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ESTIMATION OF PARAMETERS OF THE QUASI STABLE OBJECT USING A SYMMETRIC INTERACTION OF CHANNELS OF INFORMATION AND MEASUREMENT SYSTEM WHICH STRUCTURE ARE REBUILT

Annotation. *The algorithm for obtaining the estimates of unknown parameters of the quasi-stationary control target using an information and measurement system with two adaptive channels, which structure are rebuilt and parameters are changed intentionally developed by the author is shown. The considered adaptive algorithm operates on a sequential estimation procedures of unknown parameters object. At each stage of estimating unknown parameters structures of channels are rebuilt, which allows them to get as close to the properties of the object under study. The basis of this change is the principle of duality models of system and signal. Purposeful variation of parameters the channels of information-measuring system is in accordance with an algorithm that realizes the energy interaction between the two heavy balls. The influence of error of the previous estimation of parameter on the accuracy estimation of the following parameter is studied.*

Keywords: *quasi stable object, symmetric interaction of channels, information-measuring system, heavy ball method, energy interaction between the two balls.*

Problem statement

Getting characteristics managed controlled process for solving tasks of optimal control/monitoring carried out through the use of adaptive information-measuring systems (IMS). In the process of estimating the parameter values of real technical objects established that the difference in energies of channels IMS causes undesirable changes in their parameters. Undesirable oscillations of variable parameters of IMS channels using energy exchange between them can be eliminate.

Analysis of recent research and publications

Decrease in work efficiency of IMS is mainly caused by power fluctuations of variable parameters IMS channels. In [1], in order to improve the quality a characteristic of the identification process, the problem of stored energy redistribution between two identical in structure, but with different energy characteristics of adaptive models was solved. During the work described algorithm for finding the values of the parameters of the object the process of parameter settings of the adaptive model is carried out by gradient methods. On the basis of this algorithm in [2] it has been described and analyzed for efficiency

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algorithm in which the parameters of channel IMS purposefully changed realizing the principle of symmetric energy interaction between the two heavy balls [3-5].

The purpose of the article

The aim is to demonstrate the algorithm of estimate the parameters of the quasi-stationary object using the interaction parameters of two structurally equivalent channel IMS that purposefully changed that developed by the authors. At the core of these changes is the duality principle of the system and signal.

Main part

As a control object will be considered an RLC electrical circuit with a series connection of elements whose parameters L, R and C are unknown and shall be evaluation. The dynamics of the circuit is described by the differential equation:

$$L \cdot i^{(2)}(t) + R \cdot i^{(1)}(t) + \frac{1}{C}\int_0^t i(\tau)d\tau = Q \cdot t, \quad i(0) = 0, \qquad (1)$$

where $i(t)$ - he current flowing in the circuit; Q - known parameter [6].

After differentiating equation **(1)** and assuming that $x(t) = i(t)$, $a_0 = 1/Ñ$, $a_1 = R$, $a_2 = L$, we get the differential equation:

$$a_2 x^{(2)}(t) + a_1 x^{(1)}(t) + a_0 x(t) = Q, \qquad (2)$$

Evaluation of parameter a_0 of the object **(2)** will carry out by using IMS with two interacting with each other channels, whose dynamics is described by the differential equations:

$$\begin{cases} y^{(2)}(t) = -\frac{b_1}{b_2} \cdot y^{(1)}(t) - \frac{b_0}{b_2} \cdot y(t) + \frac{q_0(t)}{b_2} \\ z^{(2)}(t) = -\frac{c_1}{c_2} \cdot z^{(1)}(t) - \frac{c_0}{c_2} \cdot z(t) + \frac{q_0(t)}{c_2} \\ b_0(t) = \xi_{01}(t), \ \xi_{01}{}^{(1)}(t) = \xi_{02}(t), \ \xi_{01}(0) = b_{00}, \ \xi_{02}(0) = 0 \\ \xi_{02}{}^{(1)}(t) = -\alpha_0 x(t)\left[\left(2x(t) - y(t)\right)\xi_{01}(t) - z(t)\zeta_{01}(t)\right] - \beta_0 \cdot \xi_{02}(t) \\ c_0(t) = \zeta_{01}(t), \ \zeta_{01}{}^{(1)}(t) = \zeta_{02}(t), \ \zeta_{01}(0) = c_{00}, \ \zeta_{02}(0) = 0 \\ \zeta_{02}{}^{(1)}(t) = -\alpha_0 x(t)\left[\left(2x(t) - z(t)\right)\zeta_{01}(t) - y(t)\xi_{01}(t)\right] - \beta_0 \cdot \zeta_{02}(t) \end{cases} \qquad (3)$$

