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Short Communication

Condition Absolute Stability of Control System with Electro Elastic Actuator for Nano Bioengineering and Microsurgery

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Abstract

In this paper, we used the frequency methods for Lyapunov stable control system to calculate the condition absolute stability of the control system with electro elastic actuator for nano bioengineering and microsurgery. We receive the stationary set of the control system of the hysteresis and butterfly deformation of the electro elastic actuator in form the segment of the straight line.

Keywords: Condition absolute stability; Control system; Electro elastic actuator; Transfer f unction; Hysteresis and butterfly characteristics; Stationary set; Piezoactuator

Introduction

The condition absolute stability on the derivative for the control system deformation of the electro elastic actuator for nano bioengineering and microsurgery is determined [1,2]. The control systems with electro elastic actuator on piezoelectric, electrostrictive effects solves problems of the matching in the nano bioengineering and microsurgery, the compensation of the temperature and gravitational deformations of the equipment, the correction in the adaptive laser system [1-14]. The electro elastic actuator for nano bioengineering and microsurgery is used in the scanning tunneling microscopy and the gene manipulator [15-31].

Condition Absolute Stability of Control System

The electro elastic actuator on piezoelectric, electrostrictive effects is used in the control systems for the micro and nano surgical repairs, the micro and nano robotics, the micro and nano manipulators and injectors for electro elastic [1-6]. The aim of this work is to calculate the condition of the absolute stability for control system of the deformation of the electro elastic actuator for nano bioengineering and microsurgery. The frequency methods for Lyapunov stable control system are used to determine the condition of the absolute stability of control system [2] with electro elastic actuator. We receive the sufficient absolute stability condition of the Lyapunov stable control system with the hysteresis nonlinearity of the electro elastic actuator using the Yakubovich absolute stability criterion with the condition on the derivative. This criterion is the development of the Popov absolute stability criterion [2]. The description of the hysteresis nonlinearity of the electro elastic actuator [16] in the form

$$S_j = F[E|_0^t, t, S_i(0), signE_j^{'}]$$

where S_j is the relative displacement of the cross section of the electro elastic actuator along j axis, $E_i^{'}$ is the control parameter in the form the electric field strength of the electro elastic actuator along i axis on the interval $[o,t]$, the initial value of the electric field strength $E_i(0)$ the value of t, the initial value the relative displacement $S_j(0)$, and the sign of the rate $\dot{E}_i$ of the electric field strength variation. Let us consider hysteresis characteristic of the deformation of the electro elastic actuator on (Figure 1). The set $S_j^0[E_i(0)]$ the vertical segment $S_j^0, -S_j^0$ bounded by the points of intersection of the ordinate axis with the hysteresis loop at the maximum admissible field strength in the piezoactuator. We receive for the stable linear part of the control system the stationary set N and the equation for the straight-line L has the form

$$E_i + W_{ij}(0)S_j = 0.$$

In static regime for the control system for the deformation of the piezoactuator we receive the value of the transfer function $W_{ij}(0)$ of the linear part of the control system. The set of points N for intersection of this straight line L with the hysteresis characteristic represents the segment of the straight line marked. At $E_{i0} = E_i(0)$ and $S_{j0} = S_j(0)$ we have the stationary solution to the control system with hysteresis on Figure 1. We obtain the stationary set in the form of the marked segment N of straight-line L in Figure 1 with the set of pairs E_{i0}, S_{j0} The set of points N for intersection of this straight line L with the hysteresis characteristic. For the stationary set the equation has the following form

$$E_{i0} + W_{ij}(0)S_{j0} = 0$$

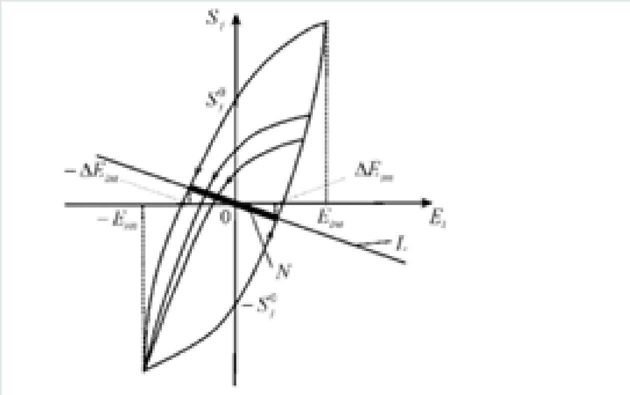

Figure 1: Hysteresis characteristic deformation of piezo-actuator.

