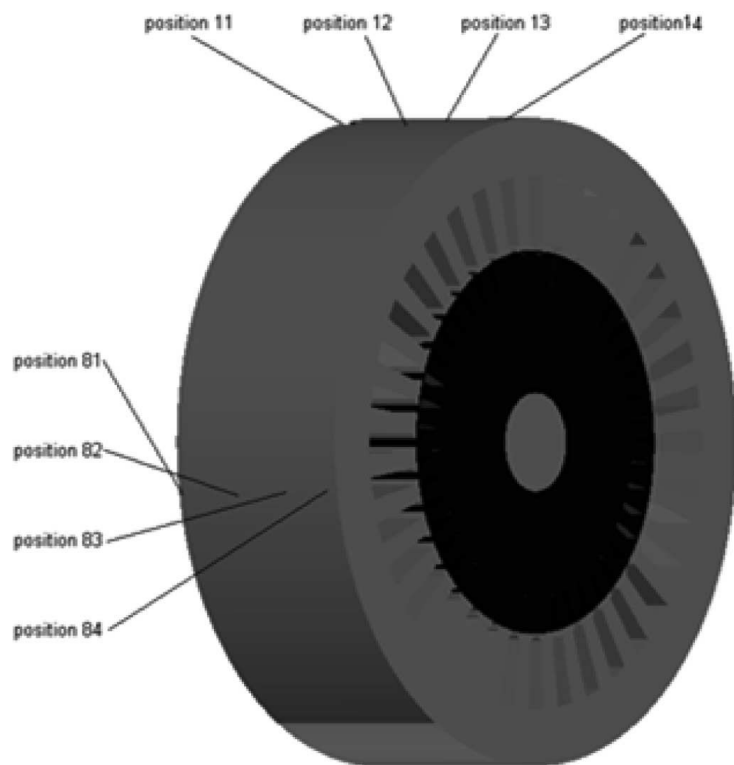
Masina cu excentricitate neuniforma
45.78% intr-un capat, respectiv 65.06%
la celalalt capat



Masina cu excentricitate neuniforma -
50% intr-un capat, respectiv 50% la
celalalt capat



□ Monitorizarea vibratiilor



Nivelul vibratiilor in pozitia 13

	Sanatoasa	+25% -25%	Uniform 50%	+12.5% -75%	+25% -75%
1448Hz	-41	-42	-32	-37	-36
1328Hz	-49	-45	-46	-43	-47
1208Hz	-60	-65	-51	-59	-58
1088Hz	-58	-48	-46	-42	-54

Nivelul vibratiilor in pozitia 83

	Sanatoasa	+25%/- 25%	Uniform 50%	+12.5% -75%	+25% -75%
1448Hz	-39	-41	-36	-46	-36
1328Hz	-56	-41	-49	-45	-56
1208Hz	-54	-52	-47	-49	-54
1088Hz	-49	-51	-43	-39	-52

Nivelul vibratiilor in pozitia 11

	Sanatoasa	+/- 25%	50%	+12.5% - 75%	+25% -75%
1448Hz	-35	-34	-25	-48	-33
1328Hz	-55	-40	-33	-37	-37
1208Hz	-47	-42	-42	-48	-49
1088Hz	-53	-47	-46	-48	-52

Nivelul vibratiilor in pozitia 81

	Sanatoasa	+/- 25%	50%	+12.5% - 75%	+25% -75%
1448Hz	-37	-38	-24	-34	-34
1328Hz	-40	-38	-36	-37	-35
1208Hz	-54	-43	-47	-47	-61
1088Hz	-45	-48	-41	-39	-46