$$q_0(t) = Q(t).$$

If the evaluation a_0^* of value of the parameter a_0 was made with an uncertainty Δ_0, than instead of the input signal $q_1(t)=\int_0^t Qdt - a_0^*\int_0^t x(t)dt,$

$a_0^* = a_0 = \frac{1}{C}$, $q_1^{(1)}(t) = q_0(t) - a_0^* x(t)$, $q_0(t) = Q$ at an estimation value of the next model parameter a_1 of the object (2) input signal will be:

$$\overline{q_1(t)} = \int_0^t Qdt - a_0^*\int_0^t x(t)dt \pm \Delta_0\int_0^t x(t)dt = q_1(t) \pm \Delta_0(t),\ \ a_0^* = a_0 \pm \Delta_0,\ \ \Delta_0(t) = \Delta_0\int_0^t x(t)dt,$$

$$\overline{q_1^{(1)}(t)} = q_0(t) - a_0^* x(t),\quad q_0(t) = Q.$$

Then, at estimation the parameter a_1 the structure channels of IMS will be reconstructed as follows:

$$\begin{cases} y^{(1)}(t) = -\frac{b_1}{b_2}\cdot y(t) + \frac{\overline{q_1(t)}}{b_2} \\ z^{(1)}(t) = -\frac{c_1}{c_2}\cdot z(t) + \frac{\overline{q_1(t)}}{c_2} \\ \overline{q_1^{(1)}(t)} = q_0(t) - a_0^*\cdot x(t) \\ a_0^* = a_0 \pm \Delta_0 \\ b_1(t) = \xi_{11}(t),\ \xi_{11}^{(1)}(t) = \xi_{12}(t),\ \xi_{11}(0) = b_{10},\ \xi_{12}(0) = 0 \\ \xi_{12}^{(1)}(t) = -\alpha_1 x(t)\left[\left(2x(t) - y(t)\right)\xi_{11}(t) - z(t)\zeta_{11}(t)\right] - \beta_1\cdot\xi_{12}(t) \\ c_1(t) = \zeta_{11}(t),\ \zeta_{11}^{(1)}(t) = \zeta_{12}(t),\ \zeta_{11}(0) = c_{10},\ \zeta_{12}(0) = 0 \\ \zeta_{12}^{(1)}(t) = -\alpha_1 x(t)\left[\left(2x(t) - z(t)\right)\zeta_{11}(t) - y(t)\xi_{11}(t)\right] - \beta_1\cdot\zeta_{12}(t) \end{cases} \tag{4}$$

In the case when the parameter a0 was found accurately as evaluation a1* of parameter values a1 was made with an uncertainty Δ_1, instead of the input signal:

$$q_2(t) = \int_0^t\int_0^t Qdt^2 - a_0^*\int_0^t\int_0^t x(t)dt^2 - a_1^*\int_0^t x(t)dt,$$

$$q_0(t) = Q,\quad a_1^* = a_1 = R,$$

$$q_2^{(1)}(t) = q_1(t) - a_1^* x(t),$$

at an estimation value of the next model parameter a_2 of the object (2) input signal will be:

