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Research Article

Construction of Structural Diagrams a Piezo Drive for Nanobiology

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Abstract

A piezo drive is used scanning microscopy, adaptive optics, delivery DNA for nanobiology. In construction structural diagrams a piezo drive for nanobiology are using the equation of reverse piezo effect and the linear ordinary second-order differential equation. The structural diagrams a piezo drive at distributed and lumped parameters are derived for nanobiology.

Keywords: Structural diagram, Piezo drive, Nanobiology

Introduction

A piezo drive is used for actuation of systemss for engine for nano displacement and delivery DNA in nanobiology. This piezo drive is used to actuate or control nano mechanisms and convert electrical energy into mechanical energy at the nanometric accuracy in laser systems, atomic force microscopes for nano displacement and compensation of vibration [1-10]. By method mathematical physics the structural diagram of a piezo drive is determined for nanobiology. The structural diagrams of a piezo drive are determined the transformation of electrical energy into mechanical energy in difference from Cady's and Mason's equivalent circuits [8-35]. The structural diagram of a piezo drive is obtained with using the equation of reverse piezo effect and the linear ordinary second-order differential equation [36- 64].

Block diagram

By method mathematical physics the structural diagram of a piezo drive is calculated for nanobiology. The method mathematical physics is used to construct the structural diagram of a piezo drive from the equation of reverse piezo effect and its ordinary differential equation for nanobiology. We use for the structural diagram of a piezo drive the equation of reverse piezo effect and the second-order linear ordinary differential equation. The equation of reverse piezo effect [1-19] for the relative deformation has the form

$$S_i = s_{ij}^{\Psi} T_j + \nu_{mi} \Psi_m,$$

here the S_i – relative deformation $s_{ij}^{\Psi} = \begin{cases} s_{33}^E, s_{11}^E, s_{55}^E \\ s_{33}^D, s_{11}^D, s_{55}^D \end{cases}$ – the elastic compliances, T_J -the mechanical strength, $\nu_{mi} = \begin{cases} d_{33}, d_{31}, d_{15} \\ g_{33}, g_{31}, g_{15} \end{cases}$ – the piezoelectric constant, $\Psi_m = \begin{cases} E_3, E_3, E_1 \\ D_3, D_3, D_1 \end{cases}$ – the control parameter, E electlic field strength, D the electric induction, γ - the coefficient of wave propagation, i = 1, 2, ... , 6; j = 1, 2, ... , 6; m = 1, 2, 3.

The differential equation is derived

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

with solution

$$\Xi(x,p) = Ce^{-\gamma x} + Be^{\gamma x},$$

Here $\Xi(x,p)$, x, p are the Laplace transform of the displacement, the coordinate, operator.

In solution the coefficients C and B are established

$$C = (\Xi_1 e^{\gamma l} - \Xi_2) / [2\,\mathrm{sh}(\gamma l)],\ B = (\Xi_2 - \Xi_1 e^{-\gamma l}) / [2\,\mathrm{sh}(\gamma l)].$$

The solution is obtained [19-61]

$$\Xi(x,p) = \{\Xi_1(p)\mathrm{sh}[l - x)] + \Xi_2(p)\mathrm{sh}(\gamma x)\} / \mathrm{sh}(\gamma l).$$

The equations for the forces at faces are established

$$T_j(0,p)S_0 = F_1(p) + M_1 p^2 \Xi_1(p) \text{ at } x=0;$$

$$T_j(l,p)\,S_0 = -F_2(p) - M_2 p^2 \Xi_2(p) \text{ at } x=l.$$

The equations for mechanical stresses at faces are derived

$$T_j(0,p) = \frac{1}{s_{ij}^{\Psi}} \frac{d\Xi(x,p)}{dx}\bigg|_{x=0} - \frac{\nu_{mi}}{s_{ij}^{\Psi}} E_m(p);$$

$$T_j(l,p) = \frac{1}{s_{ij}^{\Psi}} \frac{d\Xi(x,p)}{dx}\bigg|_{x=l} - \frac{\nu_{mi}}{s_{ij}^{\Psi}} E_m(p).$$

The structural diagram at distributed parameters is established on Figure 1.

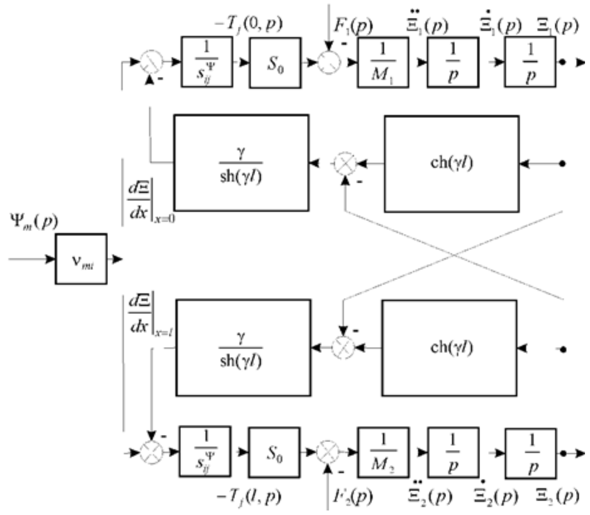

Figure 1: Structural diagram piezo drive at distributed parameters.

