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INVESTIGATION OF THE AUTOMATIC CONTROL SYSTEM FOR TWO-MASS POSITION ELECTRIC DRIVE

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Abstract. *Increasing requirements for speed, accuracy, smoothness, safety and energy consumption of various electromechanical systems determine their continuous improvement. The aim of this work is to develop and research an automatic control system of a two-mass positioning electric drive with a tracing single-mass actuator in the inner circuit. The basis of the research is the methods of the theory of automatic control and the method of mathematical modeling for the development of control systems for tracing actuator of the first mass and for positional actuator of the second mass, as well as for the synthesis of the regulator of the position of the second mass and finding the coefficients of the PID controller. Physical experiments were also performed, the results of which were compared with those of mathematical modeling.*

Positional drives are widely used in industry. The safety and quality of these mechanisms depends on the speed of the system, which requires constant improvement and proper development. This makes the task of developing and optimizing electric drive systems of executive positioning mechanisms relevant [1, 2]. This is facilitated by the use of PID controllers in automatic control systems.

The aim of this work is to develop and research a system for automatic control of a two-mass positioning electric drive with a tracing single-mass actuator in the inner circuit.

To achieve this goal, the following tasks were solved: development of a mathematical and physical model of the tracing and positional electric drives; synthesis of the regulator of position of the second mass; development and research of the PID controller. The object of the study is the positioning electric drive of a two-mass system with a tracing actuator of a single-mass system in the inner circuit. The subject of the study is the transient processes of the two-mass positional drive.

A stand that was created earlier was used for research [3], where: 1 - a microcontroller implemented on the basis of the microprocessor ADuC841; 2 - LEGO NXT direct-current motor equipped with integrated gearbox and incremental encoder; 3 - downshift gearbox with 1:3 gear ratio; 4 - elastic element - a metal twisted spring that creates oscillations in a two-mass system; 5 - four fans representing the moment of resistance; 6 - actuating device represented by a metal plate having holes for M10 bolts, which is used for changing of inertia moment; 7 - incremental second mass encoder; 8 - PCI-1711U analog I/O board; 9 - display unit - a data display device consisting of two seven-segment indicators and an LCD monitor having a field of 16 × 2 characters; 10 - fan control board; 11 - potentiometer, which sends position assignment signal of φ2a using ADC.

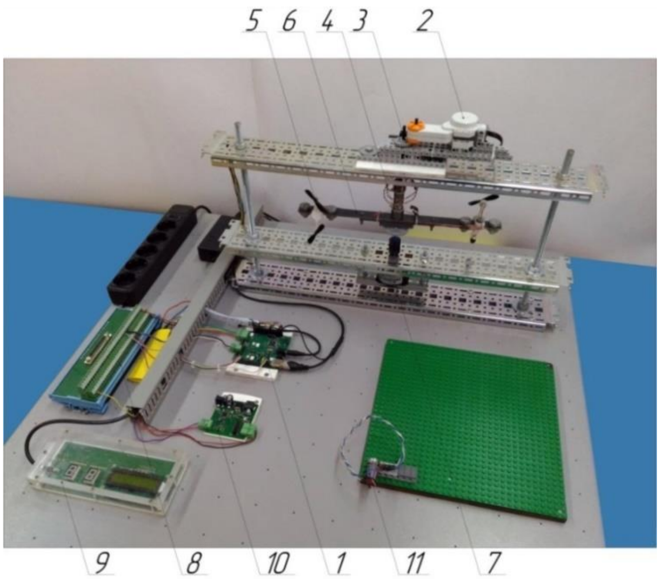

Figure 1. Photo of a laboratory stand

To rotate the second mass to a given angle, a closed deflection control system was developed, where the first mass is controlled by the tracking actuator and the second mass by the positioning electric drive. The main feature of the tracking system is the ability to work out an unknown variable input signal, unlike the positional system, which moves along a predetermined, previously known trajectory. Therefore, the task of the positional system is the formation of a given variable influence, which will provide a rotation of the second mass at a given angle. This effect is applied to the input of the tracking system and is worked out by the first mass, taking into account the disturbing effect caused by the elastic properties of the spring that connects the output shaft of the motor and the actuating device [4]

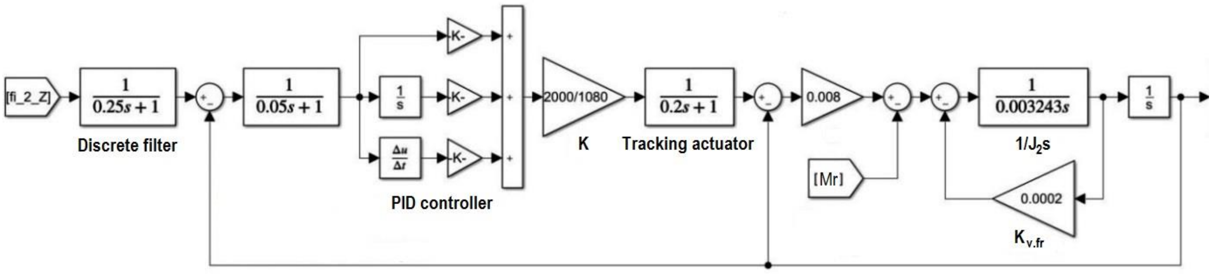

Figure 2. The mathematical model of the positioning electric drive of the two-mass system.