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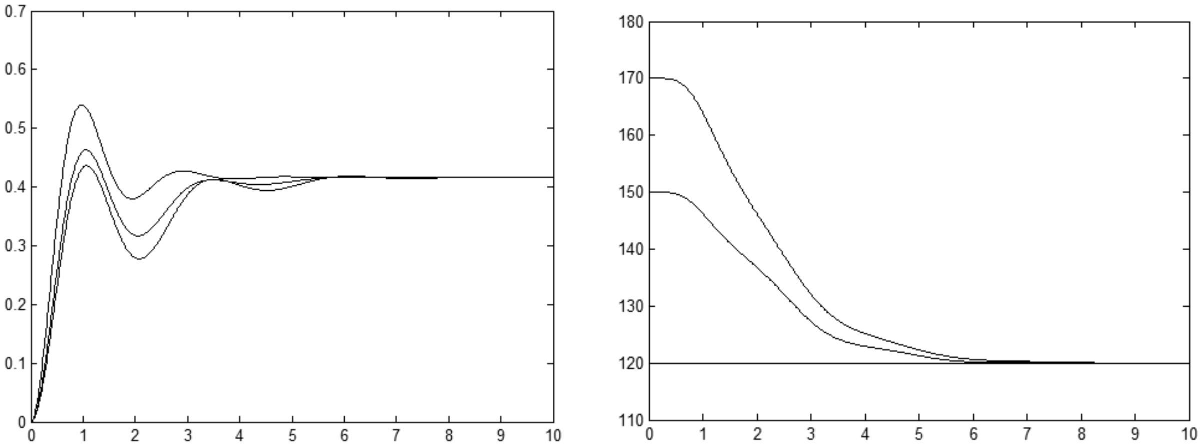
$$\overline{q_2(t)} = \int\limits_T^t \int\limits_T^t Q dt^2 - a_0^* \int\limits_T^t \int\limits_T^t x(t) dt^2 - a_1^* \int\limits_T^t x(t) dt \pm \Delta_1 \int\limits_T^t x(t) dt = q_2(t) \pm \Delta_1(t)$$

$$a_0^* = a_0, \quad a_1^* = a_1 \pm \Delta_1,$$

$$\Delta_1(t) = \pm \Delta_1 \int\limits_T^t x(t) dt, \quad \overline{q_2^{(1)}(t)} = q_1(t) - a_1^* x(t).$$

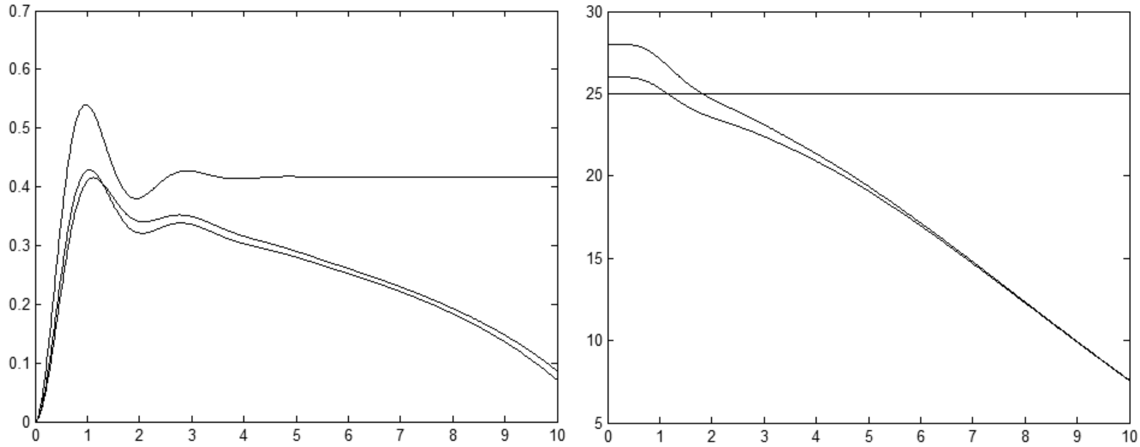


a) transient processes of object and IMS channels

b) processes of the variation of parameters of IMS channels

Fig. 1. Graphs of simulation results of parameter estimation process a_0

$\left(\alpha_0 = 2.4,\ \beta_0 = 1.8,\ b_{00} = 150,\ c_{00} = 170\right)$.



