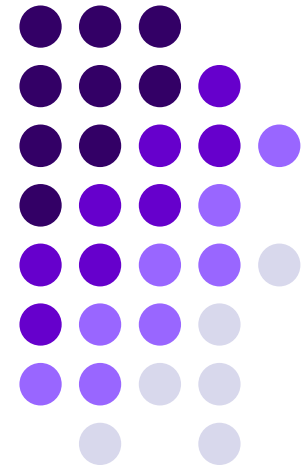
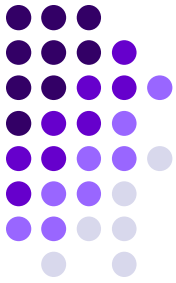


Senzori si traductoare

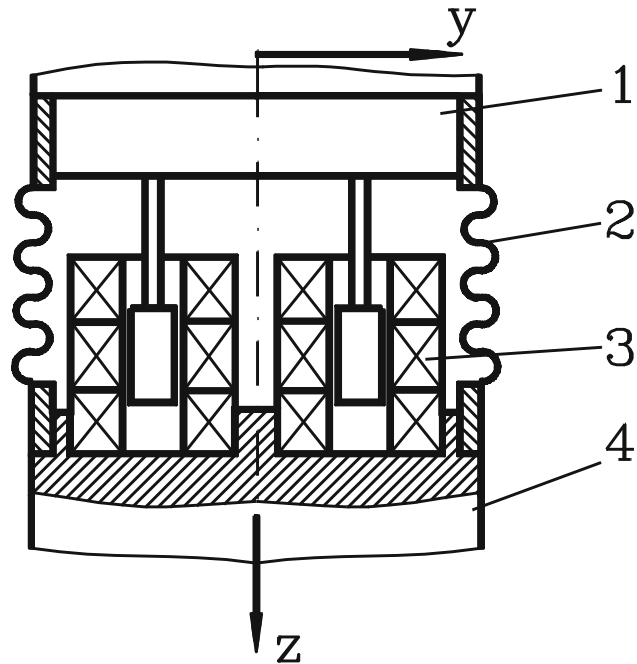
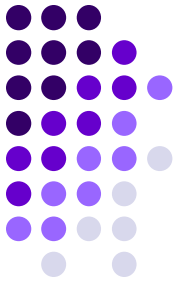


Cuprins 10

- Masurarea fortei pe baza deplasarii
- Masurarea momentului de torsiune
- Senzori de forta cu coarda vibranta
- Senzori de forta piezoelectrice



Masurarea fortei pe baza deplasarii



- Universitatea Leuven (Belgia)
- 3 componente
- DG - dispozitiv de ghidare (1)
- element elastic (2) (silfon)
- traductoare inductive diferentiale (3) (4 traductoare)
- flansa inferioara (4)

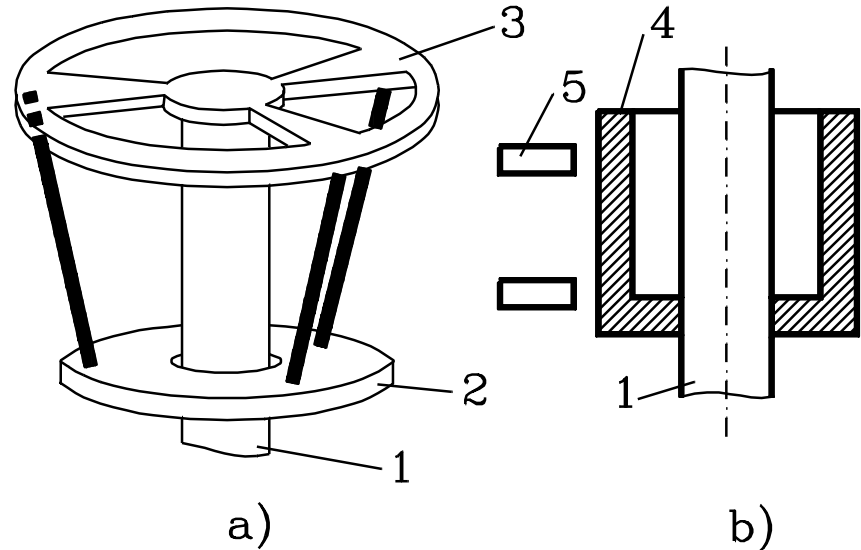
$$F_z = -c_z \cdot \frac{z_1 + z_2 + z_3 + z_4}{4}$$

$$M_x = c_\alpha \cdot (z_3 - z_1)$$

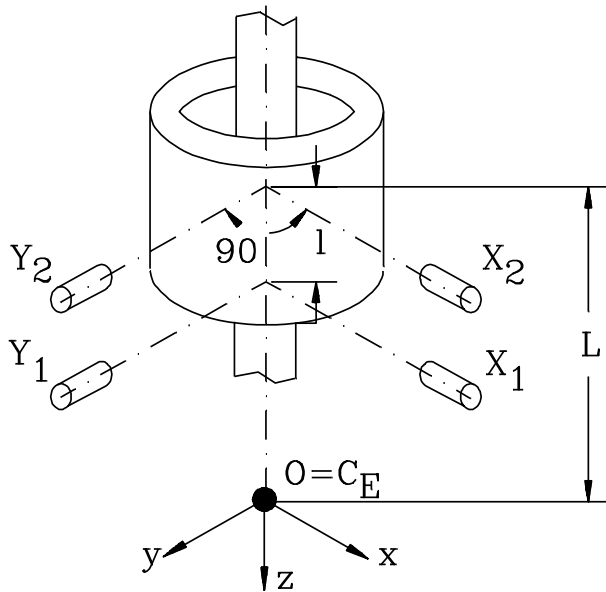
$$M_y = c_\alpha \cdot (z_2 - z_4)$$

- c_z este rigiditatea elementului elastic în direcția z;
- c_α este rigiditatea unghiulară a elementului elastic;
- z_i ($i = 1 \dots 4$) sunt deplasările indicate de cele 4 traductoare inductive

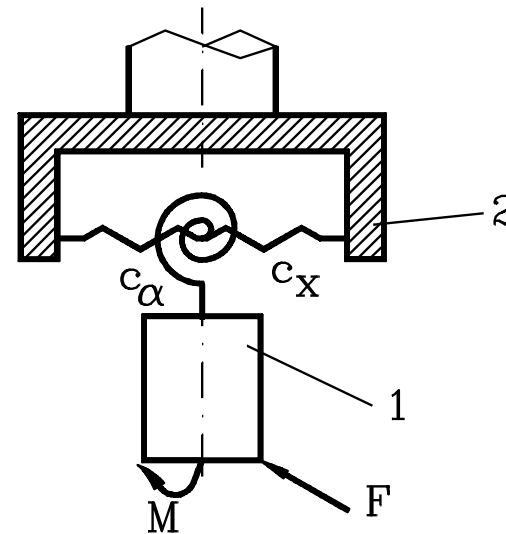
- Charles Draper Laboratory;
- RCC (1- tijă centrală; 2 – flanșă inferioară; 3 – flanșa superioară);
- piesa de referinta (4) feromagnetica;
- traductoare de pozitie “5”



