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Analysis of a two-position regulation system with correction

Introduction

Two-position systems (*Układy automatycznej regulacji* 2010; Findeisen 1969; Pułaczewski 1966; Rakowski 1976; Sokół 2005; *Skrypt laboratorium teorii sterowania*) are frequently used in technology due to the low cost and simplicity of construction. The controller in this system gives the control object a signal value of {0,1} or {-1,1}. In order to protect the switching system performing the control signal, a hysteresis loop with a set width is included. This providestable control over the system when the set value is reached. Such a system is characterized by objectively large changes in the output signal. To reduce these changes, as it is shown in an example, a correction module is used.

Two-position system

The exampleto consideris a closed two-position system (Figure 1) with an ideal inertial first-raw object described by the operator's transfer function given by a formula (1):

$$G(s) = \frac{1}{0.5\, s + 1} \tag{1}$$

Fig. 1. Block diagram of a two-position control system

The hysteresis loop of the two-position controller (Relay) has the width [-0.05 0.05]. For these parameters, function blocks, and assuming equal values of unit step response of 0.8 that was properly calculated. The step response of the test system is shown in Fig. 2.

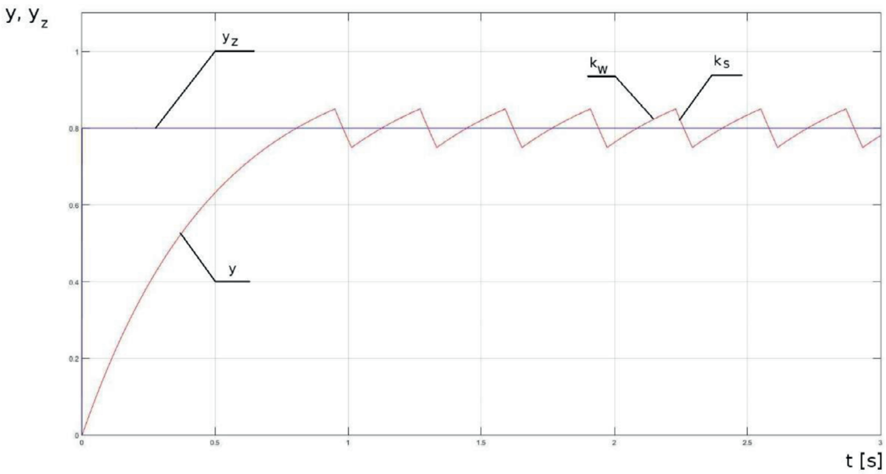

Fig. 2. Step response of the two-position system from Fig. 1

In the figure has been marked:

- y – the output signal of the control system
- y_z – the set command signal
- k_w – the growth curve (at which an increase in the output $y$signal)
- k_o – descent curve (after which the value of the output $y$signal decreases)

Such a system is characterized by large changes in the output value. This is a disadvantageous phenomenon. In order to reduce the oscillation of the y signal around set yzvalue, the corrector is used as it is shown in Fig. 3.

Two-position system with equalizer

The introduction of the corrective element entails changes in the regulator operation itself and consequently changes the initial y value.

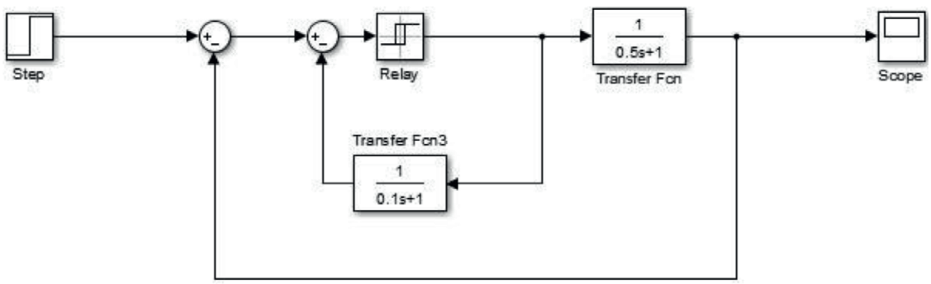

Fig. 3. A two-position system with equalizer

The introduction of an additional element to the scheme resulted in an increased regulator switching frequency. Therefore the need for a non-contact actuator, such as transistors, sawing, and the like. The introduction of the correcting element also caused an increase in average static error that's dependable on the component gain and the time of delay.

