

2. Meylan L., Susstrunk S. Bio-inspired color image enhancement // SPIE Electronic Imaging. San Jose, 2004, P. 46–56

3. Tao L., Asari K. V. Nonlinear enhancement of color images // SPIE Journal of Electronic Imaging, 2005. Vol. 14.

4. Young T., Van Vliet L. J. Recursive Implementation of the Gaussian filter : Signal Processing 44. Elsevier, 1995.

5. Yambor W. Analysis of PCA-based and Fisher discriminant-based image recognition algorithms : Technical Report CS-00-103. 2000.

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MODAL REGULATORS OF A DIRECT CURRENT ELECTRIC DRIVE WITH A PULSE-WIDTH CONVERTER

The technique of modal regulators synthesis of instantaneous coordinates values of direct current digital electric drives with a pulse-width converter by a state space method taking into account the influence of variable pure delay in the control channel is presented.

Keywords: a modal regulator, a direct current electric drive, a pulse-width converter.

The theory of digital repeated systems of the subordinated regulation of the electric drive [1–3] is developed well enough. Less attention has been paid to electric drive systems constructed on the basis of summation of feedbacks on a state vector that allows to expect the decrease of sensitivity to variations of control object parameters. In domestic literature such regulators are usually called modal because factors of a feedback vector directly influence eigenvalues (modes) of the closed system matrix. In the present paper the task of designing of such regulators is set. The task includes:

- reception of discrete equations of a control object condition according to its differential equations;
- definition of feedback factors by state variables according to the set spectrum of a matrix of the closed digital control system dynamics;
- introducing the corrective amendments connected with some features of the real pulse-width converter (PWC). It is supposed that the influence of variable pure delay in the control channel of a double digital system which is rather typical for an electric drive system with microprocessor control is taken into account.

The reasons of occurrence of two periods of discreteness as well as the nature of pure delay in microprocessor systems are considered in works [4; 5]. It is supposed that the interruption period (IP) of work of a control microcomputer contains integer N of the switching periods (SP) PWC: $T = NT_k$, where T and T_k are values IP and SP accordingly. In view of two periods of discreteness it is expedient to introduce two types of relative time – global τ and local one inside IP θ , whereby

$$\tau = \frac{t}{T}; \quad \theta = \frac{t}{T_k} = \frac{N}{T}t = N\tau; \quad \theta \in [0, N]. \quad (1)$$

Below only thus determined relative values of time are used. Let the calculation of a control signal $u[n]$ on IP with number n is completed after computing delay τ_d on k of the SP (fig. 1). Local computing delay θ_d is counted off from the beginning of SP with number k . If the local time delay θ_{PWC1} necessary for realization of $u[n]$ is more than θ_d (fig. 1) then this realization can be carried out already on k of the SP. The previous value of a control signal $u[n-1]$ is realized on the first k of the SP.

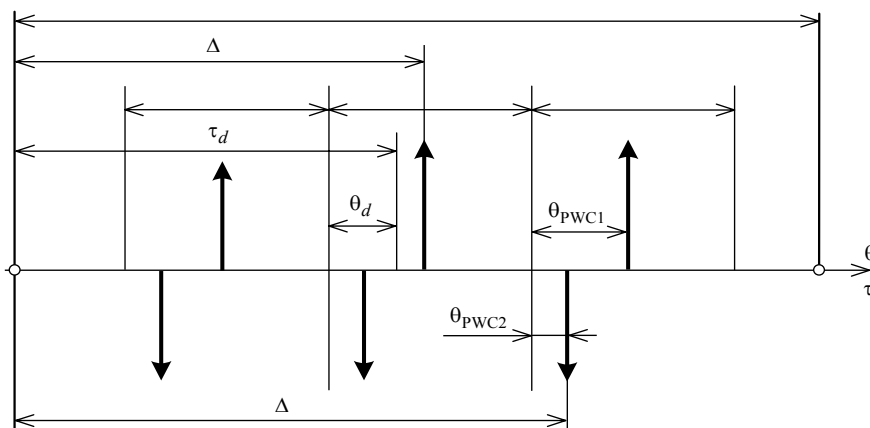


Fig. 1

If $\theta_{PWC2} < \theta_d$ (fig. 1) then the realization of $u[n]$ is postponed up to SP with number $k + 1$. In that specific case when $k = N - 1$ it will begin only from the SP with number zero on $n + 1$ of the IP.

The delay of θ_{PWC} is caused by the nature of semi-conductor PWC the output voltage of which is adjusted due to the change of its size.

In a local time scale the size of pure delay belongs to the range: $0 \leq \theta_\Delta \leq N + 1$ [5]. Therefore it is convenient to break it into whole K and fractional δ parts: $\theta_\Delta = K + \delta$.

Digital regulators designing includes calculation of discrete state equations parameters of a control object in view of the influence of pure delay having a general view according to [4; 5]:

$$\tilde{X}[n+1] = \tilde{\Phi}_{IP} \tilde{X}[n] + \tilde{W}_{IP} u[n], \quad (2)$$

where the vector of state variables, transitive and weight matrices for IP will be written down as:

$$\tilde{X}[n] = \begin{bmatrix} X[n] \\ y_1[n] \end{bmatrix}; \quad \tilde{\Phi}_{IP} = \begin{bmatrix} \Phi_{IP}(1) & F \\ 0 & 0 \end{bmatrix};$$

$$\tilde{W}_{IP} = \begin{bmatrix} H \\ 1 \end{bmatrix}; \quad y_1[n+1] = u[n]. \quad (3)$$

In matrices (3) an additional variable of a condition y_1 is introduced for the case when the whole part of pure delay on a global scale to time is equal to one IP.