a) transient processes of object and IMS channels

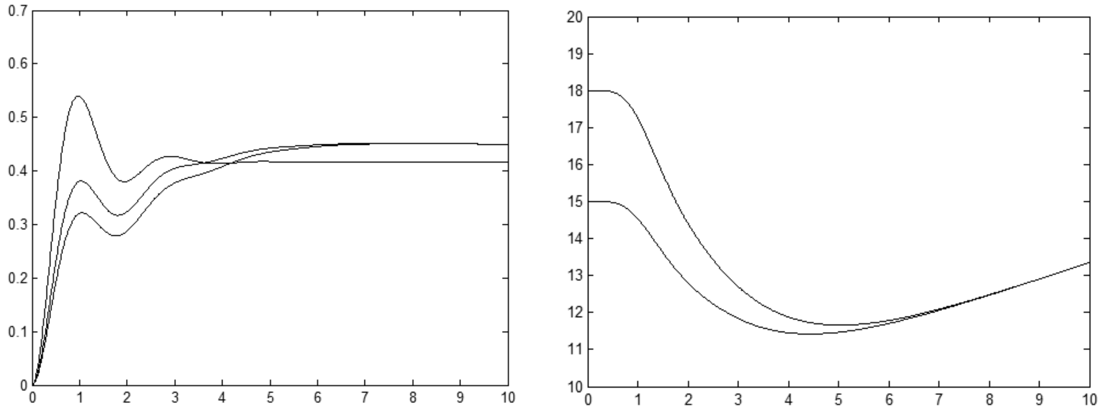
b) processes of the variation of parameters of IMS channels

Fig. 2. Graphs of process simulation results of parameter estimation a_1, with an uncertainty in the evaluation of the parameter a_0

$\left(\alpha_1 = 2.05,\ \beta_1 = 1.99,\ b_{10} = 28,\ c_{10} = 26\right)$.

The structures of two interacting IMS channels in the evaluation of the parameter a2 described by differential equations:

$$\begin{cases} y(t) = \dfrac{\overline{q_2(t)}}{b_2} \\ z(t) = \dfrac{\overline{q_2(t)}}{c_2} \\ \overline{q_2^{(1)}(t)} = q_1(t) - a_1^{*} \cdot x(t) \\ a_1^{*} = a_1 \pm \Delta \\ b_2(t) = \xi_{21}(t),\ \ \xi_{21}^{(1)}(t) = \xi_{22}(t),\ \ \xi_{21}(0) = b_{20},\ \ \xi_{22}(0) = 0 \\ \xi_{22}^{(1)}(t) = -2 \cdot \alpha_2 x(t)\left[x(t) \cdot \xi_{21}(t) - q_2(t)\right] - \beta_2 \cdot \xi_{22}(t) \\ c_2(t) = \zeta_{21}(t),\ \ \zeta_{21}^{(1)}(t) = \zeta_{22}(t),\ \ \zeta_{21}(0) = c_{20},\ \ \zeta_{22}(0) = 0 \\ \zeta_{22}^{(1)}(t) = -2 \cdot \alpha_2 x(t)\left[x(t) \cdot \zeta_{21}(t) - q_2(t)\right] - \beta_2 \cdot \zeta_{22}(t) \end{cases} \quad (5)$$



a) transient processes of object and IMS channels

b) processes of the variation of parameters of IMS channels

Fig. 3. Graphs of process simulation results of parameter estimation a_2, with an uncertainty in the evaluation of the parameter a_1 and correct evaluation of parameter a_0 $\left(\alpha_2 = 1.84,\ \beta_2 = 1.5,\ b_{20} = 15,\ c_{20} = 18\right)$.

