Pol. J. Appl. Sci., **2016**, *2*, 7-10

STUDYING THE IMPACT OF OBJECT PARAMETERS AND TWO-POSITION CONTROLLER ON THE DYNAMIC BEHAVIOR OF THE CONTROL SYSTEM

Leszek Gołdyn, Ryszard Szczebiot

Computer Science and Automation Institute
Lomza State University of Applied Sciences, Lomza, Poland

E-mail: lgoldyn@pwsip.edu.pl, ryszard@szczebiot.pl

Abstract: A two-position control system must supply discontinuity, so at least one of the static characteristics has to be non-continuous. These systems are commonly used in refrigerators and irons. A very important parameter associated with the operation of the entire system is the determination of the average value of the parameter regulated in the facility in relation to the value determined for the not controlled object. The paper concerns computer modeling of a two-position control system and studies the influence of system parameters on the course of the controlled variable.

Key words: mathematical modeling, computer simulation, control system, two-position controller.

A two-position control system must supply discontinuity. In practice, this means that there is at least one element of a static characteristic discontinuous example – relay control action (Fig. 1).

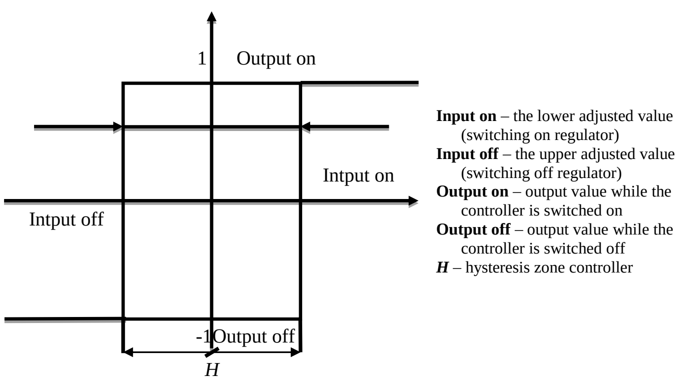

Fig. 1: Characteristics of static two-position controller [1].

Two-position control systems are used in manufacturing processes, where it is not required to maintain the process variable at a predetermined exactly fixed setpoint. Many processes do not require constant control; they allow for variation within certain limits. This situation is often encountered in refrigeration or heating devices. Commonly these types of solutions are used in refrigerators, or irons.

In the present arrangement the course of the controlled variable will affect, among other things [2]:

- zone H hysteresis controller, the controller with adjustable limit controlled variable (upper and lower);
- transport delay the controlled T_t;
- the time constant of the control object T;
- the average value of the manipulated variable w.

Parameters faults can be divided in the system of the associated facility and connected to the controller. For the former we have no direct impact, in a sense we are not stuck with creating a controlled system. On the parameters of the controller we have a direct effect without interfering in its design, e.g. by the setting. A very important parameter associated with the operation of the entire system is to determine the average value of an adjustable parameter in the facility in relation to the value determined in the notcontrolled object.

In order to assess the course of the controlled variable during fixed (not temporary) work for the system, the following parameters characteristics must be set [1]:

- the value of the regulated running time T_r;
- controlled variable amplitude A;
- the ratio of time from rise to fallof the controlled variable t_n/t_o;
- the difference between the setpoint and the average value of the adjustable y_{sr}

A simulation study was performed with a static object of transmittance [2, 3]:

$$G_1(s) = \frac{ke^{-T_t s}}{(T_t s + 1)}, \tag{1}$$

and for an astatic object of the transfer function:

$$G_2(s) = \frac{ke^{-T_t s}}{[(T_t s + 1)s]}, \tag{2}$$

where:

e – base of natural logarithm,
s – Laplace operator,

k – static gain.

An analysis of the impact of each of the devices on the controlled variable waveforms modeled in Simulink program with transmittances (1) and (2) was performed.

The modeled control systems utilized an on-off control in Fig. 1 and the object model (1). In such systems, a simulation was performed to give a series of waveforms shown in the graphs in Fig. 3 and Fig. 5. Figure 2 shows a test control circuit in the Simulink [4, 5] environment at different setpoints (w1=0.5, w2=2.5, w3=4.5).