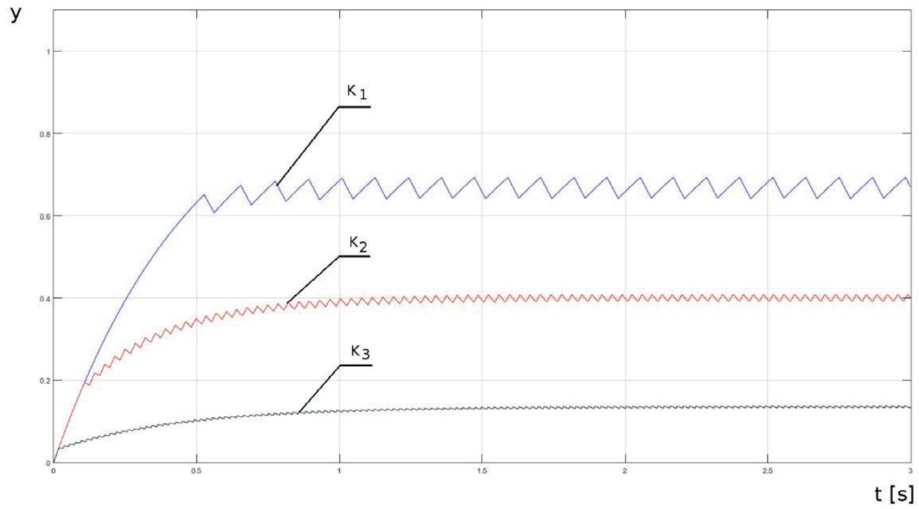

Fig. 4. The output signal waveforms of tested control system with a different values of the correction gain

Based on figure 4 signals K1, K2, K3 is a correction gain as the relationship exists by an equation:

$$K_1 < K_2 < K_3$$

As shown in Fig. 4, the values of the output signal are characterized by a significant average static error. The value of set unit was 0.8. The higher gain of the correcting element, the smaller the oscillation of the output signal is, the greater the switching frequency of the regulator and the greater the value of the average static error.

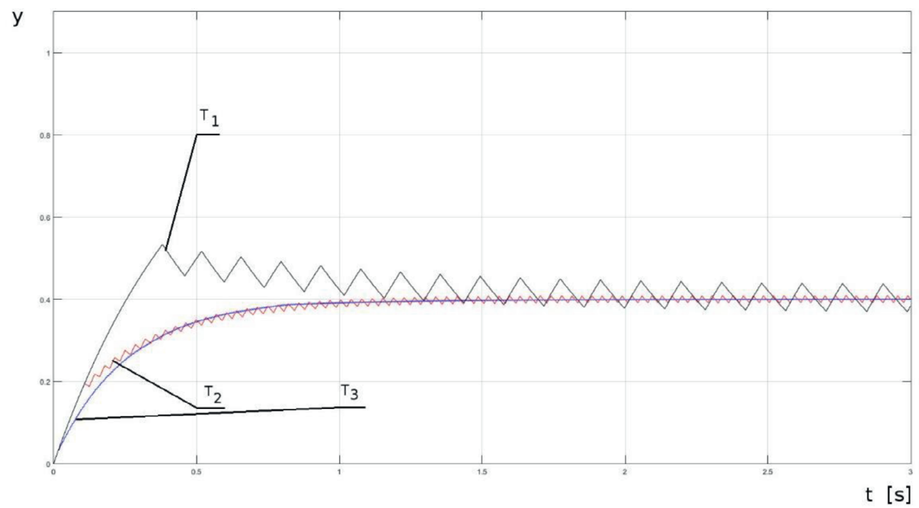

Fig. 5. Time graph of the output signal from tested control system for different delay time values

In figure 5 T1, T2, T3 are the delay times of the correcting element, with the relation based on equation:

$$T_1 < T_2 < T_3$$

As shown in Fig. 5 with delay time changes of the correction module also gives changes the oscillation frequency of output signal. The higher the value of the parameter Ti (i = 1,2,3), the frequency of changes is greater.