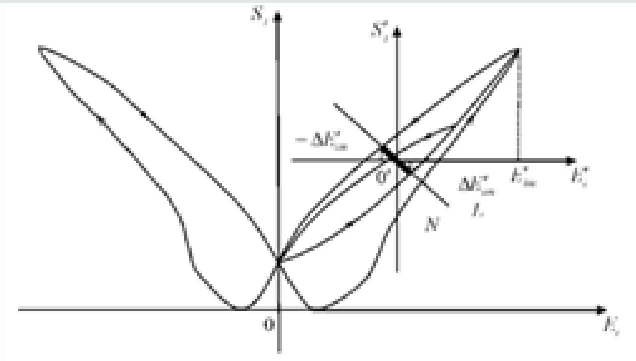

Figure 2: Butterfly characteristic deformation of actuator with electrostrictive effect

Let us consider butterfly characteristic of the deformation of the electro elastic actuator for nano bioengineering and microsurgery. For the actuator with the electrostrictive effect the deformation characteristic on butterfly wings is observed for unipolar change of the electric field strength on Figure 2. We have the particular cycle on one wing of butterfly in the form of the hysteresis loop. For butterfly type characteristic deformation of actuator in the control system the coordinate origin is moved to new zero with top dash on Figure 2. We have stationary set N of the system marked segment of straight-line L in Figure 2. We receive the continuous function $S_j(E_i)$ the hysteresis loop of the piezoactuator and the quantities of the derivative

$$v_{1ij}, v_{2ij} \in [0, v_{ij}], v_{ij} = \max\left[\frac{dS_j}{dE_j}\right]$$

where the quantities of the derivative and are calculated using the hysteresis characteristic on Figure 1 for the maximum admissible electric field strength in the piezoactuator. The quantities and are the minimum and the maximum values of the tangent of the inclination angle of the tangent line to the hysteresis nonlinearity of the piezoactuator. Thus, we obtain

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

Where the ratios of the tangents of the inclination angle of the tangent line to the hysteresis nonlinearity of the piezoactuator for longitudinal, transverse and shift piezoeffects are proportional to the ratios of the piezomodules. We have the expression for the sufficient condition absolute stability of the system with the hysteresis nonlinearity of the electro elastic actuator using the Yakubovich absolute stability criterion with the condition on the derivative. The Yalubovich criterion is the development of the Popov absolute stability criterion [2]. The sufficient condition absolute stability the control system for the deformation of the actuator at $v_{1ij} = 0$ and $v_{2ij} = v_{ij}$ have the form

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

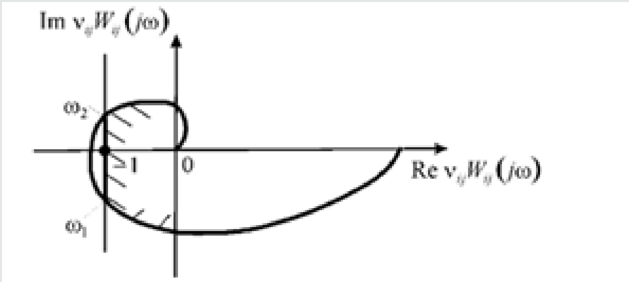

Figure 3: Absolute stability criterion for control system with electro magneto elastic actuator, shaded corrected characteristic

Here $v_{ij}W_{ij}(j\omega)$ is the amplitude-phase characteristic of the open-loop system and in brackets j is the imaginary unity and is the frequency? The amplitude-phase characteristic of the open-loop system $v_{ij}W_{ij}(j\omega)$ on (Figure 3) should be situated to the right of the straight line

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

for all values of $\omega \geq 0$

For the piezo actuator from PZT we received the value of the maximum tangent of the inclination angle of the tangent line to hysteresis nonlinearity about 1 nm/V for longitudinal piezo effect and 0.6 nm/V for transverse piezo effect.

Conclusion

For hysteresis and butterfly characteristic in the control system of the deformation of the electro elastic actuator we obtained the stationary set in the form the segment of the straight line bounded by hysteresis loop. The frequency methods are used for calculating the condition absolute stability of the control system with electro elastic actuator for nano bioengineering and microsurgery. We received condition absolute stability on the derivative for the control system with the electro elastic actuator for nano bioengineering and microsurgery.

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