

How to Shorten First Order Unit Testing Time

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Abstract- One of the methods of shortening the response time of first order inertial device is using the step signal with overshooting. In the article it is discussed the source of step signal with overshooting with one calibrator and with two calibrators and analog multiplexer. There are described results of simulation tests of the response time on input signal from both sources. Results of tests proved accuracy of the solutions proposed.

I. Introduction

Development of engineering of the measuring equipment involves increasing request for testing devices used for verification of performance of the measuring equipment on the production line. Testing is based on the suitable controlling of selected parameters in specified conditions [1]. It is very important to reduce costs by shortening of testing time and reducing testing system price. Modification of excitation signal form is one of methods of shortening the response time. The excitation signal sources are very expensive and difficult in handling.

The devices response time can be shortened by constraining suggested signal form. Using the signal source with one calibrator or using signal source with two calibrators and analog multiplexer allows generating this signal. This method makes possible to shortening device response time.

II. Step signal with overshooting

Application of the step signal with overshooting, shown on figure 1 allows to shorten time response of first order inertial device [2].

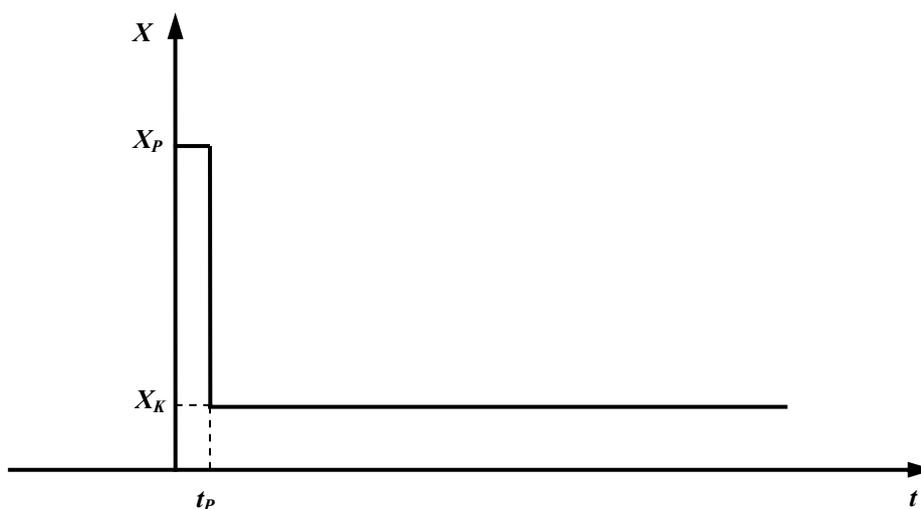


Figure 1. Step signal with overshooting

Theoretical maximal shortening of the object time response is achieved, when the equation (1) is fulfilled [4].

$$t_p = -T \ln \left(1 - \frac{X_K}{X_P} \right) \quad (1)$$

where:

- t_p – overshooting time,
- T – object time constant,
- X_K – step signal amplitude after time t_p ,
- X_P – overshooting amplitude.

Overshooting amplitude X_P must be of the maximal value that would not destroy the object under test. For this overshooting amplitude X_P the overshooting time t_p is obtained from equation (1).

III. The step signal source with calibrator

Step signal with overshooting can be obtained either from a single calibrator or from two calibrators and analogue multiplexer.

A. Source with a single calibrator

Figure 2 shows step signal source with overshooting with a single calibrator. It consists of a calibrator and a control unit.