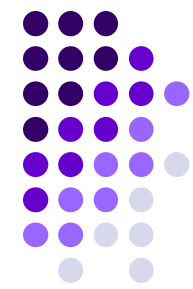
Modelul IRCC



Poziția traductoarelor



Echivalarea modelului RCC

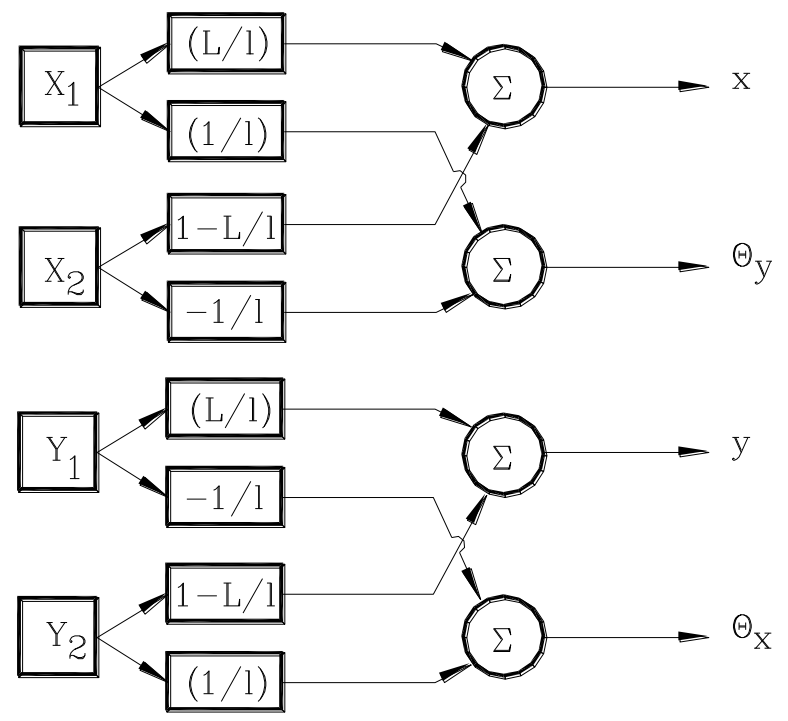


$$F_x = c_1 \cdot \left(x_2 + \frac{x_1 - x_2}{l} \cdot L \right)$$

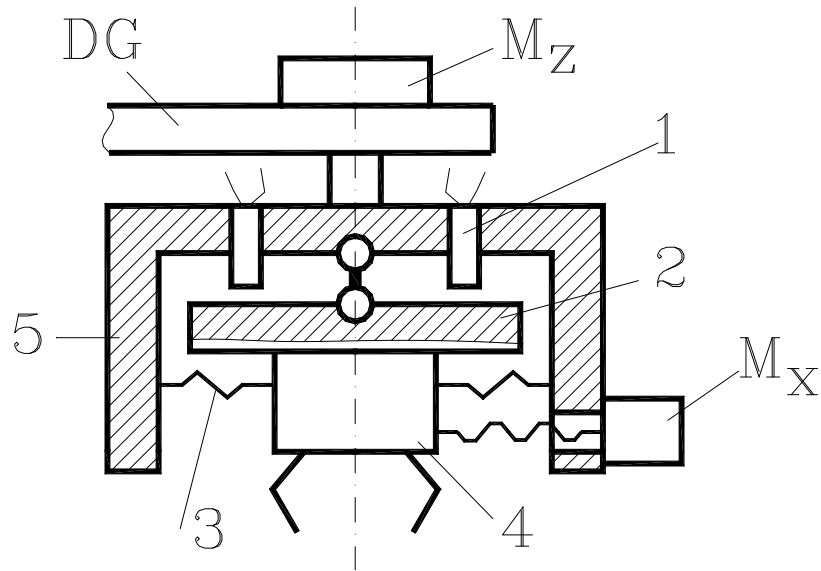
$$M_x = c_3 \cdot \frac{y_2 - y_1}{l}$$

$$F_y = c_2 \cdot \left(y_2 + \frac{y_1 - y_2}{l} \cdot L \right)$$

$$M_y = c_4 \cdot \frac{x_2 - x_1}{l}$$

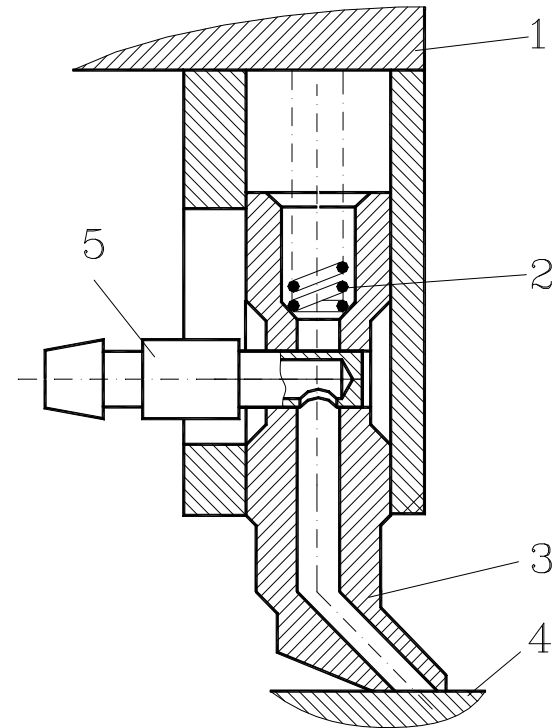


Schema de prelucrare a informației

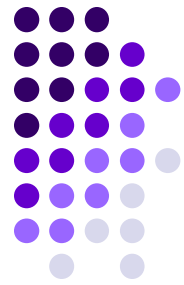


VARIANTĂ pentru un senzor de forță / moment:

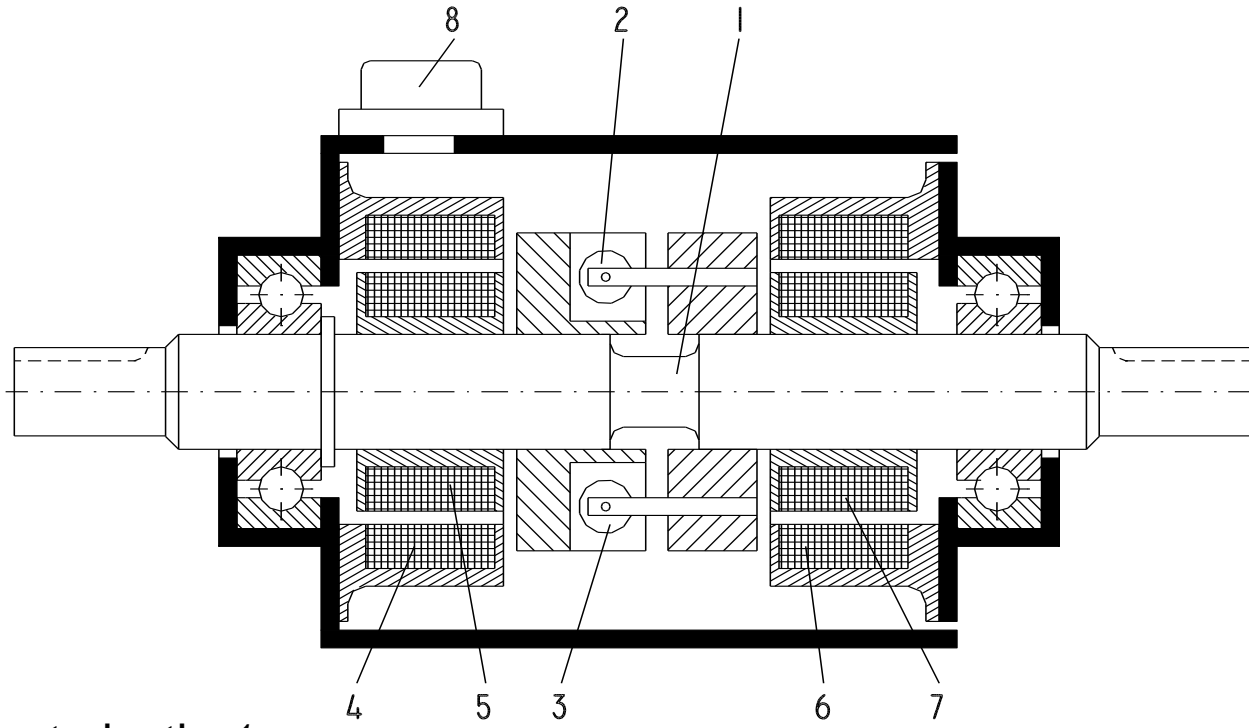
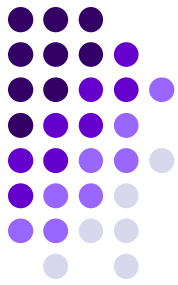
1 – traductor inductiv; 2 – placă de referință; 3 – element elastic; 4 – efector; 5 - carcasa