Curs 9

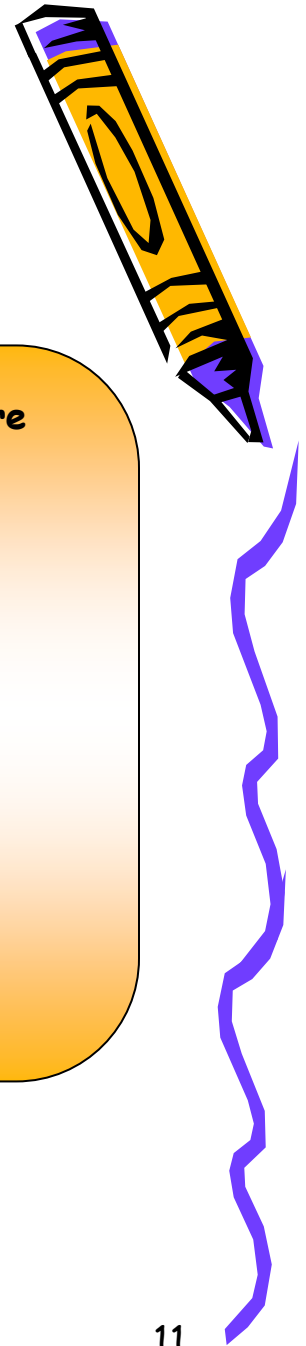


PROBLEME IN LAGARELE MASINILOR ELECTRICE

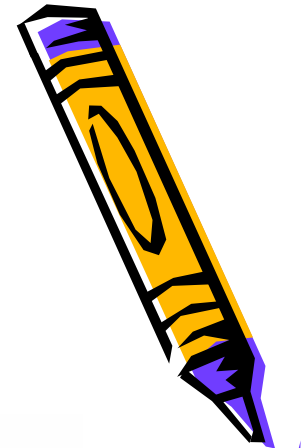
Defectele din lagăre reprezintă aproximativ 40÷50% din totalul defectelor care apar în mașinile electrice.

Cauze ale apariției defectelor la nivelul lagarelor:

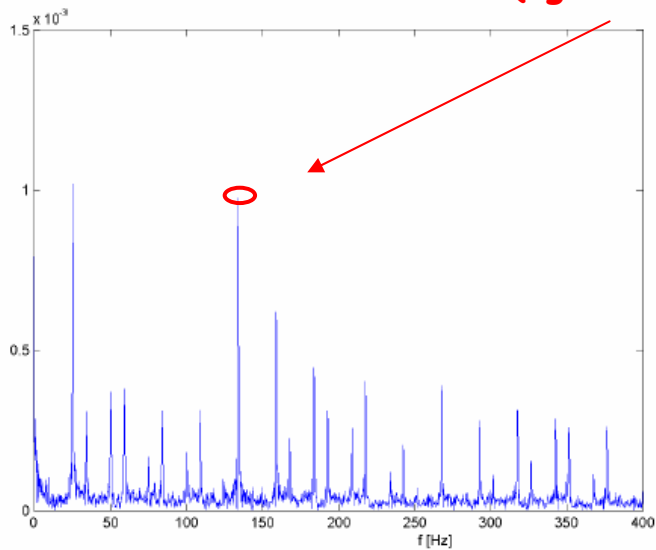
- lubrifierea neadecvată sau insuficientă
- suprasolicitare axială și radială datorită deformării arborelui
- montare, centrare sau fundamentare necorespunzătoare
- acțiunea corosivă a apei, acizilor, etc.
- contaminarea datorată particulelor minuscule abrazive
- Probleme legate de circuitul electric al mașinii electrice



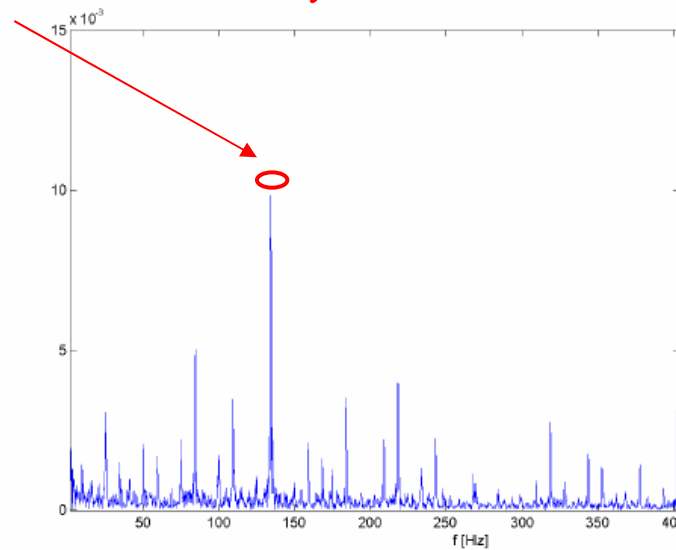
ANALIZA VIBRATIILOR IN DETECTAREA DEFECTELOR IN LAGARE



Armonica data de tipul de defect(zgarietura pe calea interioara)



Lagar cu o zgarietura pe calea interioara



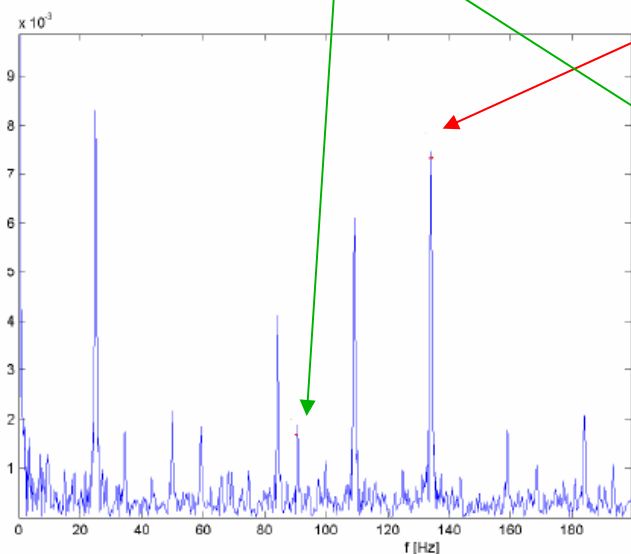
Lagar cu mai multe zgarieturi pe calea interioara



