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Drive for Nanobiotechnology

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ABSTRACT

The structural model of the drive for nanobiotechnology is obtained. The structural scheme of the drive is constructed. In nanobiotechnology for the control systems with the drive its deformations are determined.

Keywords
Drive, Piezo drive, Structural model and scheme, Nanobiotechnology.

Introduction
Piezo drive on the reverse piezo effect is applied for conversion energy in the control systems for nanobiotechnology [1-8]. Drive on the piezoelectric or electrostriction effects are used for nanomovements. The energy conversion in the structural scheme of the drive is visibility and logical [7-14].

The structural model and scheme of the drive are constructed from it matrix equations and differential equation for the drive [8-28].

Piezo drives are used for atomic force microscopy, nanomanipulators, nanotechnology, biotechnology, astronomy, space research, metrology, laser resonator [16-35].

Two matrix equations [8, 11-19] for the piezo drive have the form

$$(D)=(d)(T)+(\varepsilon^T)(E)$$

$$(S)=(s^E)(T)+(d)^t(E)$$

where (D), (S), (T), (E) are matrices for electric induction, relative deformation, mechanical field and electric field stresses, t is transpose operator.

Matrices for the piezo modules, the dielectric constants and the elastic compliances for the piezo drive from ceramics PZT have the form

$$(d)=\begin{pmatrix} 0 & 0 & 0 & 0 & d_{15} & 0 \\ 0 & 0 & 0 & d_{15} & 0 & 0 \\ d_{31} & d_{31} & d_{33} & 0 & 0 & 0 \end{pmatrix}$$

$$(\varepsilon^T)=\begin{pmatrix} \varepsilon_{11}^T & 0 & 0 \\ 0 & \varepsilon_{22}^T & 0 \\ 0 & 0 & \varepsilon_{33}^T \end{pmatrix}$$

$$(s^E)=\begin{pmatrix} s_{11}^E & s_{12}^E & s_{13}^E & 0 & 0 & 0 \\ s_{12}^E & s_{11}^E & s_{13}^E & 0 & 0 & 0 \\ s_{13}^E & s_{13}^E & s_{33}^E & 0 & 0 & 0 \\ 0 & 0 & 0 & s_{55}^E & 0 & 0 \\ 0 & 0 & 0 & 0 & s_{55}^E & 0 \\ 0 & 0 & 0 & 0 & 0 & 2(s_{11}^E - s_{12}^E) \end{pmatrix}$$

The equation of the reverse piezo effect [8,11-48] for piezo drive on on Figure 1 has the form

$$S_i = d_{mi}E_m + s_{ij}^E T_j$$

where m, i, j are axises.

Differential equation for drive in nanobiotechnology has the form [11-38].

$$\frac{d^2\Xi(x,s)}{dx^2} - \gamma^2\Xi(x,s) = 0$$

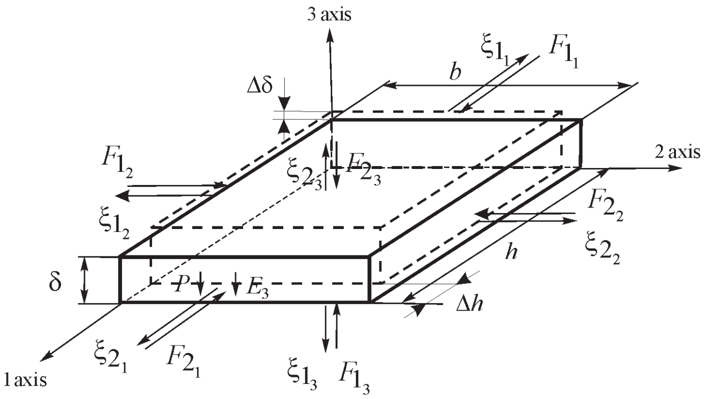

Figure 1: Piezo drive for nanobiotechnology.

$$\gamma = s/c + \alpha$$

where x is coordinate, s is operator, γ, α are coefficients, c is speed of sound.