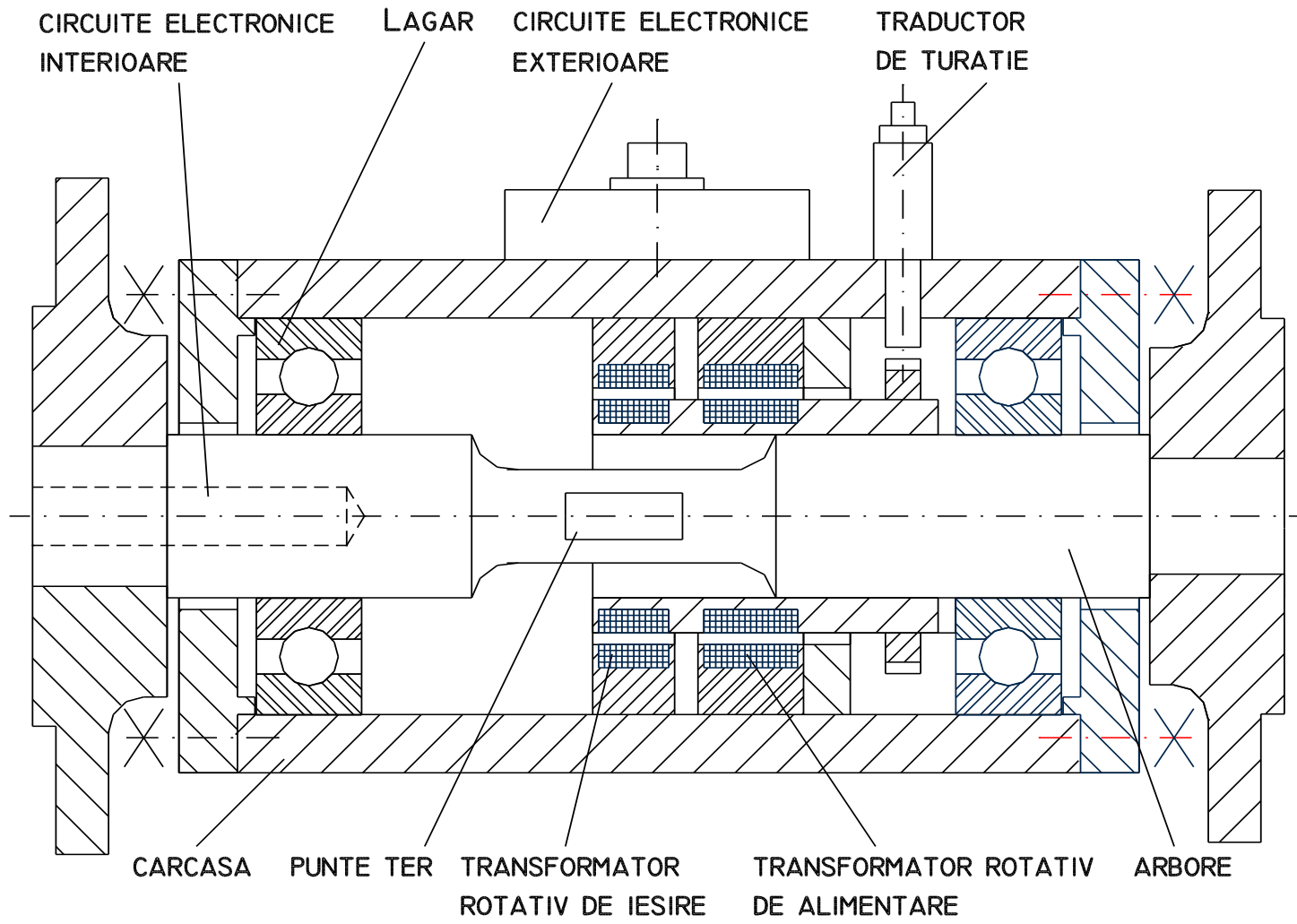
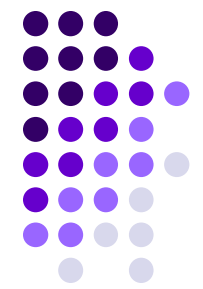
VARIANTĂ de senzor de proximitate cu mobilitate pe verticală

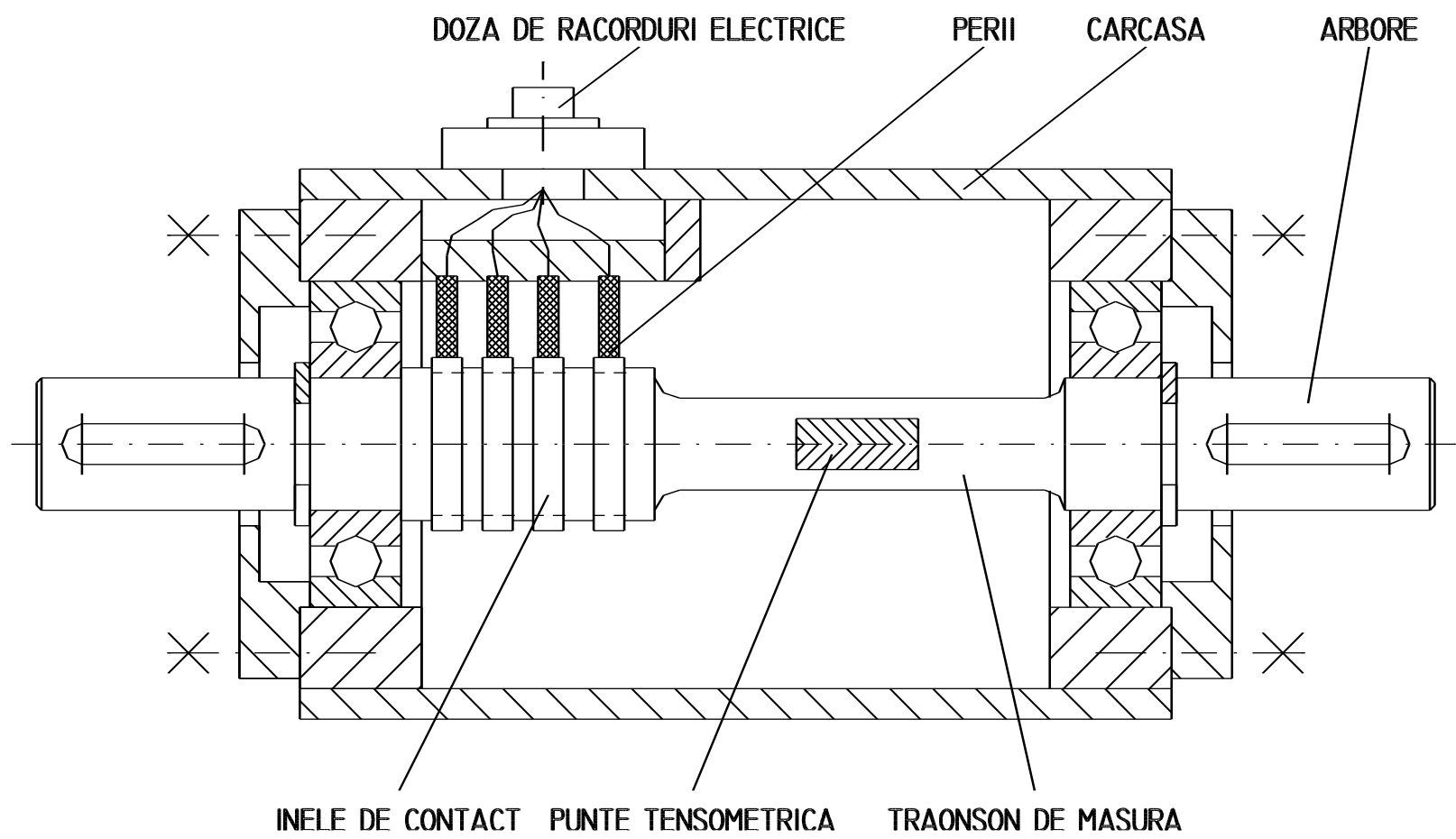
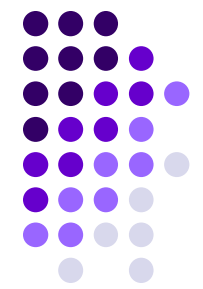