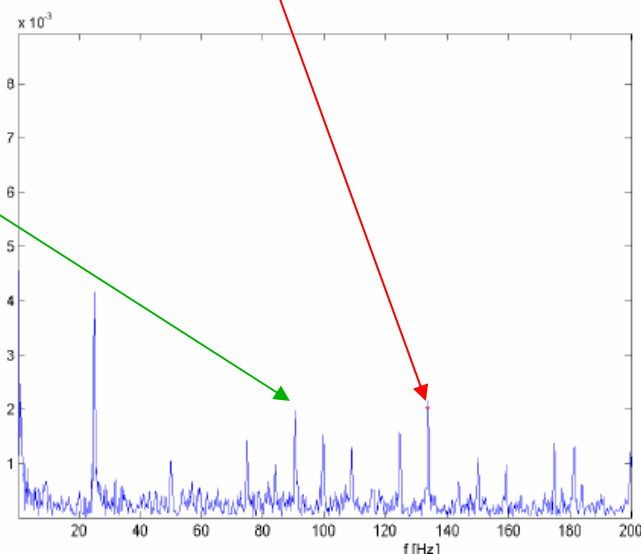
INFLUENTA LUBRIFICARII ASUPRA SPECTRULUI DE VIBRATII

Armonica data de zgarieturi pe calea exterioara

Armonica data de zgarieturi pe calea interioara



Inainte de ungere



Dupa ungere



POTENTIALUL DE ARBORE SI CURENTII DE LAGAR



Disimetrii magnetice

Excentricitati ale rotorului

Curenti de mod normal si de mod comun



Flux axial diferit de zero

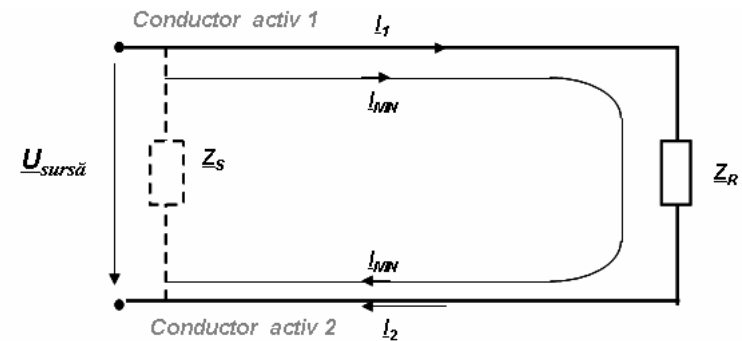
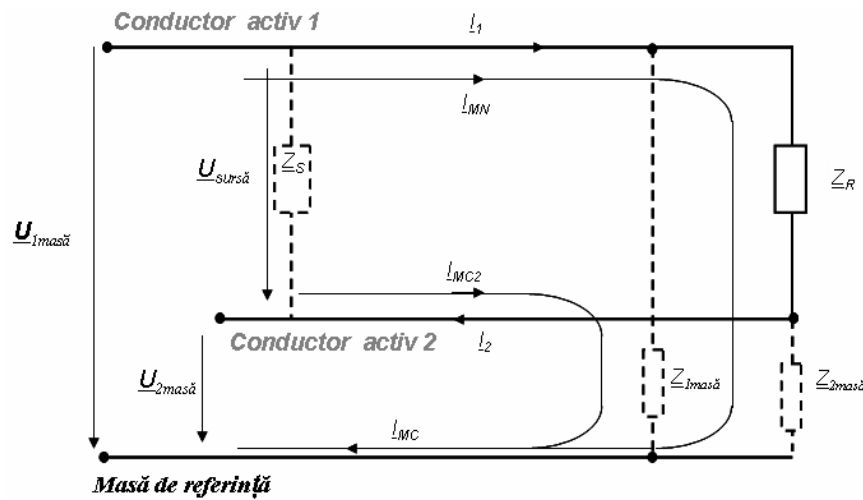