If the estimate of the parameter *a₀* also was done with an uncertainty, the input signal will contain an uncertainty in the evaluation of the previous parameters:

$$\overline{q_2(t)} = \int_T^t \int_T^t Q dt^2 - a_0^{*} \int_T^t \int_T^t x(t) dt^2 \pm \Delta_0 \int_T^t \int_T^t x(t) dt^2 - a_1^{*} \int_T^t x(t) dt \pm \Delta_1 \int_T^t x(t) dt = q_2(t) \pm \Delta_{01}(t),$$

$$a_0^{*} = a_0 \pm \Delta_0, \quad a_1^{*} = a_1 \pm \Delta_1$$

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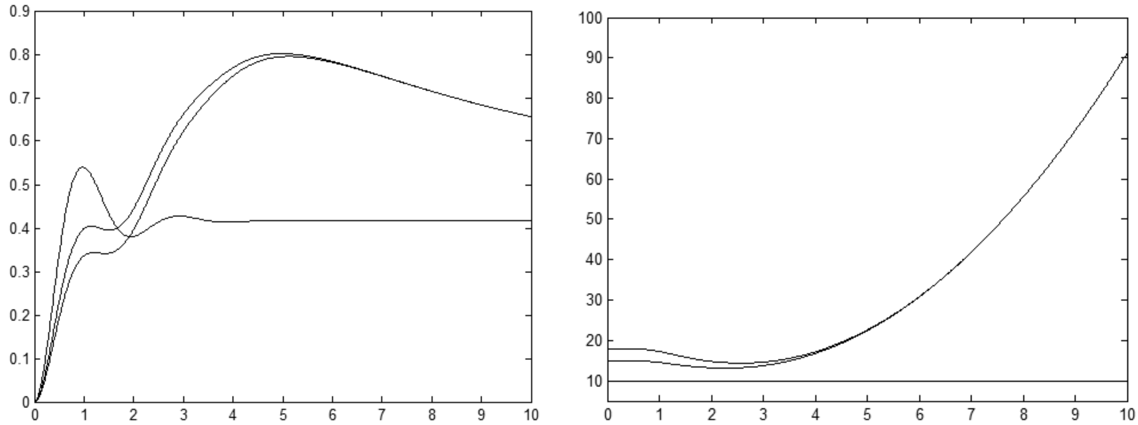
$$\Delta_{01}(t) = \pm\Delta_0 \int_T^t \int_T^t x(t)dt^2 \pm \Delta_1 \int_T^t x(t)dt,$$

$$\overline{q_2^{(1)}(t)} = \overline{q_1(t)} - a_1^* x(t).$$



a) transient processes of object and IMS channels

b) processes of the variation of parameters of IMS channels

Fig. 4. Graphs of process simulation results of parameter estimation a_2, with an uncertainty in the evaluation of the parameters a_0 and a_1

$$\left(\alpha_2 = 1.84,\ \beta_2 = 1.5,\ b_{20} = 15,\ c_{20} = 18\right).$$

In this case the patterns of two interacting channel IMS in the evaluation of parameter a_2 will be described in according to differential equations (5), with the substitution of $q_1(t)$ for $\overline{q_1(t)}$ (figure 4).

The results of mathematical modeling parameter estimation process according to algorithms (3) - (5) are shown in Figure 1 - Figure 3, respectively. Convergence time of parameters $b_i(t)$ and $\tilde{n}_i(t)$ to each other and to the estimated parameter a_i depends on the value of the coefficients α_i and β_i.

Conclusions and perspectives for further research

The paper investigated the behavior of adaptive channels of IMS with an uncertainty in the evaluation of the previous parameter. The study results showed that, in evaluation of next parameter the presence of uncertainty in the evaluation of the previous parameter is adversely affect the IMS efficiency - with time parameters $b_i(t)$, $c_i(t)$ of models whose structures are rebuilt not converge towards each other and the a_i, $\left(i = \overline{0,2}\right)$ object parameters. Uncertainties of evaluating subsequent parameters

a_i, $\left(i = \overline{0,2}\right)$ can be decreased by a more accurate estimate of the previous parameters of IMS channels. This can be achieved by selecting appropriate values α_i, β_i $(i = \overline{0,2})$ and increasing the observation time t.

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