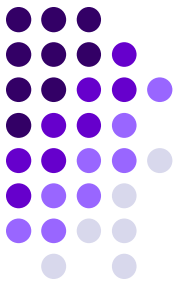
Masurarea momentului de torsiune



- element elastic 1;
- transductoare inductive diferențiale 2 și 3 .
- transformatorul rotativ (4,5) pentru alimentarea transductoarelor
- transformatorul (6,7) – preluare semnal
- doza 8 asigură conectările electrice necesare.







Coarda metalica tensionata:

$$f_0 = \frac{1}{2 \cdot l} \cdot \sqrt{\frac{\sigma}{\rho}}$$

l este lungimea corzii,

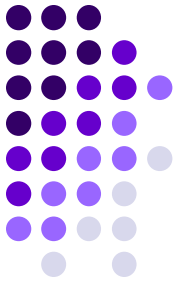
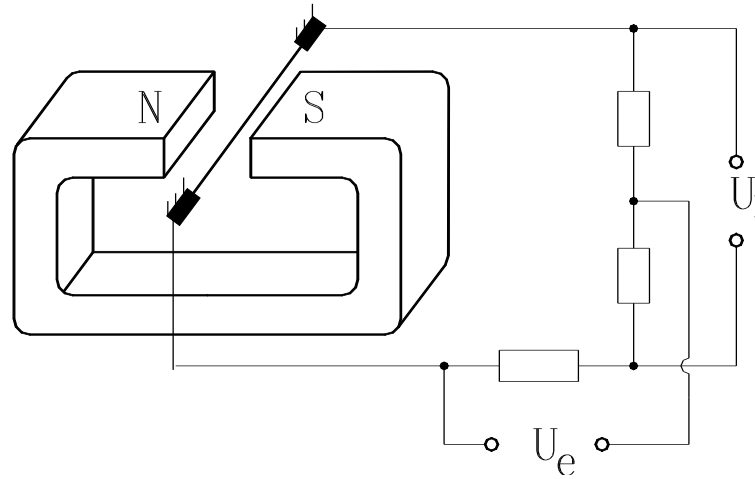
σ este tensiunea în coardă

ρ masa pe unitatea de lungime a materialului coardei

Senzorii cu coardă vibrantă:

- precizie de pină la 0.1 % (dacă se asigură o stabilitate a frecvenței de rezonanță);
- histereză practic inexistentă;
- repetabilitate foarte bună;
- stabilitate pe termen lung și invarianță la modificarea temperaturii.

Pentru asigurarea stabilității în funcționare și a sensibilității maxime, trebuie să se asigure menținerea în permanență la rezonanță a coardei.

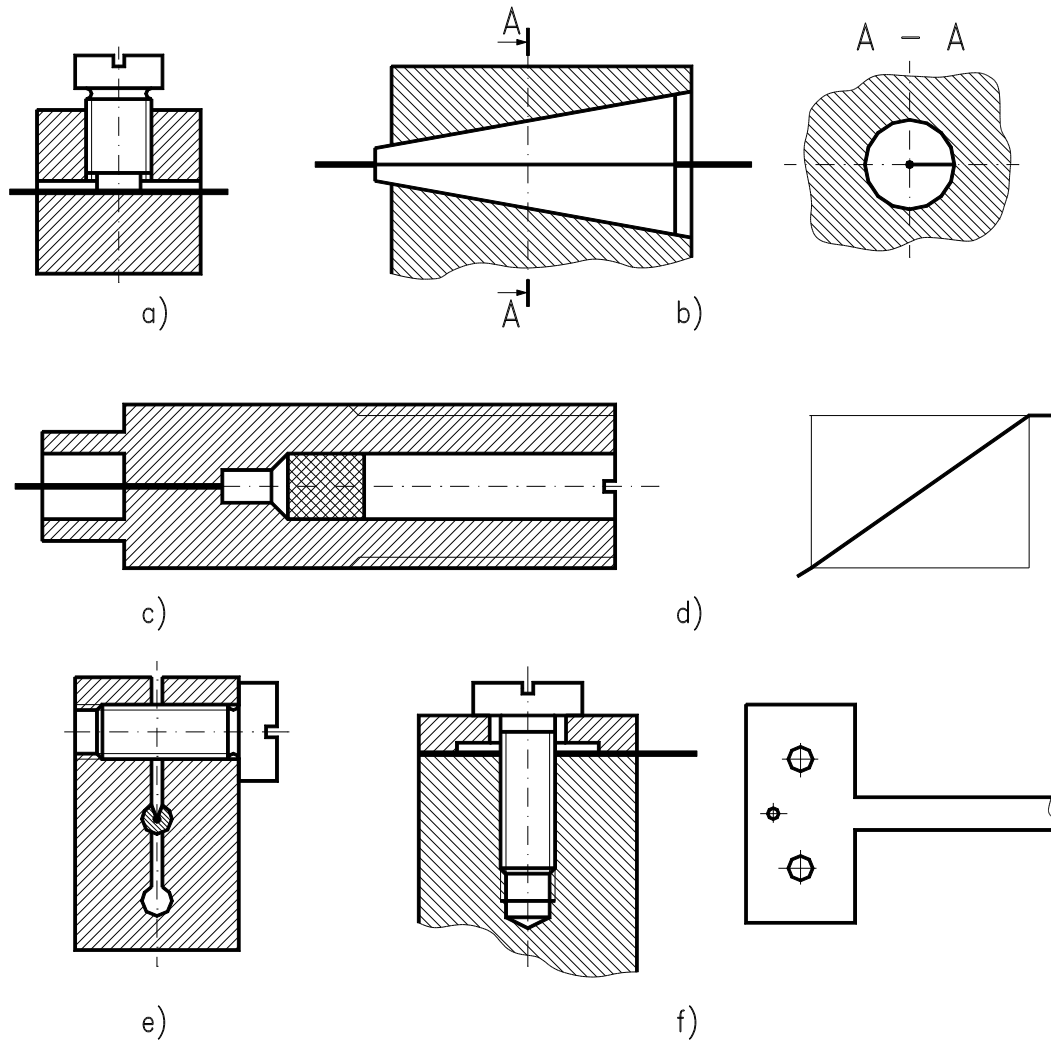
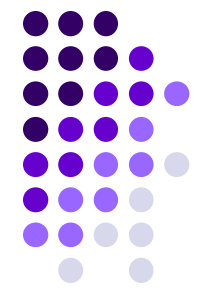