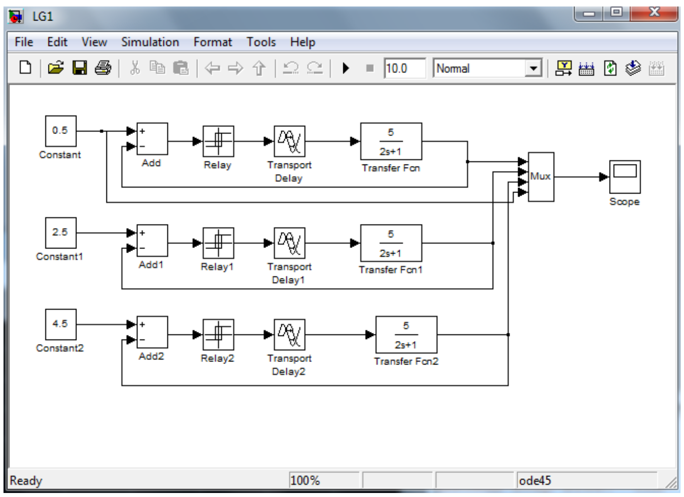

Fig. 2: Scheme on-off control system in simulink environment at different set points [1].

As a result are of the simulation obtained three dynamic characteristics shown in Fig. 3.

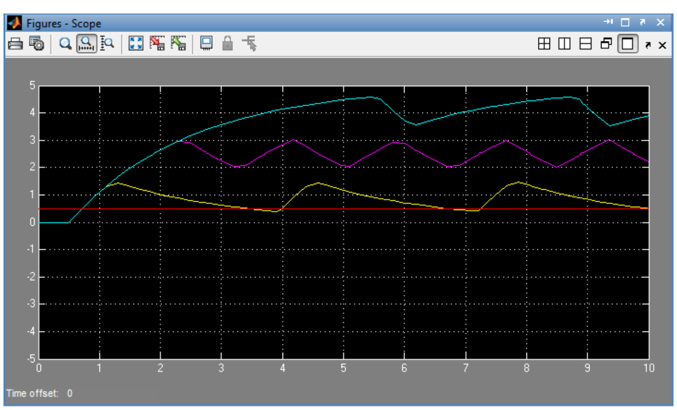

Fig. 3: Running dynamic characteristics of the controlled variable in case of change in the average set point.

One can notice that with the change of the average setpoint the rise times and the fall times of the signal change. This causes an on-time percentage change in the total process equipment during the period cycle. An analysis of the parameters of the waveform shown in Fig. 3 [5] justifies the use of on-off adjustment in the system. Also, specify energy savings with the possibility of carrying out the tasks of the process were found. In the case of a delayed transport, with an average reference value, there is also a shift of the average control value to the average reference value. This feature should be taken into account at the design stage of the system.

In order to determine the effect of the delay of the transport object model the control system shown in Fig. 4 [4,5]. The parameter T_t determined in the flowchart as a Transport Delay and adopted the values: 0.1, 0.5, 1.5.

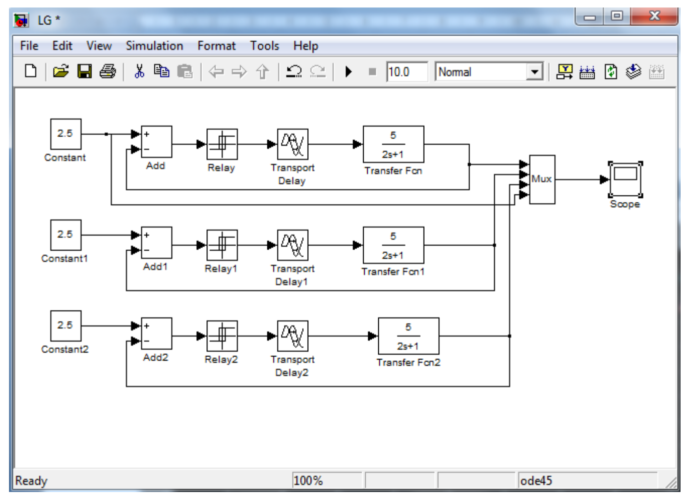

Fig. 4: Dynamic characteristics of on-off control systems, objects of different sizes transport delay.

The effect of the time constant of the control object on the course of the manipulated variable in the control system on-off is shown in Fig. 5 [5].