Aparitia unei diferente de potential intre cele doua capete ale arborei

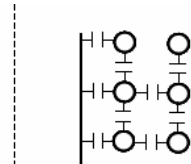
Tensiuni de mod comun



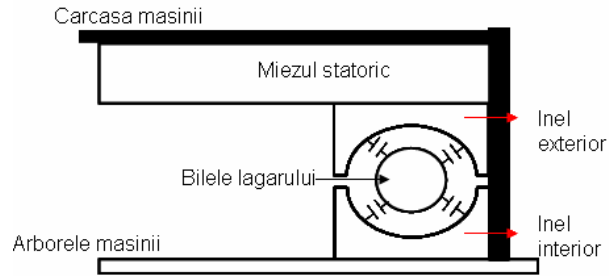
Curenti de lagar



Capacități parazite în mașini electrice

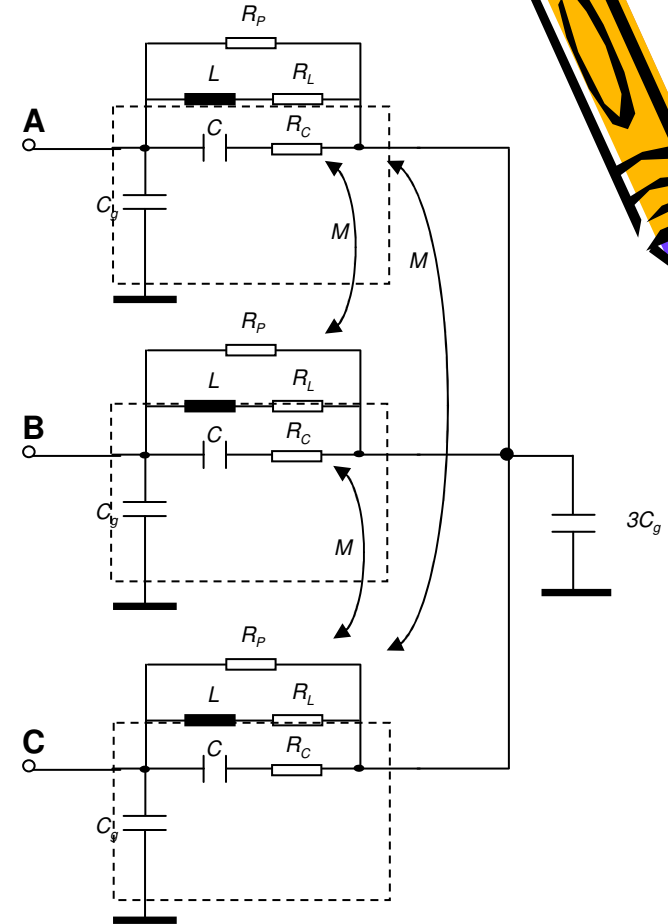


Capacități parazite între spirele înfășurării



Capacități parazite datorate lagarelor

