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Mini Review

Condition Absolute Stability of Control System Electro magnetoelastic Actuator Nano displacement for Nano research in Sciences

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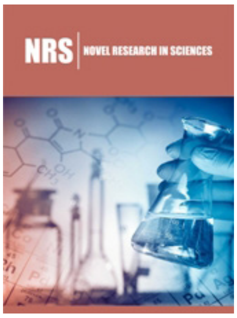

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Submission: September 9, 2020
Published: October 07, 2020

Volume 5 - Issue 1

How to cite this article: Afonin SM. Condition Absolute Stability of Control System Electro magnetoelastic Actuator Nano displacement for Nano research in Sciences. Nov Res Sci. 5(1). NRS.000602. 2020. DOI: 10.31031/NRS.2020.5.000602

Abstract

The condition absolute stability of the control system the electro magnetoelastic actuator nano displacement for nano research in sciences and the stationary set of this system are obtained. The stationary set of the control system with the hysteresis deformation of the electro magnetoelastic actuator has the form of the segment of the straight line. The aim of this work is to determine the condition on the derivative of the absolute stability for control system of the hysteresis deformation of the electro magnetoelastic actuator for nanotechnology research. The frequency methods for Lyapunov stable control system are used for determined the condition absolute stability of the control system with electro magnetoelastic actuator. In result the condition on the derivative is obtained for the absolute stability of control system with the hysteresis deformation of the electro magnetoelastic actuator nano displacement for nano research in sciences.

Keywords: Condition absolute stability; Control system; Electro magnetoelastic actuator; Stationaryset;Piezo actuator;Nano displacement; Deformation; Hysteresis and butterfly characteristics; Transfer function.

Introduction

In nano research the control system with electro magnetoelastic actuator is used for the precise matching, the compensation of the temperature and gravitational deformations, the wave front correction for adaptive optics [1-15]. The piezo actuator for nano research in sciences is used in the scanning tunneling microscopy, the gene manipulator [16-35]. We determined the stationary set of the control system of the deformation of the electro magnetoelastic actuator. The condition of the absolute stability for control system for the deformation of the electro magnetoelastic actuator is calculated. The frequency criteria absolute stability is obtained for the control system with electro magnetoelastic actuator nano displacement for nano research in sciences.

Stationary Set and Condition Absolute Stability of Control System

The aim of this work is to calculate the condition on the derivative of the absolute stability for the control system of the hysteresis deformation of the electro magnetoelastic actuator nano displacement for nano research in sciences. We used the frequency methods for Lyapunov stable control system to determine the condition absolute stability of the control system of the hysteresis deformation of the electro magnetoelastic actuator for nanotechnology research. We obtained the sufficient condition absolute stability of the control system with the hysteresis deformation of the electro magnetoelastic actuator using the Yakubovich VA, et al. [2] absolute stability criterion as the development of the Popov absolute stability criterion with the condition on the derivative to hysteresis characteristic [2,16]. This condition absolute stability of the control system on the Yalubovich absolute stability criterion has the simplest and pictorial representation of results of the investigation of the stability of the control system with the hysteresis deformation of the electro magnetoelastic actuator.

Let us consider the stationary set of the control system with the hysteresis deformation of the electro magnetoelastic actuator. The hysteresis nonlinearity of the deformation of the electro magnetoelastic actuator has following form

$$S_j = \left[\Psi_i, \Psi_i, (0), S_j(0), t, sign\Psi_i' \right]$$

where S_j is the relative displacement of the cross section of the actuator along j axis, Ψ_i is the control parameter of the actuator along i axis.

The hysteresis function S_j at each time instant t depends on the behavior of the control function in the form $\Psi_i = E_i$ or $\Psi_i = H_i$, where E_i and H_i are the electric field strength or the magnetic field strength on the interval [0,t], the value of the time t, the initial values $\Psi_i(0)$, $S_j(0)$ and the sign Ψ'_i of the control parameter change rate. For the determination of the stationary set of the control system with the hysteresis deformation of the piezo actuator on Figure 1 we used the transfer function of the linear part of the system W_{ij} (p) and the hysteresis function of the relative deformation S_j of the actuator [2,3,6,16,34].

In static regime of the control system on Figure 1 we have the straight line D with the equation

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

We received the stationary set for the hysteresis deformation of the piezo actuator in the control system on Figure 1 at the stable linear part of this control system.

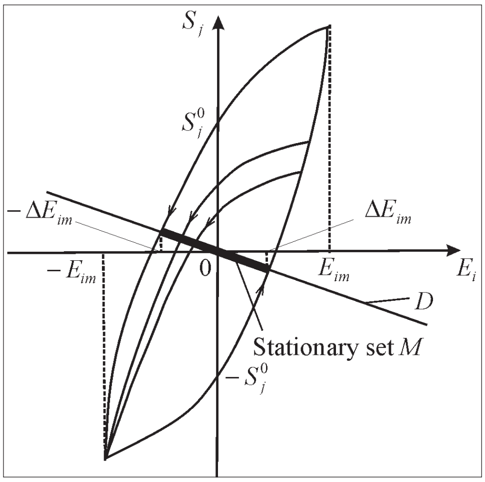

Figure 1: Hysteresis characteristic deformation of piezoactuator.

