SYNTHESIS OF ROBUST TRACKING CONTROL SYSTEM UNDER PERTURBATION CONDITIONS

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In this paper a mathematical model of a rotating mechanical system consisting of two inertial masses connected by an elastic coupling is developed. Model parameters correspond to the parameters of one of the robots. For the transfer matrix of the control system, singular values are found that determine the attenuation of disturbances and ensure the stability margin of the control system. In the process of synthesis of the system under study based on heuristic approaches, expressions for weight transfer functions were obtained.

Introduction

The constant growth of requirements to the quality of industrial products, defines the appropriate requirements for accuracy and speed of working out the given laws and trajectory tracking of Electromechanical control systems. Tracking systems are used to control radar antennas, radio telescopes, artillery installations on mobile platforms, as well as to regulate the synchronicity and in-phase rotation of the shafts of the drive and driven engines when they are located at a sufficiently large distance from each other[1,2].This determined the increased requirements for electric drives.Thus, the actual problem today is the construction of electric drive systems that provide requirements for accuracy and speed of working out the given laws and trajectories of the tracking Electromechanical control systems.

I. Mathematical description of the control system

We will consider a rotating mechanical system consisting of two inertial masses J_1, J_2,connected by an elastic coupling [2] (fig.1).

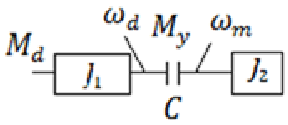

Fig. 1 – Mechanical system with elastic coupling

The moment M_y transmitted by the coupling, which is the moment of resistance for the first inertial mass and the driving moment for the second, is proportional to the difference in angular displacements of both masses with a coefficient of proportionality C. The control is the driving torque of the first mass (usually the torque of the drive motor) M_d, and the output is the speed of its rotation ω_d, since the speed sensor is usually installed on the shaft of the drive motor. For simplicity, the moment of resistance is assumed to be zero. System equations:

$$\frac{\mathrm{d}\omega_d}{\mathrm{d}t} = (M_d - M_y)/J_1 \qquad (1)$$

$$\frac{\mathrm{d}M_y}{\mathrm{d}t} = C(\omega_d - \omega_m) \qquad (2)$$

$$\frac{\mathrm{d}\omega_m}{\mathrm{d}t} = M_y/J_2 \qquad (3)$$

We take into account in the considered system (1) – (3) the moment of loading M_c and assume that the purpose of regulation is to reduce the speed deviation of the mechanism ω_m under the action of M_c.

II. Method of research

There are a number of methods for designing robust systems, we will consider the methods that are used in the Robust Control Toolbox, which is part of the Matlab computing system. These methods are based on operations with frequency characteristics of systems. What role does Amplitude-frequency characteristic (AFC) play in assessing robustness: the smaller it is, the greater the change in the parameters of the object can be allowed without loss of stability [3,4]. Since the singular value $S(j\omega)$ determines the perturbation attenuation, the required perturbation attenuation can be given as

$$\sigma_1(S(j\omega)) \le \left|W_1^{-1}(j\omega)\right|$$

With this in mind, the boundaries for the rest of the sensitivity function are given as:

$$\sigma_1(R(j\omega)) \le \left|W_2^{-1}(j\omega)\right|.$$

$$\sigma_1(T(j\omega)) \le \left|W_3^{-1}(j\omega)\right|.$$

The condition must be met

$$\sigma_1\left(W_1^{-1}(j\omega)\right) + \sigma_1\left(W_3^{-1}(j\omega)\right) > 1.$$

where W_1, W_2,W_3 are weight transfer functions; S, R, T – sensitivity functions for a given signal and control, as well as a complementary sensitivity function [5].

All the requirements for the system to mitigate disturbances and ensure the stability margin are reduced to a single requirement for the norm

$$\|T_{y1u1}\|_{\infty} \leq 1,$$

where

$$T_{y1u1} = \begin{bmatrix} \mathrm{W}_1 S \\ \mathrm{W}_2 R \\ \mathrm{W}_3 T \end{bmatrix}$$

- the so-called cost function of the mixed sensitivity method.

III. Research result

Initially we will consider the position control system. Let's form weight frequency characteristics [6 – 8]. The characteristic W_2 is assumed to be a small constant. Characteristic W_3 is accepted in the form

$$W_3 = K_{f1} S^2/100,$$

where K_{f1} –is a configurable parameter and characteristic W_1 in the form

$$W_1 = \frac{K_f b \left(as^2 + 2z_1\omega_0\sqrt{as} + \omega_0^2\right)}{bs^2 + 2z_2\omega_0\sqrt{bs} + \omega_0^2}$$

The characteristics of the system with a full-order regulator while minimizing the H_∞ norm are shown in figure 2. It is seen that the modulus of the transfer function T_{y1u1} in the essential frequency range is 1.

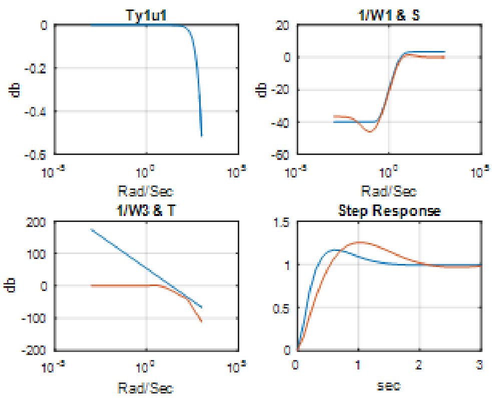

Fig. 2 – Characteristics of a system with a full-order regulator while minimizing the norm H_∞ (position regulator)

This characteristic is called ≪all-pass≫. Now consider the speed control system. The resulting curves are shown in figure 3. It can be seen that the system requirements are satisfied.

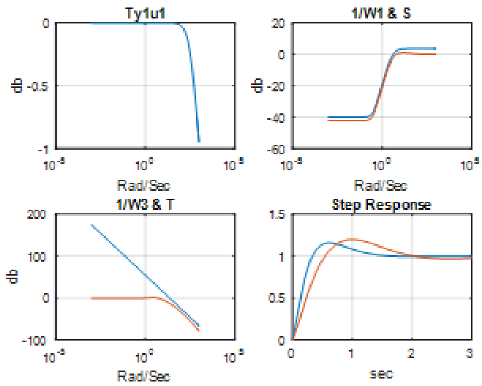

Fig. 3 – Characteristics of a system with a full-order regulator while minimizing the norm H_∞ (speed regulator)

IV. Summary

The paper presents the main approaches to robust structural synthesis of a rotating mechanical system consisting of two inertial masses connected by an elastic coupling. The model parameters correspond to the parameters of one of the robots. In developing the synthesis of a robust tracking system, methods based on operations with the frequency characteristics of systems are considered.The modeling of the system under study is carried out and the characteristics of the system are given.As a result of synthesis all requirements to the system are satisfied.

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