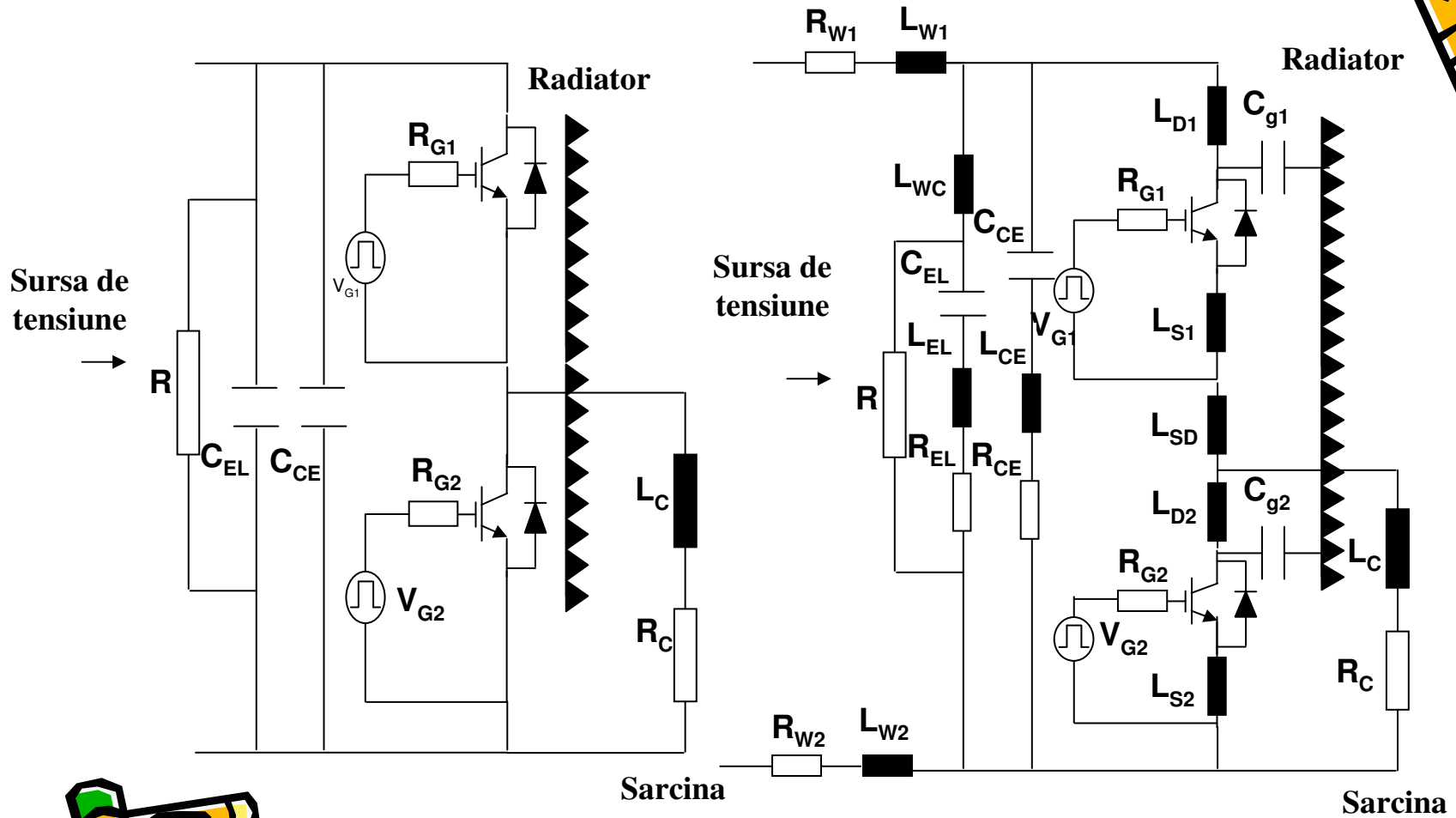
Puterea mașinii [kW]	C_p [nF]	L [mH]	R_p [k Ω]
1.1	0.250	28.12	17.49
4	0.653	7.96	5.28
4	0.797	8.86	5.10
7.5	0.739	3.46	3.69
7.5	1.000	12.97	7.32
15	1.100	1.62	2.95
15	1.790	0.775	0.885
30	2.210	0.453	0.465
33	1.650	0.096	0.530
55	2.17	0.186	0.295



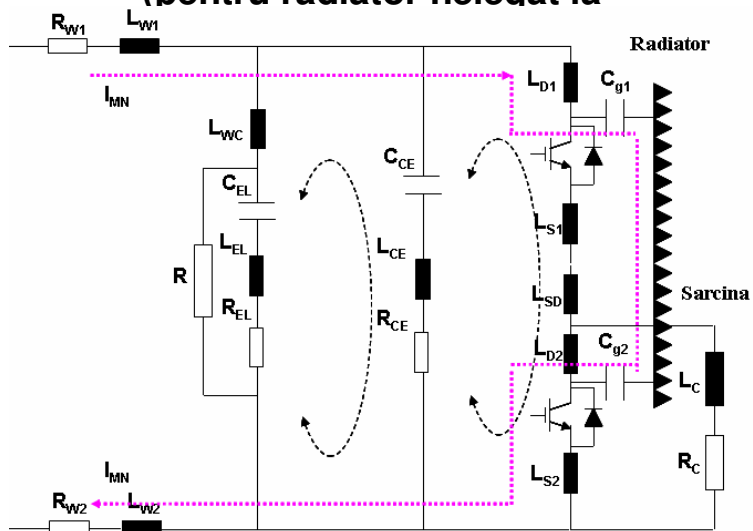
Modelul de înaltă frecvență al unei mașini de inducție