We obtained in static regime the value of the transfer function $W_{ij}(0)$ of the linear part of the control system for the deformation of the piezo actuator. The stationary set of the points M for intersection of this straight line D with the hysteresis characteristic represents the segment of the straight line marked on Figure 1. For the electro magnetoelastic actuator with the electro strictive effect we obtained the butterfly characteristic on Figure 2. The particular cycle has the form of the hysteresis loop. For the butterfly characteristic deformation of the electro strictive actuator in the control system the coordinate origin is moved to new zero with top dash on Figure 2, for the actuator with the magneto strictive effect the deformation has the form of this butterfly characteristic.

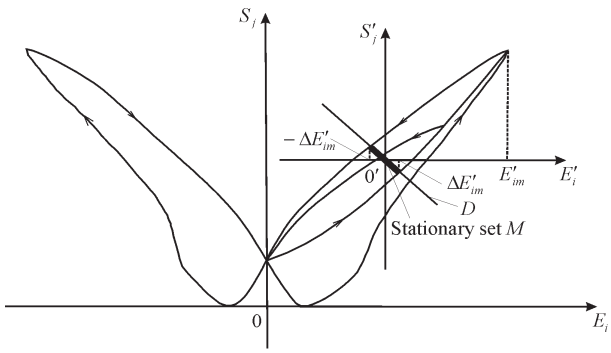

Figure 2: Butterfly characteristic deformation of electromagnetoelastic actuator.

The function $S_j(E_i)$ of the hysteresis characteristic of the piezo actuator is continuous. We received quantities of the derivative of the hysteresis characteristic of the piezo actuator in the form

$$v_{ij} = \max\left[\frac{ds_j}{dE_i}\right] v_{ij} = \max\left[\frac{ds_j}{dE_i}\right]$$

where the quantities ν_{1ij} and ν_{2ij} are obtained at the maximum admissible electric field strength in the piezo actuator. We obtained for the piezo actuator the quantities of the derivative of the hysteresis characteristic $\nu_{1ij}=0$ and $\nu_{2ij}=\nu_{ij}$ in form the minimum and the maximum values of the tangent of the inclination angle of the tangent line to the hysteresis characteristic of the piezo actuator.

We determined the ratios of the tangents of the inclination angle of the tangent line to the hysteresis nonlinearity of the piezo actuator for longitudinal, transverse and shift piezo effects proportional to the ratios of the piezo modules

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

We have the expression for the sufficient absolute stability condition of the system with the hysteresis nonlinearity of the electro magnetoelastic actuator using the Yakubovich VA, et al. [2] absolute stability criterion with the condition on the derivative. For the Lyapunov stabile control system the Yalubovich absolute stability criterion for the system with the single hysteresis nonlinearity provides the simplest and pictorial representation of results of the investigation of the stability control system.

The sufficient condition absolute stability of the control system of the deformation [2,3,6,34] the electro magnetoelastic actuator at $\nu_{1ij}=0$ and $\nu_{2ij}=\nu_{ij}$ have the form

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

where in brackets j is the imaginary unity and ω is the frequency.

We have on Figure 3 the condition absolute stability for the control system in the form the amplitude-phase characteristic of the open-loop system v_{ij} W_{ij} (jω) situated to the right of the vertical line passing through the point (-1,0)

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

for all values of ω≥0.

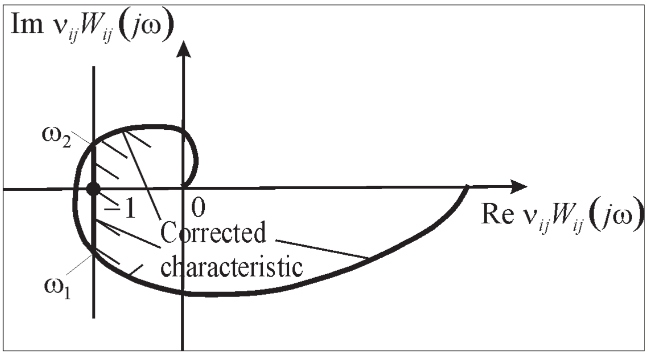

Figure 3: Condition absolute stability of control system electromagnetoelastic actuator shaded corrected amplitude-phase characteristic of the open-loop system.

Therefore, we received the corrected logarithmic amplitude frequency characteristic of the open-loop system below the boundary curve in the form

$$L(\omega) = 20 1g \left| 1/\cos\varphi \right|$$

for the absolute stability of the control system with electro magnetoelastic actuator on the plane of the logarithmic amplitude frequency characteristic and the phase frequency characteristic in the form

$$L(\omega) = 20 1g \left| v_{ij} W_{ij}(j\omega) \right| L(\omega) = 20 1g \left| v_{ij} W_{ij}(j\omega) \right|$$

We obtained for the piezo actuator from piezoceramics PZT the value of the maximum tangent of the inclination angle of the tangent line to hysteresis nonlinearity about 1nm/V for longitudinal piezo effect and 0.6nm/V for transverse piezo effect. We used the frequency methods for Lyapunov stable control system to calculate the condition on the derivative of the absolute stability the control system with electro magnetoelastic actuator.

Conclusion

The stationary set of the control system of the deformation of the electro magnetoelastic actuator nano displacement has the form of the segment of the straight line. At work we received the condition on the derivative of the absolute stability the control system with the electro magnetoelastic actuator nano displacement for nano research in sciences.

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