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

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

here $X_{IJ}^{\Psi} = s_{ij}^{\Psi}/S_0$. (Figure 1)

Discussion

The static displacements of a longitudinal piezo drive are determined at voltage control in the form

$$\xi_1(\infty) = d_{33}U\left(M_2 + m/2\right)/\left(M_1 + M_2 + m\right),$$

$$\xi_2(\infty) = d_{33}U\left(M_1 + m/2\right)/\left(M_1 + M_2 + m\right),$$

$$\xi_1(\infty) + \xi_2(\infty) = d_{33}U,$$

here m, M_1, M_2 are the masses of the piezo drive and the loads. For the PZT drive at $m \to 0$ at U=75 V, $d_{33} = 0.4\ \mathrm{nm/V}$, $M_1 = 0.5\ \mathrm{kg}$ and $M_2 = 2\ Kg$ we obtain the parameters $\xi_1(\infty) = 24\ \mathrm{nm}$, $\xi_2(\infty) = 6\ \mathrm{nm}$, $\xi_1(\infty) + \xi_2(\infty) = 30\ \mathrm{nm}$.

The electromechanical coupling coefficient K_{mi} is established for a piezo drive at voltage control

$$k_{mi} = d_{mi} \Big/ \sqrt{s_{ij}^{E}\,\varepsilon_{mk}^{T}}$$

Here ε_{mk}^{T} – the permitivity.

Then the negative feedback for block diagram at distributed parameters and voltage control of the piezo drive on (Figure 2) has the form

$$U_{\Xi_a}(p) = \frac{d_{mi}S_0 R}{\delta s_{ij}^{E}} \dot{\Xi}_a(p), \quad a = 1, 2. \text{ (Figure 2)}$$

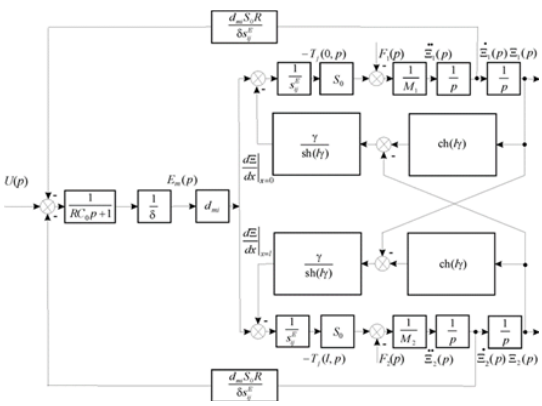

Figure 2: Structural diagram nano piezo drive at voltage control and distributed parameters with negative feedbacks.

At one rigidly fixed face the block diagram with lumped parameters at voltage control on (Figure 3) and at current control on (Figure 4) the structural diagrams are obtained (Figure 3).

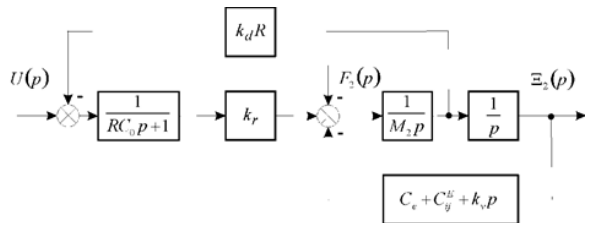

Figure 3: Structural diagram piezo drive at voltage control and lumped parameters.

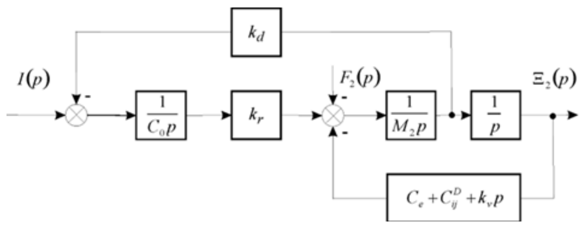

Figure 4: Structural diagram piezo drive at current control and lumped parameters.

In general the coefficient K_d is equal coefficient K_r for a piezo drive

$$K_d = K_r = \frac{d_{mi} S_0}{\delta s_{ij}^{\psi}},$$

here index $\psi = E, D$ and for voltage control, D for current control (Figure 4).

Conclusion

The structural diagrams of a nano piezo drive are derived for nanobiology. The numerical parameters of the piezo drive are determined. The structural diagram \s of the piezo drive with the back electromotive force at distributed and lumped parameters are derived for nanobiology.

Acknowledgement

None.

Conflict of Interest

None.

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