The equations of structural model for the drive have the form

$$\Xi_1(s) = \left[1/\left(M_1 s^2\right)\right]\left\{-F_1(s) + \left(1/\chi_{ij}^{\Psi}\right)\begin{bmatrix} d_{mi}\Psi_m(s) - [\gamma/\mathrm{sh}(l\gamma)] \\ \times\left[\mathrm{ch}(l\gamma)\Xi_1(s) - \Xi_2(s)\right] \end{bmatrix}\right\}$$

$$\Xi_2(s) = \left[1/\left(M_2 s^2\right)\right]\left\{-F_2(s) + \left(1/\chi_{ij}^{\Psi}\right)\begin{bmatrix} d_{mi}\Psi_m(s) - [\gamma/\mathrm{sh}(l\gamma)] \\ \times\left[\mathrm{ch}(l\gamma)\Xi_2(s) - \Xi_1(s)\right] \end{bmatrix}\right\}$$

where $v_{mi} = \begin{cases} d_{33}, d_{31}, d_{15} \\ g_{33}, g_{31}, g_{15} \end{cases}$, $\Psi_m = \begin{cases} E_3, E_1 \\ D_3, D_1 \end{cases}$, $s_{ij}^{\Psi} = \begin{cases} s_{33}^E, s_{11}^E, s_{55}^E \\ s_{33}^D, s_{11}^D, s_{55}^D \end{cases}$,

$l = \{\delta, h, b$, $\gamma = \{\gamma^E, \gamma^D$, $c = \{c^E, c^D$, $\chi_{ij}^{\Psi} = s_{ij}^{\Psi}/S_0$, and $\Psi = E, D$ is the control parameter on Figure 2, l is the length drive, M_1, M_2 are the masses.

Structural scheme of the drive on Figure 2 is used for calculation its deformations for nanobiotechnology.

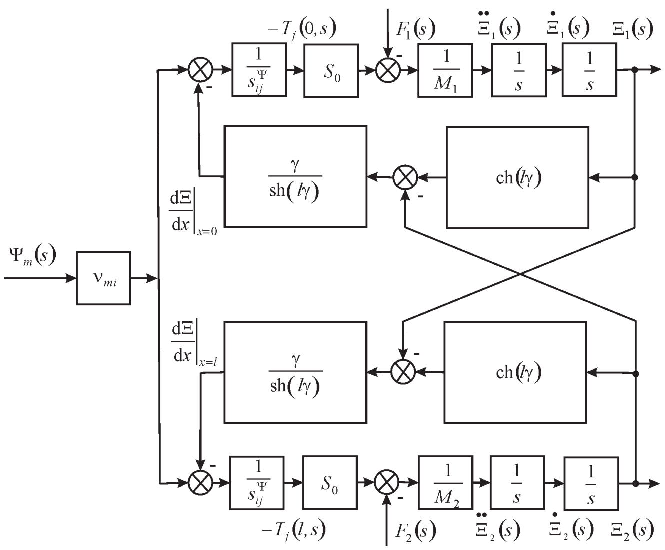

Figure 2: Structural scheme drive for nanobiotechnology.

Matrix equation of deformations for the drive in nanobiotechnology has the form

$$\begin{pmatrix} \Xi_1(s) \\ \Xi_2(s) \end{pmatrix} = \begin{pmatrix} W_{11}(s) & W_{12}(s) & W_{13}(s) \\ W_{21}(s) & W_{22}(s) & W_{23}(s) \end{pmatrix} \begin{pmatrix} \Psi_m(s) \\ F_1(s) \\ F_2(s) \end{pmatrix}$$

The steady-states of deformations for the drive have the form

$$\xi_1 = d_{mi}\Psi_m l\, M_2/(M_1 + M_2)$$

$$\xi_2 = d_{mi}\Psi_m l\, M_1/(M_1 + M_2)$$

The steady-states for its deformations for the transverse piezo drive have the form

$$\xi_1 = d_{31}(h/\delta)UM_2/(M_1 + M_2)$$

$$\xi_2 = d_{31}(h/\delta)UM_1/(M_1 + M_2)$$

For the piezo drive from PZT d_{31}= 0.25 nm/V, h/δ =10, M_1 = 0.5 kg, M_2 = 2 kg and U = 50 V its steady-states deformations are determined in the form ξ_1 = 100 nm, ξ_2 = 25 nm, $\xi_1 + \xi_2$ = 125 nm with an error of 10%.

Conclusions

The structural model of the drive for nanobiotechnology is determined from matrix equations and differential equation for the drive. The equations structural model and the structural scheme of the drive are obtained for the control system in nanobiotechnology.

The piezo drives for nanobiotechnology are widely used for atomic force microscopy, nanomanipulators of precision equipment. The energy conversion in the structural scheme of the drive is visibility and logical.

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