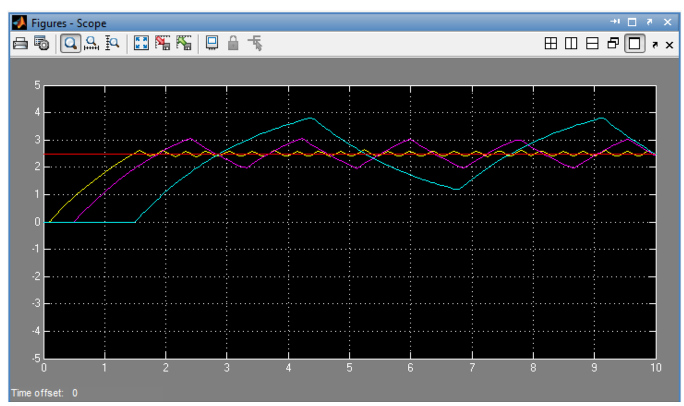

Fig. 5: Dynamic characteristics of on-off control systems, objects of different sizes of transport delay.

The waveforms in Fig. 5 can be characterized by a dependence of growth of the amplitude and period of the waveform controlled with a greater lag time T_t. This is due to the direct reaction of the delayed object to signals from the controller. The delay time transport of the object does not change the relative rise and fall of the signal (the ratio is fixed).

This scheme to study the effect of the time constant of the object on the course of the manipulated variable is represented in Fig. 6. The study integrates the object of the model (1) with a time constant values of 0.1, 0.5 and 1.5 [4, 5].

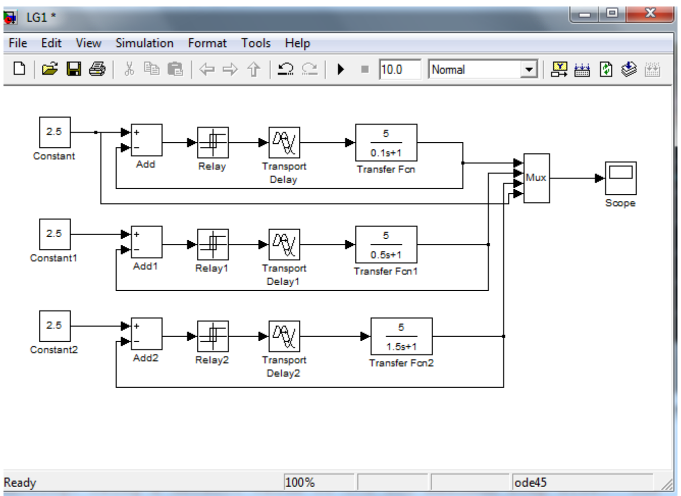

Fig. 6: Diagram of the control system on-off when changing the time constant of the object.

The effect of the time constant of the control object on the course of the manipulated variable in the control system on-off is shown in Fig. 7 [5].

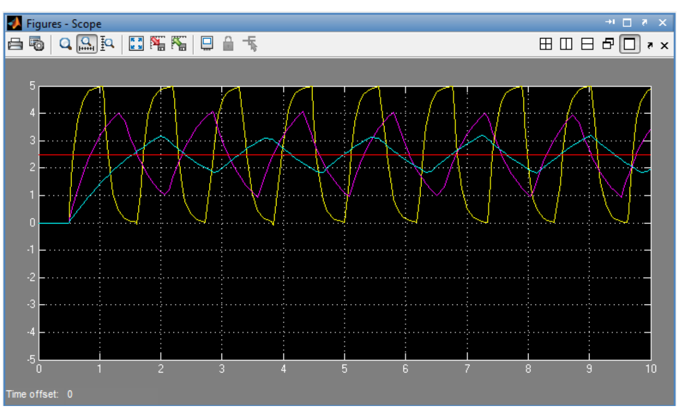

Fig. 7: Dynamic characteristics of on-off control systems of objects of different time constant.

From the description of the characteristics of the waveforms in Fig. 7 [5] it can be inferred that other things being equal the increase in a time constant of the object decreases the amplitude of the waveform and reduces the frequency. This suggests the conclusion that objects with small time constants should not use an on-off adjustment, because in such a situation, the frequency of inclusions devices would be too much, and a better solution would be to use a continuous control system.

The determination of the effect of hysteresis two-position control building control system is shown in Fig. 8 determined waveforms for the hysteresis controller / Relay / at 0.2, 0.4 and 1.7 [4, 5].