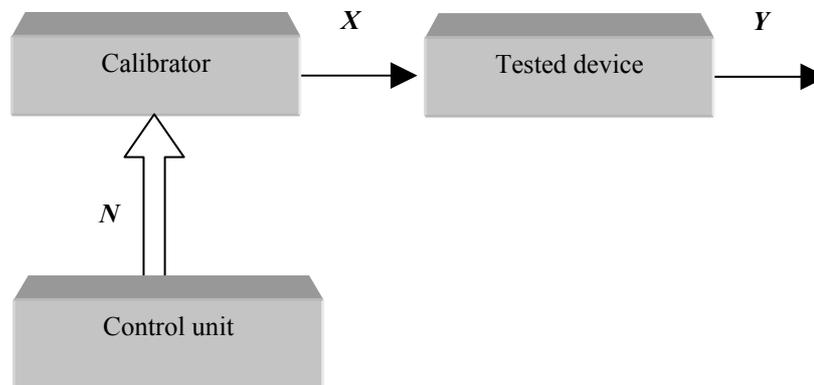


Figure 2. Step signal source with overshooting with one calibrator

To the input of the calibrator it is given a set N_P , corresponding to the output signal of amplitude X_P . After time t_p , setting is changed to N_K , corresponding to the output signal of amplitude X_K . Theoretically on the output of the source X one should get the signal about the shape shown on figure 3 (curve 1). In the real conditions one gets the signal about the shape shown as curve 2. These results from dynamic characteristics of the calibrator, being a second order inertial unit [3].

On figure 4 there are shown object responses to ideal input signal (curve 1) and real input signal (curve 2) compared to object responses to step input signal (curve 3). Giving the real input signal to the object input causes extension of its time responses. Shortening of the time response, with using real input signal, can be achieved either by shortening of overshooting time t_p (curve 3, figure 3), so that the object answer would be conforming to curve 4 on figure 4 or by use of calibrator with smaller values of the time constants.