Using this mathematical model, the coefficients of the PID controller [5-7] were found: $K_p = 1/2$, $K_i = 1/2$, $K_d = 10$ and were implemented into the physical model. Figure 3 shows the charts of working out the assignment signal by positioning drive [8], where 1 - position assignment, 2 - position of the second mass.

The graphs of transients are very similar, and therefore this developed mathematical model is adequate. Transition time is 4 s.

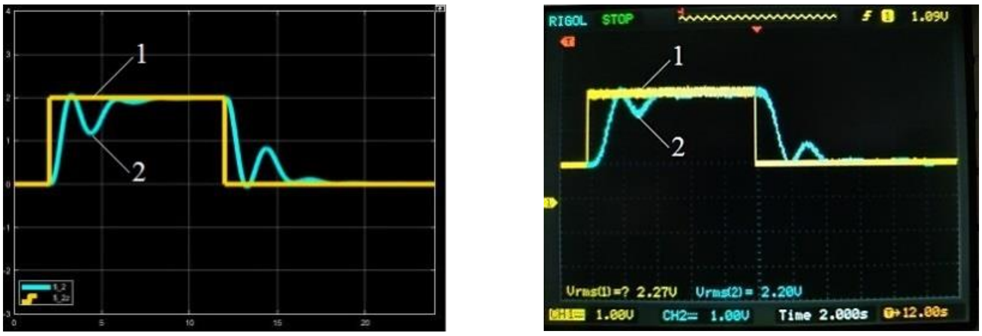

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Figure 3. The charts of the signal of the second mass position φ_2 and the position assignment φ_{2a}:
a - mathematical model, b - physical model.

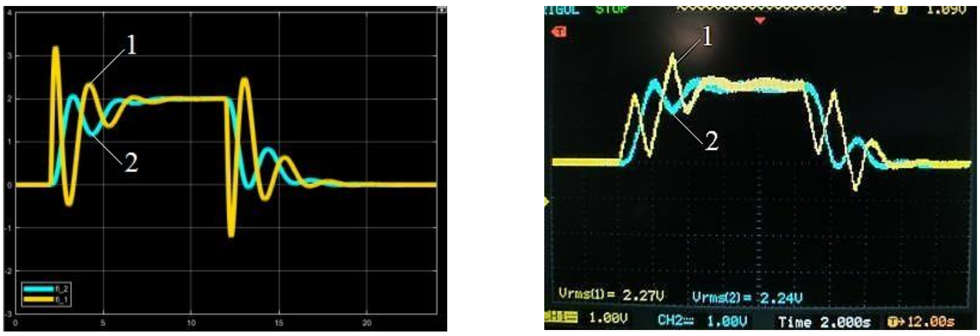

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Figure 4. The charts of the transients of the position of the first φ_1 and the second φ_2 mass:
a - mathematical model, b - physical model.

Figure 4 shows the charts of the transients of the position of the first φ_1 and the second φ_2 mass. They describe how the motor implements the assignment of the PID controller φ_{1a}, where 1 -position of the first mass, 2 - position of the second mass.

Figure 5 shows the charts of the transients with the motor running and when applying a moment of resistance M_r, where 1 - the position of the first mass, 2 - the position of the second mass. As can be seen from the charts, the set position is restored in about 2 s.

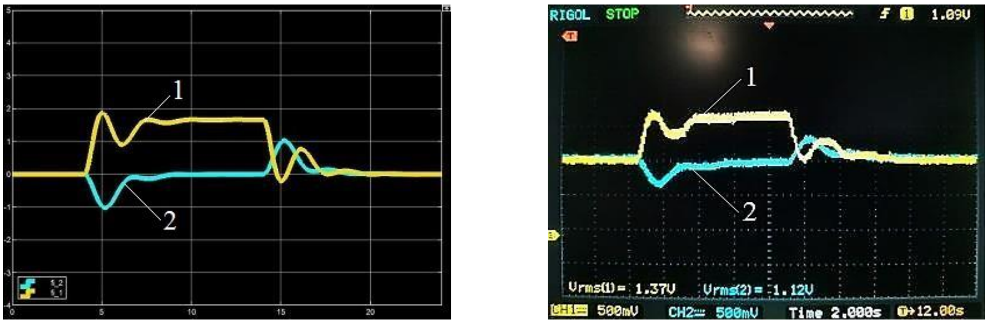

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Figure 5. Graphs of the transients of the position of the first φ_1 and second φ_2 masses with the motor running and when applying M_r: a - mathematical model, b - physical model.

CONCLUSIONS

The usage of the single-mass electric drive in the internal circuit of the positioning dual-mass electric drive allows the simplifying of the controller synthesis and reducing the required computational power in the simulation by presenting the tracking actuator with a first-order factor.

The simulation model of positioning actuator, the adequacy of which is confirmed by a physical experiment, together with the stand can be used in the study of closed-loop dual-mass systems of DC electric drive with microprocessor control.

The controller synthesized by the classical method has a low practical value due to the complexity of its implementation, which is conditioned by the high polynomial degree of the transfer function.

The usage of mathematical model in the practical method of finding the values of PID coefficients provides the desired static and dynamic characteristics of the system, reduces the searching time and decreases the risk of real equipment damage during debugging.

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