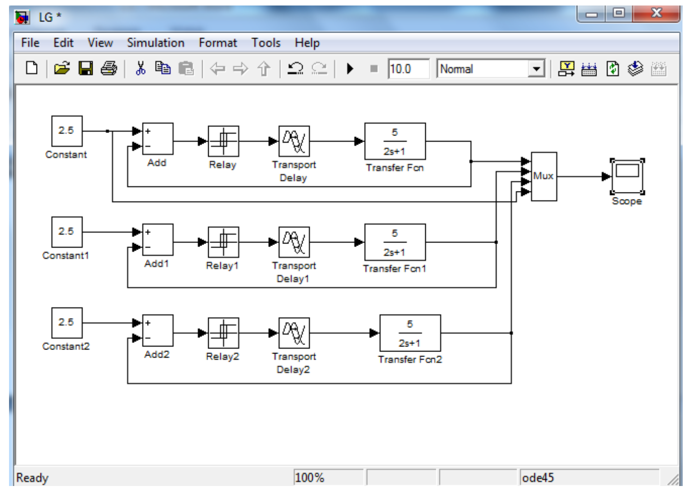

Fig. 8: The two-position diagram of the control system to study the effect of hysteresis control.

Fig. 9 reflects the impact of changes in the size of the hysteresis zone on the course of the manipulated variable. It should be noted that this parameter has a direct and active influence by the system administrator [5].

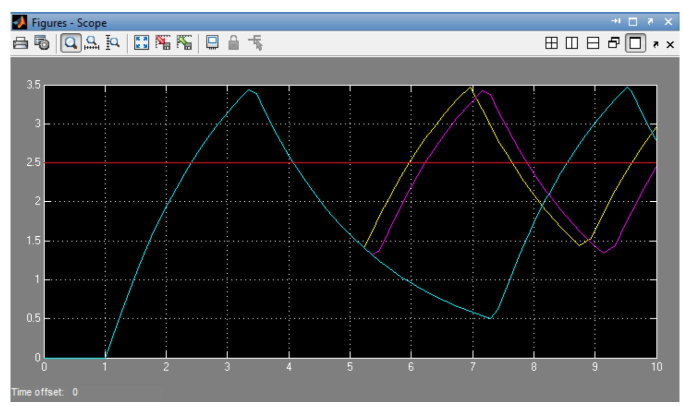

Fig. 9: Effect of hysteresis regulator for mileage dynamic control systems on-off objects with the same time constant.

The dynamic waveforms controlled variable in Fig. 9 illustrate the impact zone hysteresis controller. This leads to the general conclusion that increased hysteresis increases the amplitude course of the controlled variable (in accordance with the stated objective).

Table 1 shows the characteristic values of the parameters set on the basis of simulated waveforms of Fig. 3, Fig. 5, Fig. 7 and Fig. 9.

Table 1: Characteristics of waveforms in on-off control systems.

Parameter		Amplitude A	Period T_r[s]	t_n/t_o	$w - y_{śr}$
The average value of the manipulated variable	0,5	0,71	4,62	0,18	-0,27
	2,5	0,71	2,32	1,00	0,00
w	4,5	0,71	4,62	5,50	0,27
Delaytime of transport	0,1	0,31	1	1,00	0,00
	0,5	0,71	2,32	1,00	0,00
T_t	1,5	1,41	5,12	1,00	0,00
Object timeconstant	0,1	2,38	3,76	1,00	0,00
	0,5	1,41	5,13	1,00	0,00
T	1,5	1,21	5,69	1,00	0,00
Regulator hysteresis	0,2	0,63	2,07	1,00	0,00
	0,4	0,71	2,33	1,00	0,00
H	1,7	1,1	3,78	1,00	0,00

Analysis Summary

From the research presented, the following conclusions can be generalized [2, 3]:

1. Two-point control can reasonably be used for objects with a large time constant.
2. The presence of the delay in the building of transport is not an essential obstacle to regulating on-off; however, it requires a precise analysis if the aim is to achieve the assumed range of changes of the manipulated variable.
3. Economically advantageous controlled variable waveforms are obtained when determining the average value of the manipulated variable at a level as low as possible in relation to the fixed object is not regulated.
4. The use of on-off control systems in thermal devices is justified in the absence of the need to establish a process value at a constant level, using an actuator with a relatively high power.

Literature

[1] Siemieniako F. *Automatyka w przykładach i zadaniach*. Wydawnictwo Politechniki Białostockiej, Białystok, 2005.

[2] Kowal J. *Podstawy automatyki*. Wydawnictwo AGH, Kraków, 2006.

[3] Peszyński K, Siemieniako F. *Sterowanie procesów, podstawy i przykłady*. Wydawnictwo Uczelniane Akademii Techniczno-Rolniczej, Bydgoszcz, 2002.

[4] Ostanin A. *Metody optymalizacji z MATLAB*. Wydawnictwo Nakom, Poznań, 2009.

[5] Brzózka J., Dorobczyński L. *Programowanie w Matlab*. MIKOM, Warszawa, 1998.

Received: 2016
Accepted: 2016