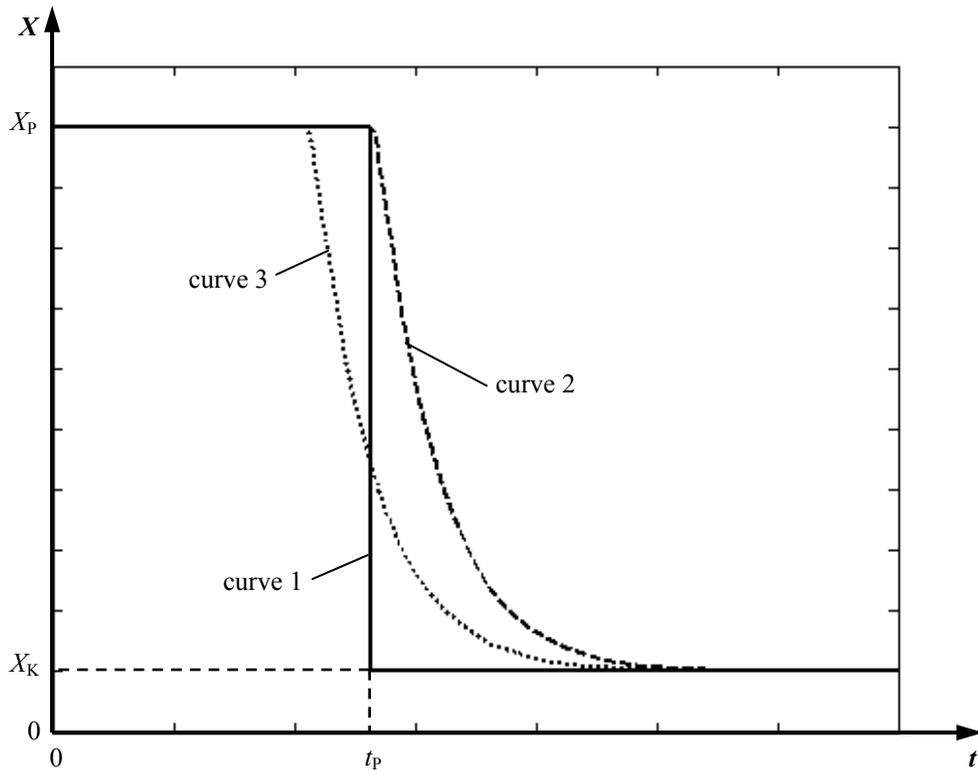


Figure 3. Step signal with overshooting with one calibrator

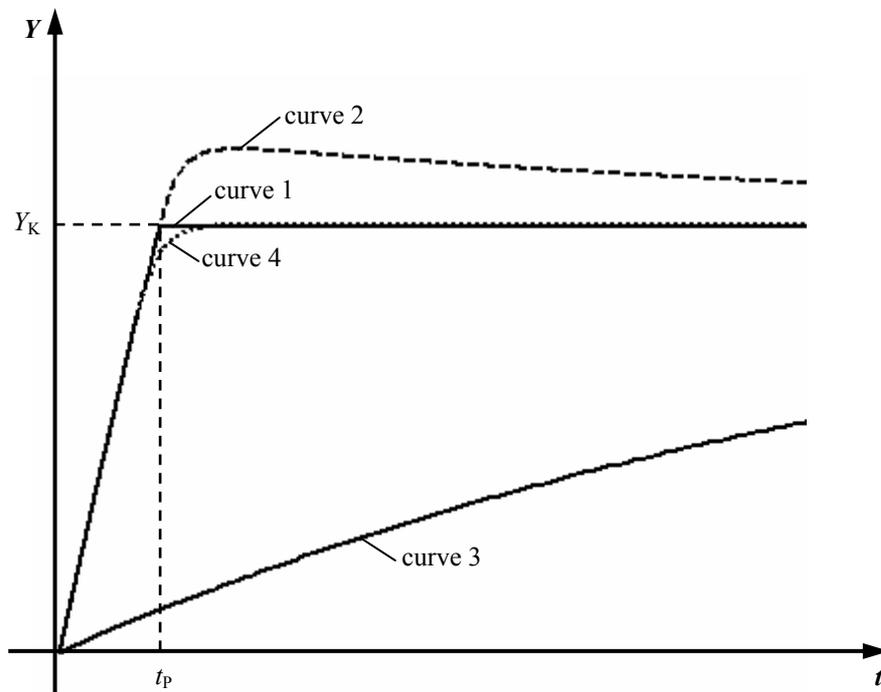


Figure 4. Response of tested object to the step signal with overshooting

B. Source with two calibrators

To generate the signal with the shape approaching the ideal signal it is proposed a circuit shown on figure 5. This circuit consists of two calibrators, an analog multiplexer and a control unit.

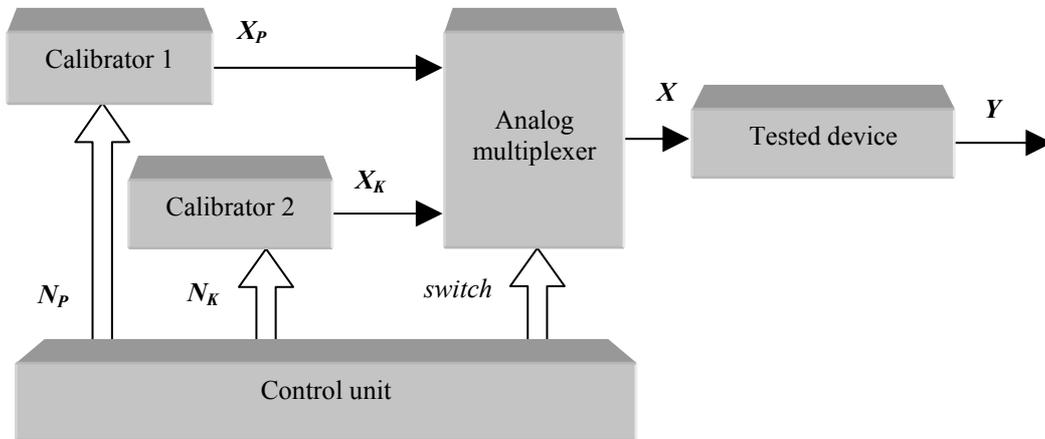


Figure 5. The circuit of the source with two calibrators generating the step signal with overshooting

Calibrator 1 is supplied with set N_p . It corresponds to output signal with amplitude X_p . Calibrator 2 is supplied with set N_k . It corresponds to output signal with amplitude X_k . After time t_p the analog multiplexer switches the X signal from X_p value to X_k value. The signal generated by the step signal with overshooting source with two calibrators is shown on figure 6. Shape of this signal is nearly ideal and any differences result from dynamic characteristic of analog multiplexer. The object answer (curve 2) to the signal from signal source with two calibrators is shown on figure 7. The object time response to this signal is close to overshooting time t_p .

