Short Communication

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Multilayer Actuator for Nano Biomedicine

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ABSTRACT

In this work we determined the mathematical description of multilayer actuator for nano biomedicine. The displacements of the multilayer actuator are received from its mathematical description.

Keywords: Multilayer actuator; Mathematical description

Introduction

For mathematical description of the multilayer actuator we used the equation of the relative deformation, the mechanical four-terminal scheme and the boundary conditions [1-30].

Mathematical Description Actuator

The equation S_i relative deformation [7-11] has the following form

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

where v_{mi}, Ψ_m, s_{ij}^{Ψ}, T_j are parameters

We received the equation the causes force in the form

$$F = v_{mi}S_0\Psi_m / s_{ij}^{\Psi}$$

where S_0 is the area actuator.

For the mechanical four-terminal scheme [23] actuator we have the matrix in the form.

$$[M]^n = \begin{bmatrix} \mathrm{ch}(l\gamma) & Z_0\mathrm{sh}(l\gamma) \\ \dfrac{\mathrm{sh}(l\gamma)}{Z_0} & \mathrm{ch}(l\gamma) \end{bmatrix}$$

where l, γ are length and coefficient.

The mathematical description and diagram on Figure 1 of the multilayer actuator we obtained as the system of the equations in the form

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

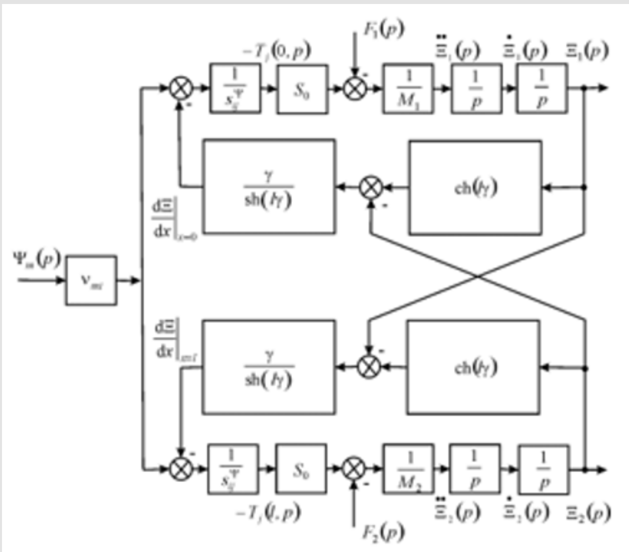

Figure 1: Structural Diagram of Multilayer Actuator.

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

$$v_{mi} = \begin{cases} d_{33}, d_{31}, d_{15} \\ g_{33}, g_{31}, g_{15} \\ d_{33}, d_{31}, d_{15} \end{cases}, \quad \Psi_m = \begin{cases} E_3, E_1 \\ D_3, D_1 \\ H_3, H_1 \end{cases}, \quad s_{ij}^{\Psi} = \begin{cases} s_{33}^E, s_{11}^E, s_{55}^E \\ s_{33}^D, s_{11}^D, s_{55}^D \\ s_{33}^H, s_{11}^H, s_{55}^H \end{cases}$$

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$$c^{\Psi}=\begin{cases}c^{E}\\c^{D}\\c^{H}\end{cases},\ \gamma=\begin{cases}\gamma^{E}\\\gamma^{D}\\\gamma^{H}\end{cases},\ l=\begin{cases}\delta\\h\\b\end{cases},\ \gamma=p/c^{\Psi}+\alpha,\ \chi_{ij}^{\Psi}=s_{ij}^{\Psi}/S_0$$

where $\Xi_1(p)$, $\Xi_2(p)$, $F_1(p)$, $F_2(p)$ are the Laplace transforms of the displacements and forces for the faces.

From the mathematical description of the multilayer actuator we have the matrix equation

$$[\Xi(p)]=[W(p)][P(p)]$$

where $[\Xi(p)]$, $[W(p)]$, $[P(p)]$ are the matrices.

For time $t\to\infty$ for the inertial load on the two faces of piezoactuator we obtain the expressions of its displacements

$$\xi_1(\infty)=\lim_{p\to 0} pW_{11}(p)(U/\delta)/p=d_{33}nUM_2/(M_1+M_2)$$

$$\xi_2(\infty)=\lim_{p\to 0} pW_{21}(p)(U/\delta)/p=d_{33}nUM_1/(M_1+M_2)$$

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

where n, U are the number piezolayers and the voltage.

At d_{33} = 4·10^{-10} m/V, n = 4, U = 100 V, M_1 = 1 kg, M_2 = 4 kg we obtained the displacements $\xi_1(\infty)$ = 128 nm, $\xi_2(\infty)$ = 32 nm, $\xi_1(\infty)+\xi_2(\infty)$ = 160 nm.

Conclusion

We determined the mathematical description of the multilayer actuator for nano biomedicine. We obtained the displacements of the multilayer actuator from its mathematical description.

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