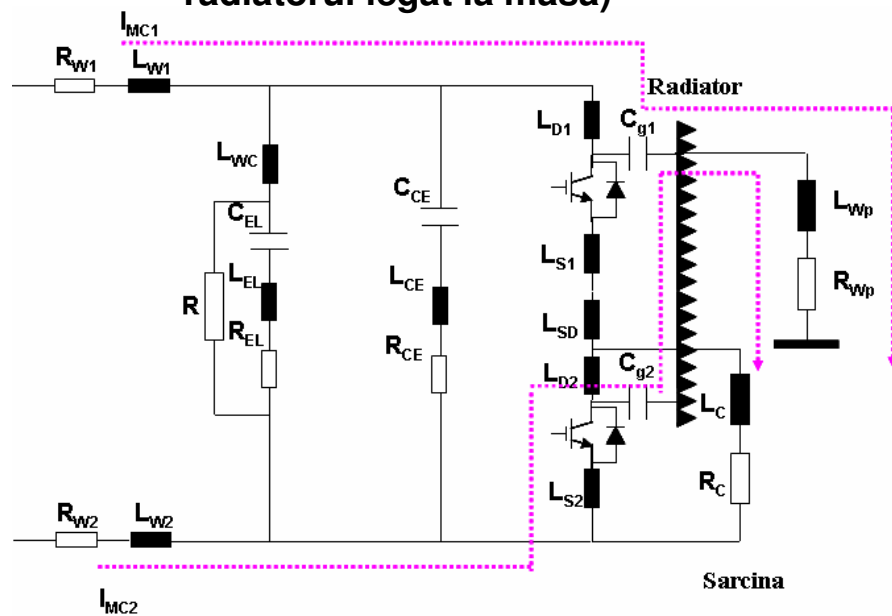
❖ Model de înaltă frecvență al unei celule de comutație a unui invertor



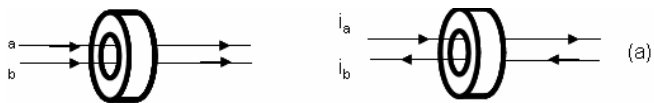
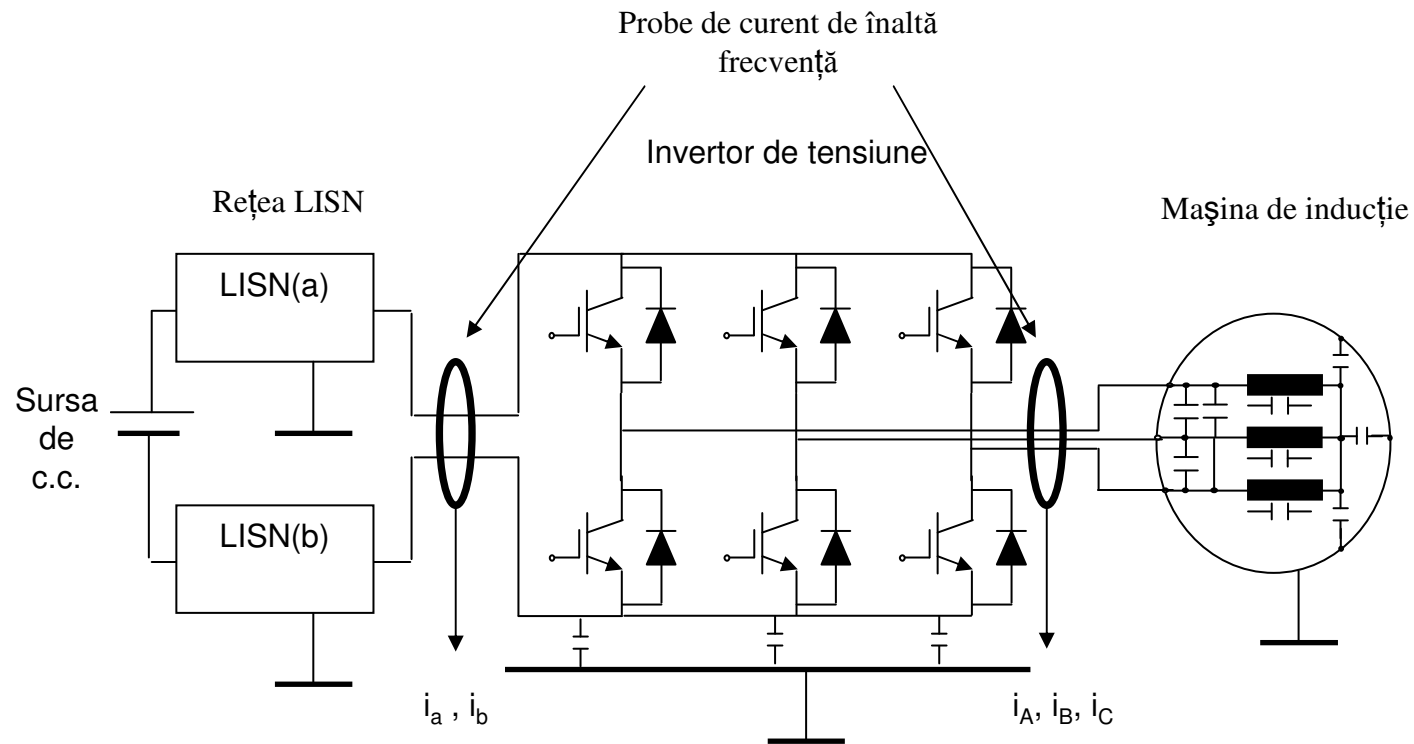
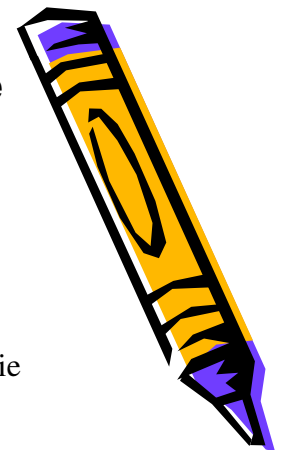
Curentul de mod normal și cele două bucle de rezonanță într-o celulă de comutație a unui convertor de putere (pentru radiator nelegat la