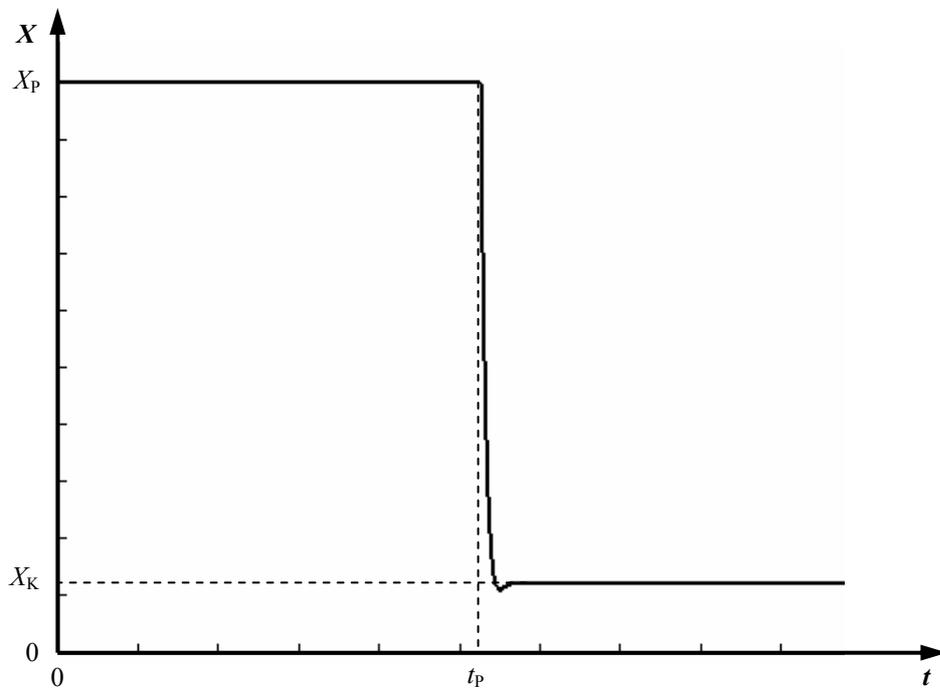


Figure 6. The shape of input signal

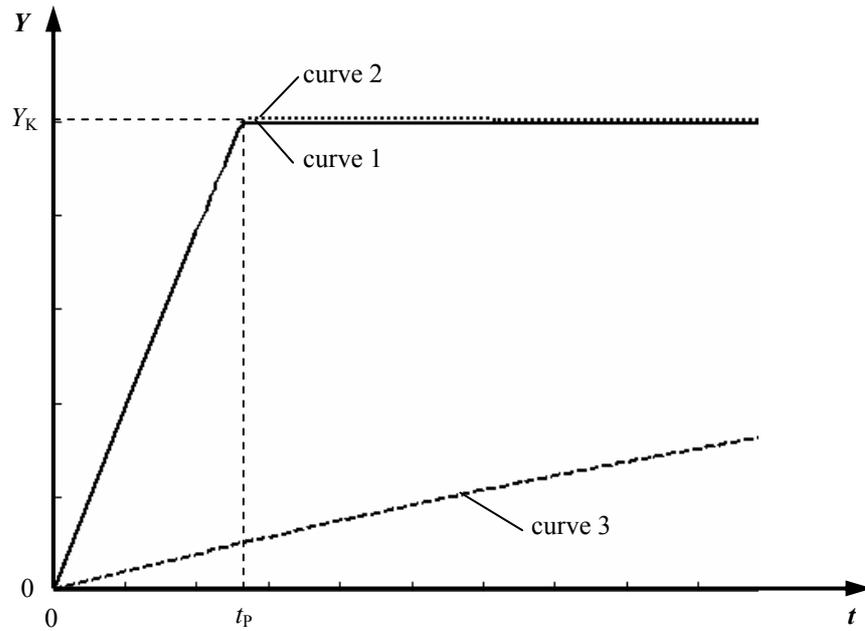


Figure 7. Response of the object to the extortion from signal source with two calibrators

IV. Testing

Verification has been made by computer simulation with *MathLab* and *Simulink*. The test was carried out for different values of object time constant T and for different values of overshooting amplitude X_p and overshooting time t_p . The tests results are shown on figure 8.

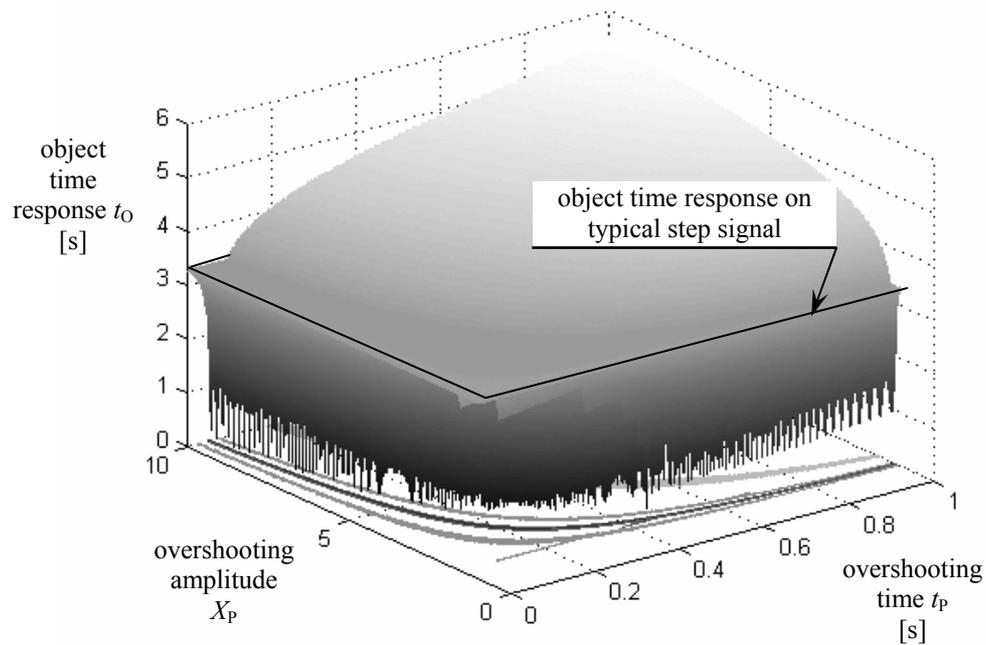


Figure 8. Object time response in function of overshooting amplitude X_p and overshooting time t_p

They confirmed the accuracy of the equation (1). The horizontal surface indicated by black edges illustrates the object time response on the step signal. There were performed tests of objects time response for different values of objects time constant T and for different values of overshooting amplitude X_p and overshooting time t_p calculated from the equations (1). Results of test confirmed that the using of the step signal with the overshooting makes possible shortening of the objects time response up to seventy times.

V. Conclusions

Proposed shape of the step signal with the overshooting allows shortening considerably the time response of the first order inertial objects. There is presented relation between signal parameters in the function of the object time constant. In the article there is analyzed a method of generating of such signal from the source with one calibrator and source with two calibrators and the analog multiplexer. Results of simulations research showed that the signal generated by the source with two calibrators and the analog multiplexer is nearly ideal, but its cost is much higher than the cost of the source with one calibrator.

References

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