$$F_{el} = B \cdot i \cdot l_m$$

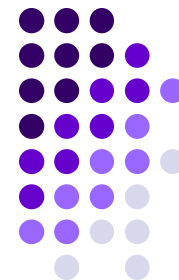
- B este inducția magnetică a magnetului permanent;
- i este curentul
- l_m este lungimea polului magnetic



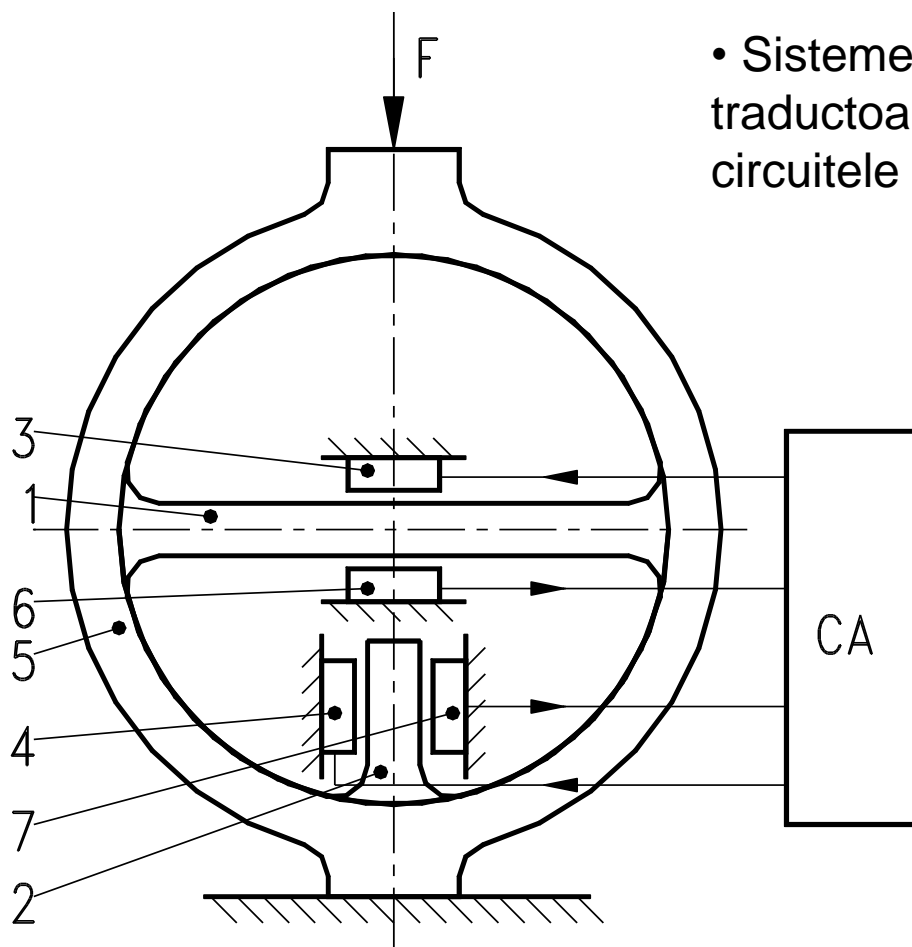
$$e = B \cdot l_m \cdot v$$



Modalități de fixare a coardei

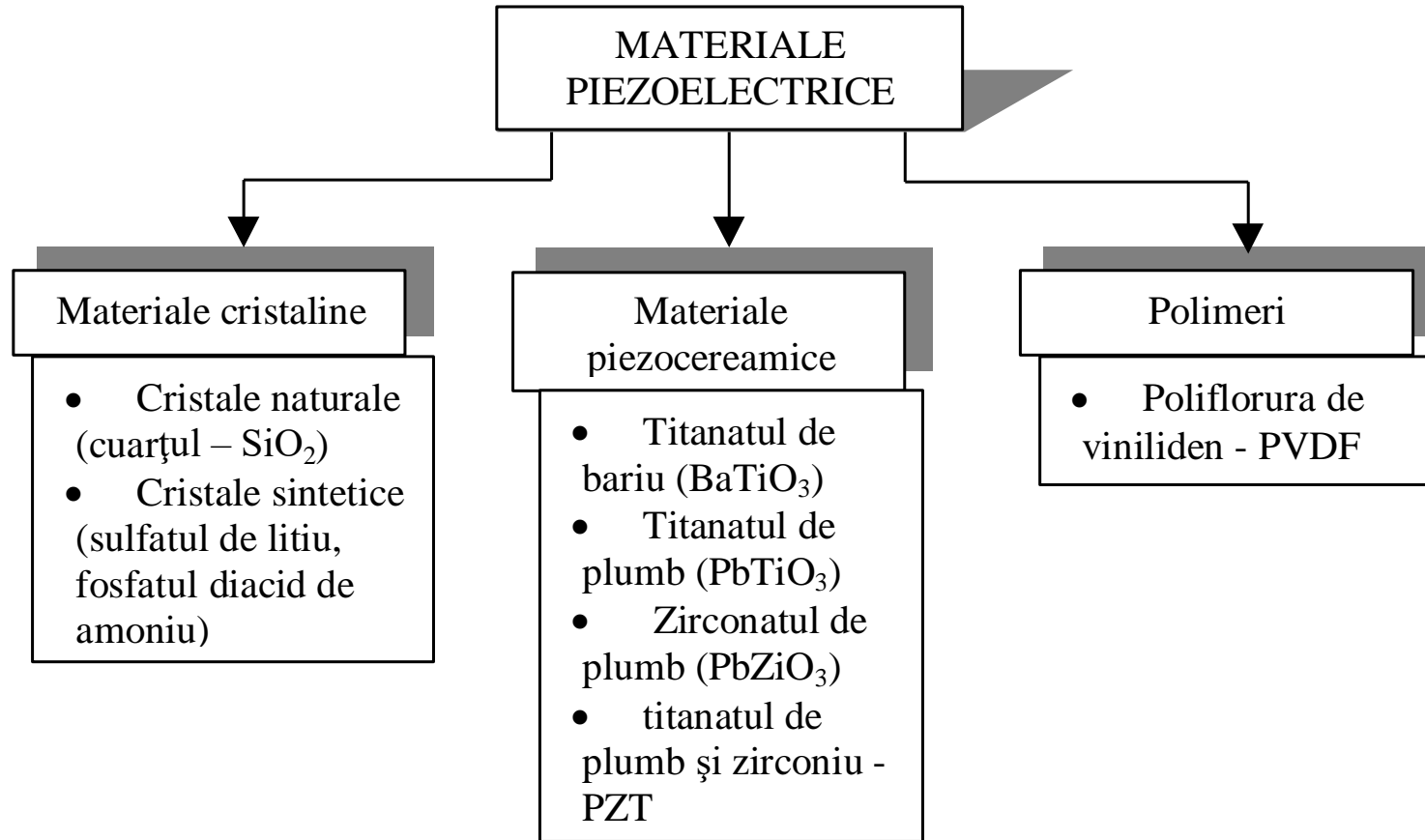
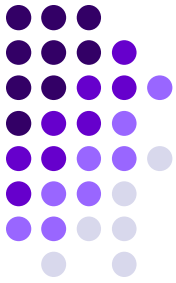


- Coarda "1", inelul elastic "5" și bara "2" formează un tot unitar fiind realizate din aceeași bucată.
- Sistemele de excitație "3" și "4" și traductoarele "6" și "7" conectate la circuitele de adaptare CA.