Curentul de mod comun într-o celulă de comutație a unui convertor de putere (cu radiatorul legat la masa)

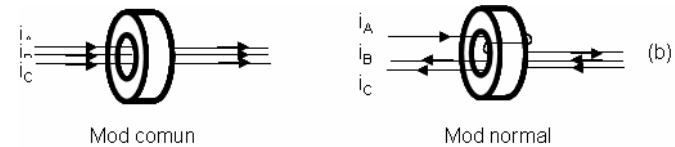


Determinarea experimentală a curenților de mod normal și de mod comun în sisteme de acționare cu mașini de inducție



$$I_{MC} = \frac{1}{2}(i_a + i_b)$$

$$I_{MN} = \frac{1}{2}(i_a - i_b)$$

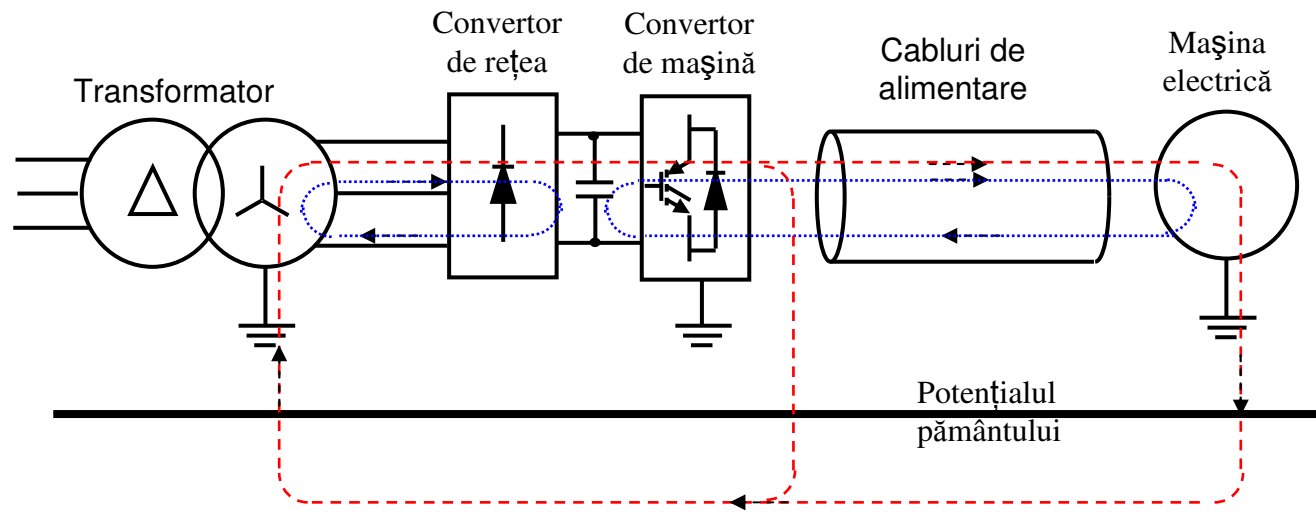


$$I_{MC} = \frac{1}{3}(i_A + i_B + i_C)$$

$$I_{MNk} = i_k - i_{MC}, \quad k = A, B, C$$



Structura unui sistem de acționare electrică cu principalele căi de închidere ale curenților perturbatori.