For this reason, one more function block has been introduced that affects the average static error. The final layout is shown in Fig. 6.

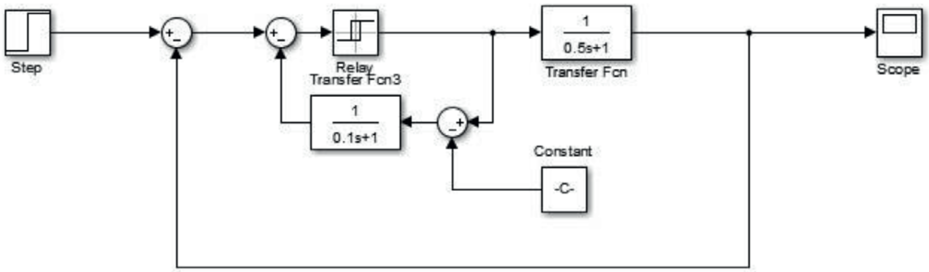

Fig. 6. A two-position system with equalizer and a block that compensates for the average static error

As noted, the value of the constant introduced into the Constant block is to have amplitude set by a signal being the unit step function. At each discrepancy between these values, an average static error occurs. Fig. 7 shows the unit response to unit step function with a signal amplitude value of 0.8.

As shown in Fig. 7, the system is characterized by an increased number of switching times per time unit than the system without an equalizer. The amplitude of the initial vibrations has been reduced.

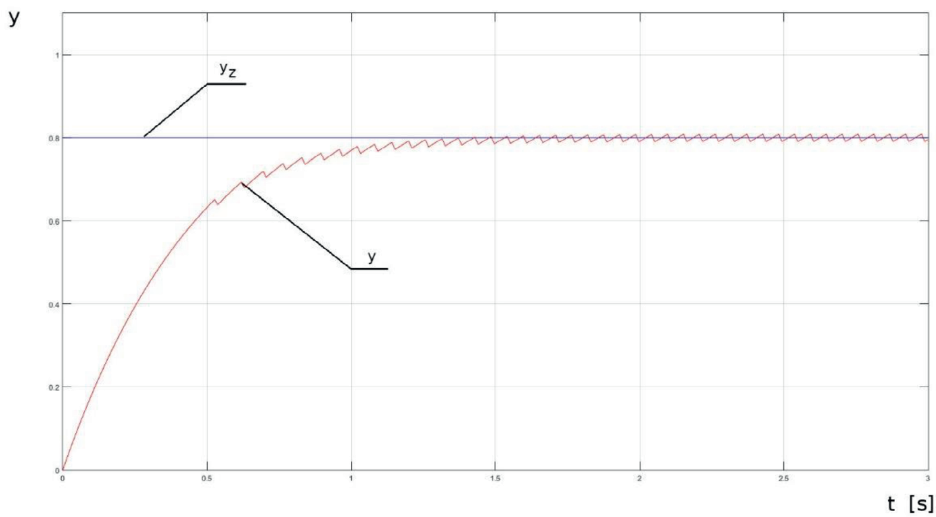

Fig. 7. Step response of the final two-position system with equalizer

Summary

Two-position systems are still frequently used due to the simplicity of the regulator's construction. They are characterized by a significant value of output signal vibrations dependent on the regulator hysteresis loop. In order to reduce the vibrations amplitude, the correcting module is attached to the regulator (Fig. 3). The existence of this element affects the vibrations amplitude of the output signal and the average static error of this system (Figures 3, 4, 5). To compensate for this error, an additional module with a constant value equal to the amplitude of the step signal is introduced.

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Abstract

The article analyses the two-position regulation system. The simulation results of a simple two-position system without correction and correction of the controller are presented. The influence of some coefficients is shown on the control quality the control system.

Key words: regulation system, two-position systems, controller

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