Senzorii cu coardă
 vibrantă permit măsurarea
 statică, sau variații lente
 ale forțelor pînă la 10^7 N.

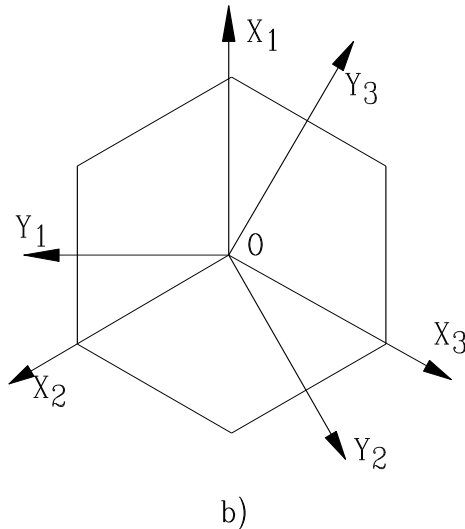
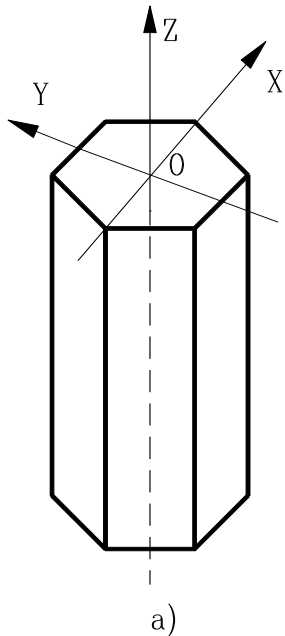
Senzori de forta piezoelectrice



• *constanta piezoelectrică sau piezomodulul*

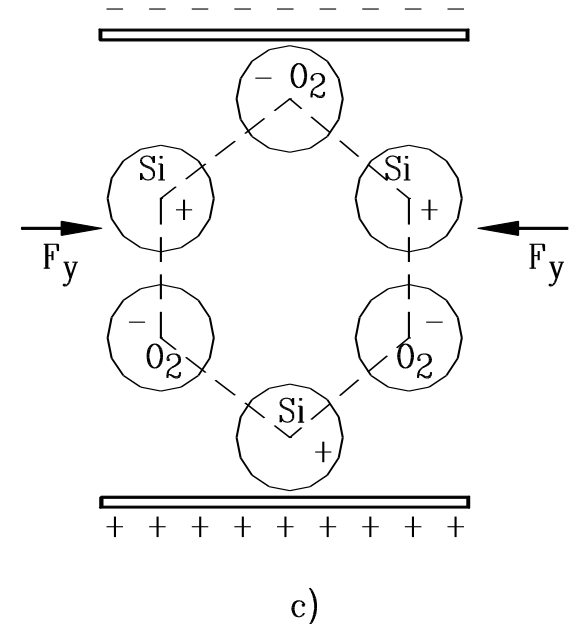
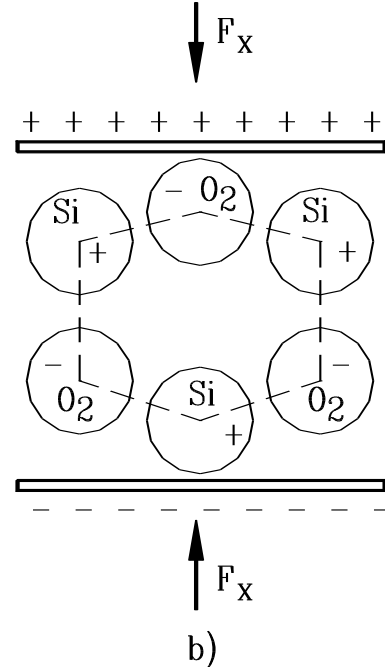
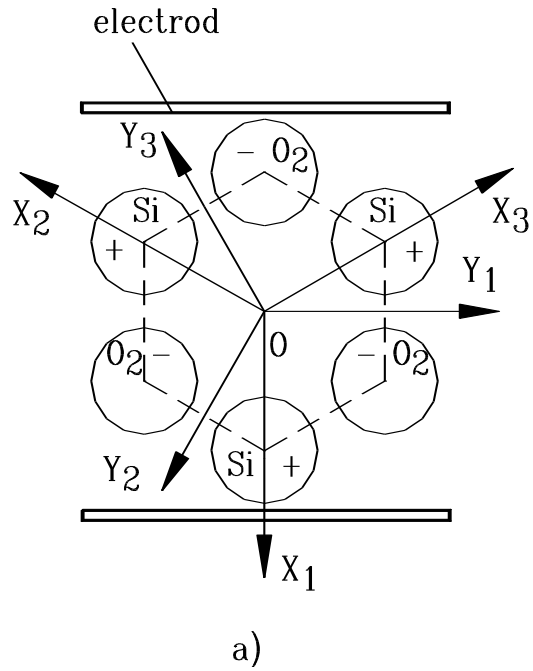
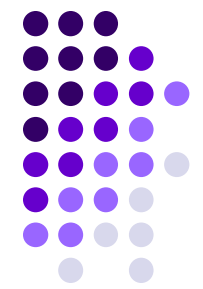
$$d = \frac{Q}{F} = \frac{C \cdot U}{F} \quad [\text{C/N}]$$

- **Q** este sarcina electrică rezultată pe fețele cristalului;
- **F** este forța aplicată
- **C** este capacitatea electrică a cristalului considerat la tensiunea **U**.