..... Curent de mod normal
 - - - - - Curent de mod comun



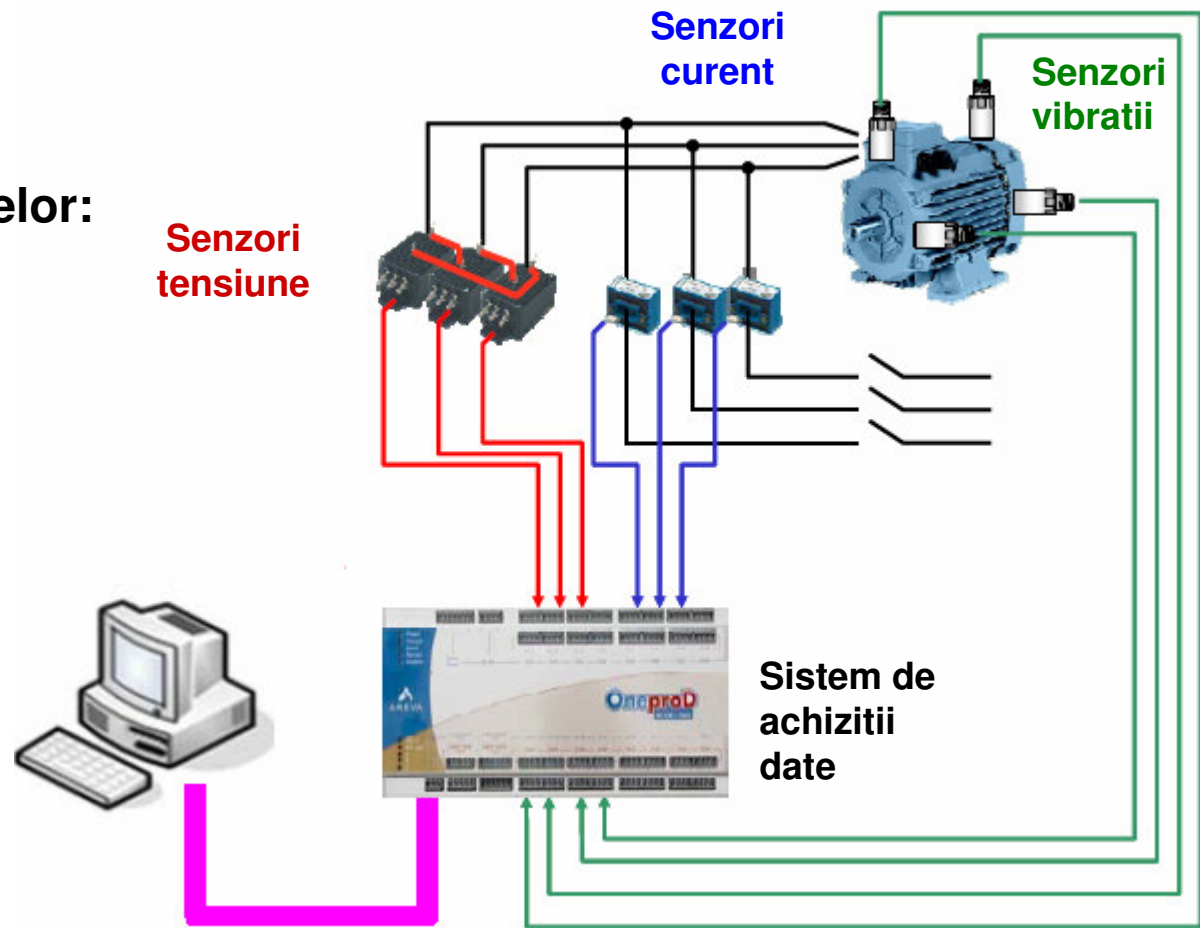
Modul in care caile de rulare ale bilelor sunt afectate



Diagrama unui sistem de monitorizare si diagnoza pentru masini de inductie

Acopera analiza defectelor:

- mecanice
- magnetice
- electrice



Cauza vibratiilor	Frecventele ce apar	Planul vibratiilor
Arbore rotoric dezechilibrat	1 x RPM	Radial
Arbore curbat sau dezaliniere unghiulara	1 x RPM, 2 x RPM	Axial
Dezaliniere paralela	1 x RPM, 2 x RPM	Radial
Slabire a legaturii mecanice	n x RPM (n+1)/1 x RPM, n intreg	Radial
Probleme ale elementelor de rostogolire ale lagarelor	Rezonanta indusa in carcasa in domeniul 1..20 kHz	-
Excentricitate statica	2 x f, $\omega \times [nZ_s(1-s)/p \pm k_1]$	Radial
Probleme statorice (slabire a prinderii, dezechilibru la nivelul fazelor, scurtcircuite la nivelul tolelor/spirelor)	2 x f	Radial
Slabire a sistemului de strangere a tolelor statorice	2 x f si componentele laterale in jur de 1kHz	Radial
Excentricitate dinamica	1 x RPM, cu componente laterale la 2 x f si componente la $\omega \times [nZ_s(1-s)/p \pm k_1]$	Radial
Probleme rotorice	1 x RPM, cu componente laterale la 2 x f si componente la $\omega \times [nZ_s(1-s)/p \pm k_1]$	Radial

