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Absolute Stability of Control System for Piezo Actuator Nano Robotics

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Abstract

We used frequency criterion absolute stability of stable control system with the condition on the derivative for control system for the piezo actuator nano robotics. The stationary set of the control system of the hysteresis deformation of the piezo actuator nano robotics is the segment of the straight line.

Keywords: Absolute stability; Control system; Piezo actuator; Nano robotics; Hysteresis deformation

Introduction

The application of the piezo actuator based on the piezoelectric effect is promising in the control system for piezo actuator nano robotics. The piezo actuator is used for matching in nano robotics, adaptive optics, microsurgery, nano pump. The piezo actuator for nano robotics is applied in scanning microscopy, interferometry, automatic focus system and image stabilization [1-16]. The piezo actuator for nano robotics has the displacement from nanometers to hundreds of micrometers, the force to 1000N, and the transmission band to 100Hz. The nano robotic manipulator with the piezo actuator used in adaptive optics and nano mechatronics [11-39]. Yakubovich [2] criterion absolute stability system with the condition on the derivative is used for control system for piezo actuator nano robotics [3,18]. The stationary set of the control system for piezo actuator with its hysteresis deformation is the segment of the straight line, which contains points of intersection of the hysteresis partial loops and this straight line.

We received condition of the absolute stability on the derivative for the control system with the piezo actuator for nano robotics. The condition of the Yakubovich [2] absolute stability on the derivative for the control system of the piezo actuator for nano robotics is obtained. The stationary set of the control system of the deformation of the piezo actuator is found. The condition absolute stability on the derivative for the control systems of the piezo actuator is obtained.

Condition of Absolute Stability

We received condition of the absolute stability on the derivative for the control system with the piezo actuator for nano robotics. The condition of the absolute stability on the derivative for the control system of the piezo actuator for nano robotics is obtained. The stationary set of the control system of the deformation of the piezo actuator is found. We found the enough condition absolute stability of the control system with the piezo actuator for nano robotics using the Yakubovich [2] frequency criterion, the Yakubovich [2] criterion is development of the Popov criterion [3-18]. The hysteresis relative deformation of the piezo actuator on Figure 1 has the form

$$S_j = F[E_i|_0^t, t, S_j(0), \text{ sign}(dE_i/dt)]$$

where S_j is the relative deformation along j axis, E_i is the electric field strength along i axis, t is the time, $S_j(0)$ is the value relative deformation at $t = 0$, sign(dE_i/dt) is the sign of the rate dE_i/dt is the sign the rate of the electric field strength variation. On Figure 1 for the piezo actuator in the control system the equation of straight-line D has the form

$$E_i + k_{ij} S_j = 0$$

where $k_{ij} = W_{ij}(0)$ is the transmission coefficient for the linear part, $W_{ij}(0)$ is the value transfer function of the linear part at $\omega = 0$. Respectively, we have the $W_{ij}(s)$ with the operator $s = j\omega$, the imaginary unity j and the frequency ω. We received the stationary set *M* of the control system in the form the marked segment of the straight-line *D*. In the stationary set *M* contains points of intersection of the hysteresis partial loops and the straight-line *D*. We obtained the derivative dS_j / dE_i for the function $S_j(E_i)$ on Figure 1, where zero is the minimum value and v_{ij} is the maximum value of the derivative. Respectively, for longitudinal, transverse and shift piezo effects we have obtained the ratios

$$v_{33} : v_{31} : v_{15} = d_{33} : d_{31} : d_{15}$$

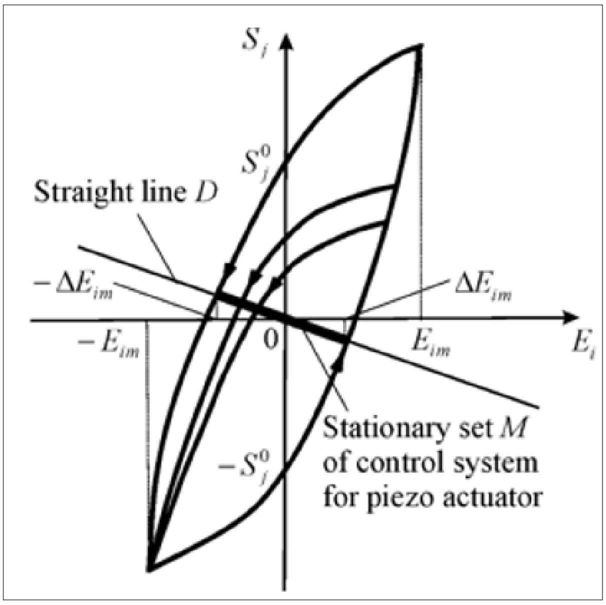

Figure 1: Hysteresis relative deformation of piezo actuator.

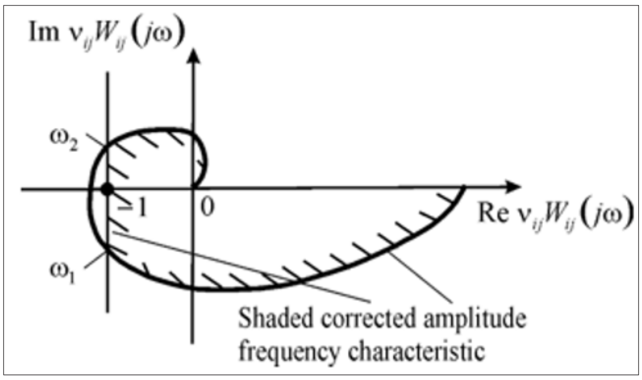

Figure 2: Condition of absolute stability on derivative for control system with piezo actuator for nano robotics.

The condition of the absolute stability on the derivative for the control system with the piezo actuator for nano robotics [2,3,18] on Figure 2 have the form

$$\operatorname{Re} v_{ij} W_{ij}(j\omega) \geq -1$$

We obtained the value of the maximum derivative for the piezo actuator from PZT for longitudinal piezo effect 1nm/V and for transverse piezo effect 0.6nm/V. The parameters of the correction device for the control system is obtained from the condition of the absolute stability on the derivative for control system with piezo actuator.

Conclusion

We received the stationary set of the control system of the hysteresis deformation of the piezo actuator as the segment of the straight line. We used frequency criterion absolute stability system with the condition on the derivative for control system for piezo actuator nano robotics. We obtained the condition of the absolute stability on the derivative for the control system with the piezo actuator for nano robotics.

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