Axele pentru un cristal piezoelectric:

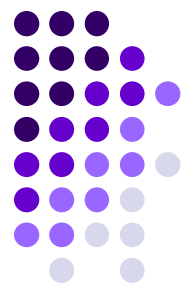
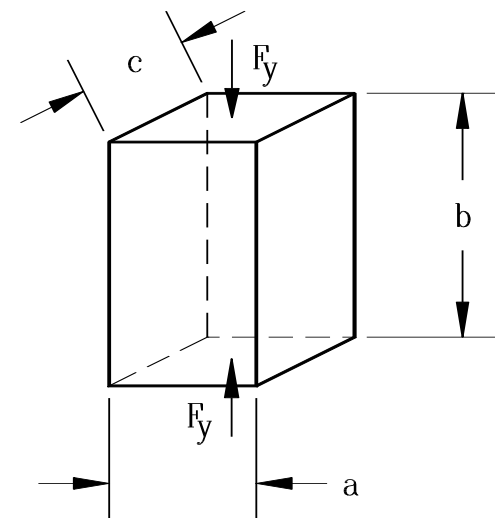
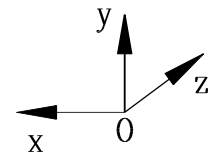
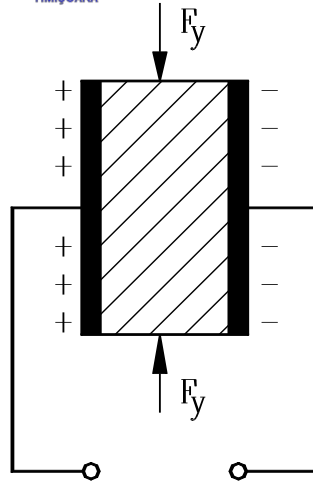
- trei axe electrice (OX_i , $i = 1, 2, 3$)
- trei axe neutre (OY_j , $j = 1, 2, 3$)
- axa optică (OZ)



Cristalul de cuarț în stare nesolicitată (a) și în stare sollicitată (b, c)

$$Q_x = d_{xx} \cdot F_x$$

$$Q_y = d_{xy} \cdot F_y$$

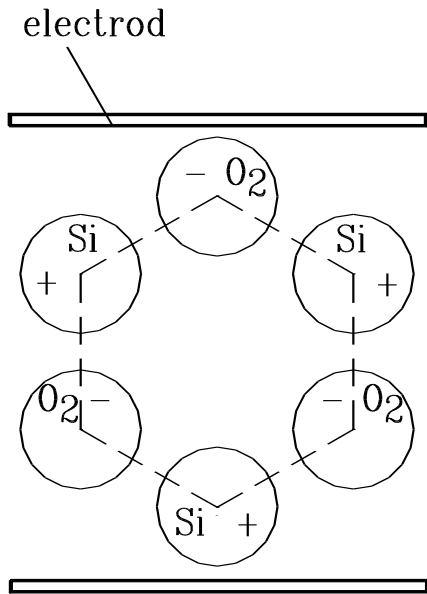
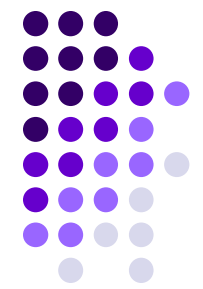


Efectul transversal pe un element piezoelectric de formă paralelipipedică

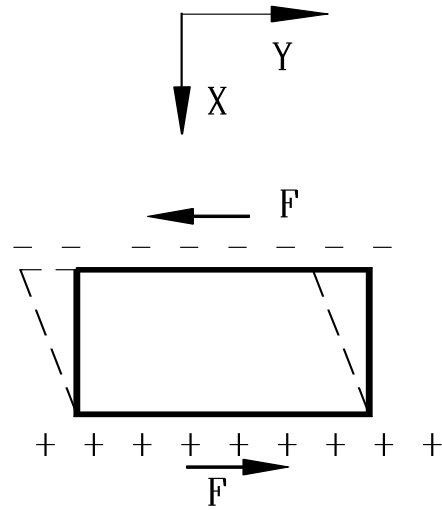
$$C_0 = \frac{\epsilon_0 \cdot \epsilon_r \cdot A}{l}$$

- ϵ_0 este permitivitatea electrică a vidului;
- ϵ_r este permitivitatea relativa
- A este suprafața transversală a elementului;
- l este grosimea acestuia

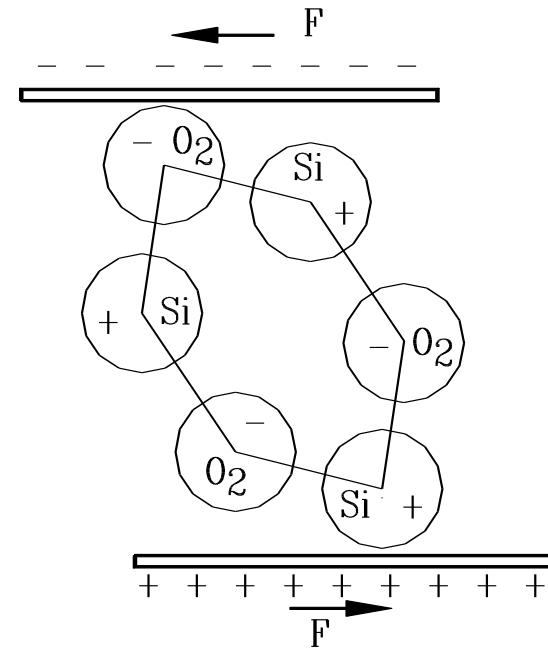
$$Q_y = -d_{xx} \cdot \frac{b}{a} \cdot F_y$$



a)

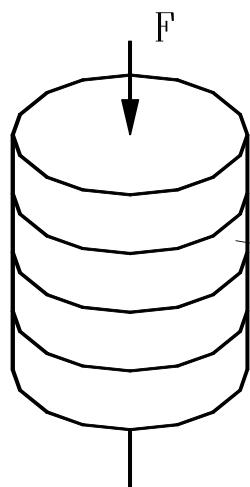


b)

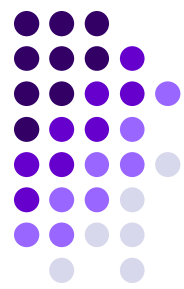
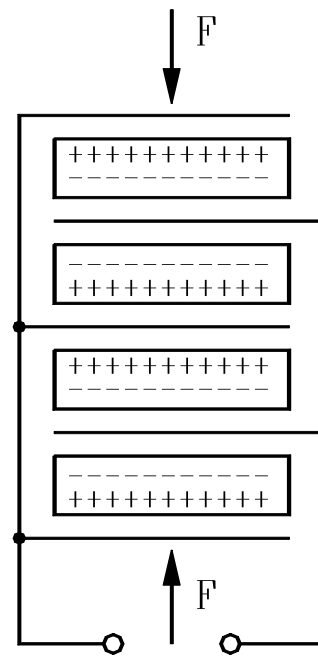


c)

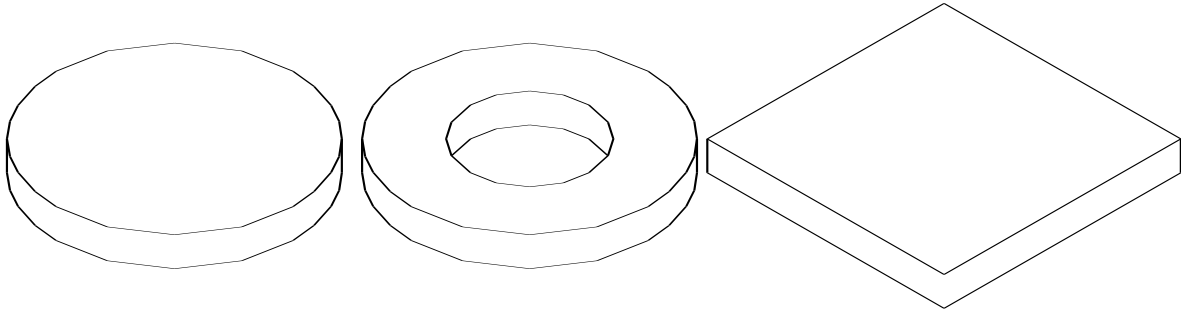
Efectul piezoelectric de forfecare



"n" elemente piezoelectrice



Conectarea în pachet a elementelor piezoelectrice



Forme pentru elementele piezoelectrice

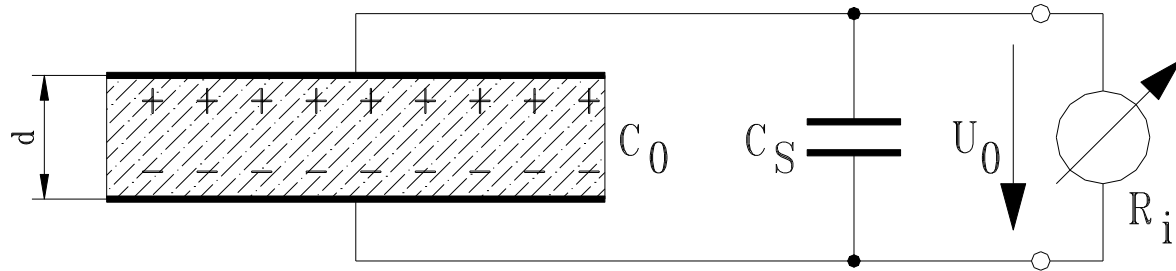
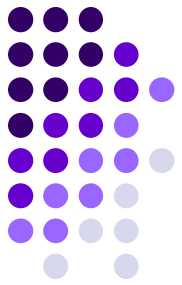
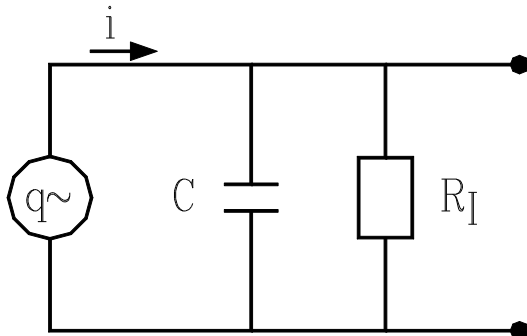


Fig.4.15 Schema electrică de principiu a unui senzor piezoelectric

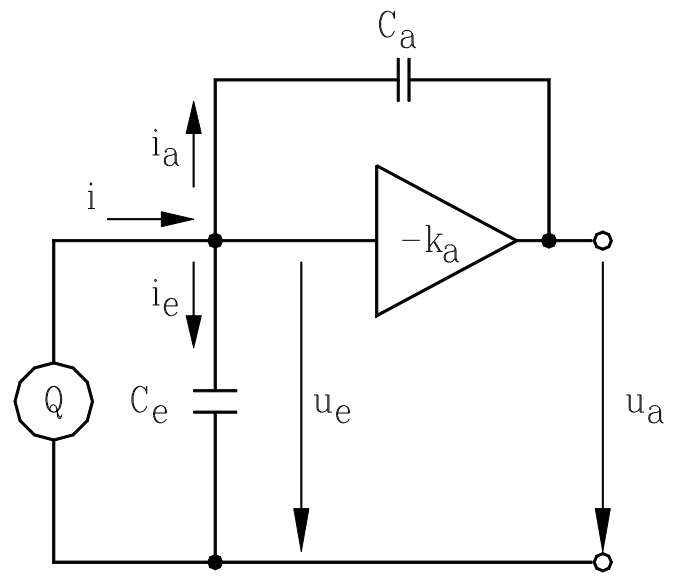
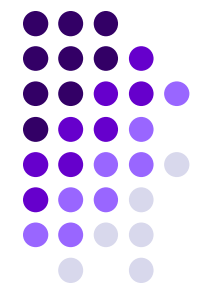
$$C_0 = n \cdot C'_0$$

$$U_0 = \frac{Q}{C} = \frac{n \cdot d_{ij} \cdot F}{C_S + nC'_0}$$



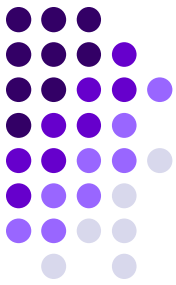
$$u = U_0 \cdot e^{-\frac{t}{R_I \cdot (C_0 + C_S)}}$$

$$\Delta u[\%] \approx \left(-\right) \frac{t}{\tau} \cdot 100$$



$$u_a = \frac{-Q}{C_a \cdot \left(1 + \frac{1}{k_a}\right) + C_e \cdot \frac{1}{k_a}} \approx \frac{-Q}{C_a}$$

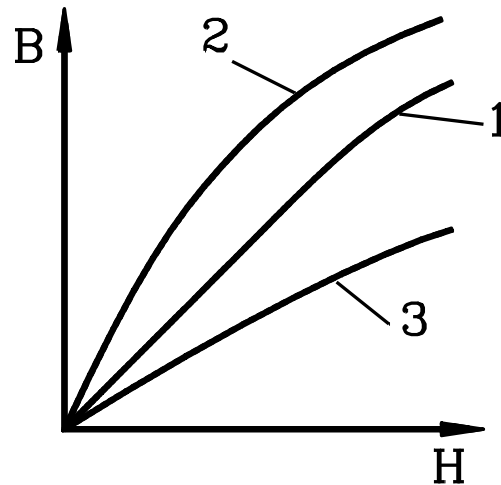
$$f_0 = \frac{1}{2 \cdot \pi} \cdot \sqrt{\frac{k}{m}} \quad \Rightarrow \quad (0.3 \dots 0.5) \cdot f_0$$



magnetostricțiune - variația dimensiunilor fizice ale unui material feromagnetic sub influența unui câmp magnetic exterior.

Fenomenul este reversibil.

$$\lambda = \frac{\Delta l}{l}$$



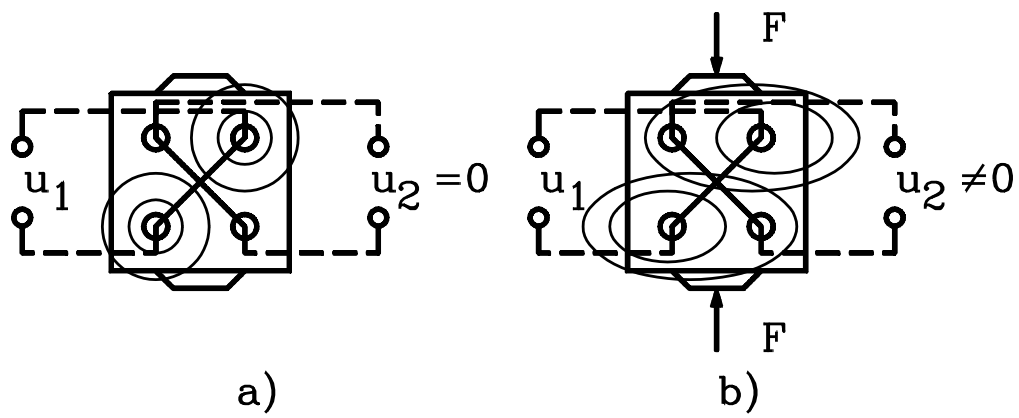
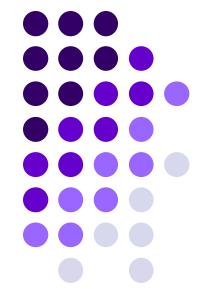
1 – stare nesolicitata

2 - solicitare de intindere

3 – solicitare la compresiune

Materialele specifice magnetostrictive:

- cobaltul (magnetostricțiune pozitivă);
- nichelul (magnetostricțiune negativă) și o serie de aliaje ale acestora (de ex. permalloy – magnetostricțiune pozitivă);
- Siferrit (Siemens) și 7 (A, A2, B) (Philips).



Principiul de funcționare a senzorilor magnetoanizotropici