If regulation is carried out according to instant values of coordinates then the calculation of matrices F and H is carried out according to formulas [4]:

$$F = \Phi_{SP}^{N-K} (1) \underbrace{\{\Phi_{SP}(1) \dots \{\Phi_{SP}(1) + E\} + \dots + E\}}_{K-1} W_{SP} (1 - \delta); \quad (4)$$

$$H = \underbrace{\{\Phi_{SP}(1) \dots \{\Phi_{SP}(1) + E\} + \dots + E\}}_{N-K-1} W_{SP} (1 - \delta), \quad (5)$$

where Φ_{SP} and W_{SP} are transitive and weight matrices for SP, E is an individual matrix.

The synthesis of a digital modal state regulator by the set spectrum of a matrix of dynamics is possible in the only case when [6] the pair of matrices $[\tilde{\Phi}_{IP}, \tilde{W}_{IP}]$ is completely controlled. Let P be a vector of feedback factors of dimension l , where l is the amount of state variables (the order of a characteristic polynomial of a system). Value P can be found from [6]:

$$P = [(GS^T)^{-1}(\gamma - g)]^T, \quad (6)$$

where

$$S = [\tilde{W}_{IP} \quad \tilde{\Phi}_{IP} \tilde{W}_{IP} \quad \tilde{\Phi}_{IP}^2 \tilde{W}_{IP} \quad \dots \quad \tilde{\Phi}_{IP}^{n-1} \tilde{W}_{IP}];$$

$$\gamma = [\gamma_{l-1} \quad \gamma_{l-2} \quad \dots \quad \gamma_0]^T; \quad g = [g_{l-1} \quad g_{l-2} \quad \dots \quad g_0]^T;$$

$$G = \begin{bmatrix} g_l & 0 & 0 & \dots & 0 \\ g_{l-1} & g_l & 0 & \dots & 0 \\ g_{l-2} & g_{l-1} & g_l & \dots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ g_1 & g_2 & g_3 & \dots & g_l \end{bmatrix},$$

where γ и g are factors of a characteristic polynomial of a closed system and a control object.

If factor $g_l \neq 0$ then triangular matrix G is not degenerate [6]. Therefore, for the existence of vector P the matrix of controllability S should have a rank l , or, which is the same, the pair of matrices $[\tilde{\Phi}_{IP}, \tilde{W}_{IP}]$ should be controlled.

In a real system with the PWC the size of pure delay is variable and it is necessary to take into account this fact while synthesizing the regulators of digital systems. Let us consider the synthesis of a modal regulator and the research of a closed digital system of a direct current electric drive with the PWC. In view of variable character of pure delay Δ some values of feedback factors corresponding to the range of changes Δ of the latter are counted. Intermediate values are derived by interpolation.

The system of continuous differential equations for the SP does not depend on the model of a power converter and looks like [3]:

$$\left. \begin{aligned} \frac{di}{d\theta} &= -\frac{1}{\theta_a} i - \frac{1}{\theta_a} \omega + \frac{1}{\theta_a} u, \\ \frac{d\omega}{d\theta} &= \frac{1}{\theta_m} i. \end{aligned} \right\}, \quad (7)$$

where i , ω are relative values of armature current and frequency of an engine shaft rotation accordingly; θ_a и θ_m are relative electromagnetic and electromechanical constants of time. Let, for example, $\theta_a = 8$, $\theta_m = 32$ и $N = 4$ then matrices of dynamics and an input of continuous equations of condition (7) are equal:

$$A = \begin{bmatrix} -0.125 & -0.125 \\ 0.03125 & 0 \end{bmatrix}, \quad B = \begin{bmatrix} 0.125 \\ 0 \end{bmatrix}.$$

Factors $P(\Delta)$ in the model are set as the table of conformity between size Δ and eigenvalues of feedback factors which should be calculated prior to the beginning of modelling. The values of vector P are calculated for a linear model with an ideal pulse element in the assumption of the steady-state mode. A part which realizes variable factor $P(\Delta)$ carries out linear interpolation between two values nearest to it if size Δ does not coincide with the calculated values. It allows to reduce the number of elements of the table of conformity because calculations show that the curve of dependence of factors values $P(\Delta)$ is monotonous and smooth enough.

In table the values of feedback factors in a direct current electric drive system with PWC calculated according to the technique described above for a number of values Δ are shown. Here P_I is a vector of feedback factors on an instant armature current, P_ω is a vector of feedback factors on instant frequency of rotation of an engine shaft, P_U is a vector of feedback factors on the value of a control signal on previous IP which is an additional state variable.

A binomial spectrum of a matrix of a closed system dynamics with an equivalent constant of time τ_ω describing its speed and equal to 1,5 was chosen as an example for calculation of values of factors $P(\Delta)$.

Factors of feedback

Δ	0	0,2	0,25 ₋	0,25 ₊	0,45	0,65	0,85	1,05	1,25 ₋
P_l	1,1103	1,0963	1,0926	0,5029	0,4912	0,4795	0,4677	0,456	0,4442
P_ω	3,9081	3,7977	3,7704	1,5461	1,4964	1,4478	1,4004	1,3543	1,3093
P_U	0	0	0	-0,223	-0,16	-0,099	-0,04	-0,017	-0,017

One can see in the table that if the size of pure delay is greater than the SP of the PWC then there is an additional feedback [4] – nonzero factor P_U in the model. At the same time the presence of a feedback on one more coordinate of a system can appear to be useful from the point of view of increase of roughness of an electric drive system.

Let's consider the calculation of transients in the described system by means of a package of imitating modelling *Matlab* of the firm *The MathWorks, Inc.* The corresponding structure of a closed system for modelling in a tool *Simulink* of package *Matlab* is shown in fig. 2.

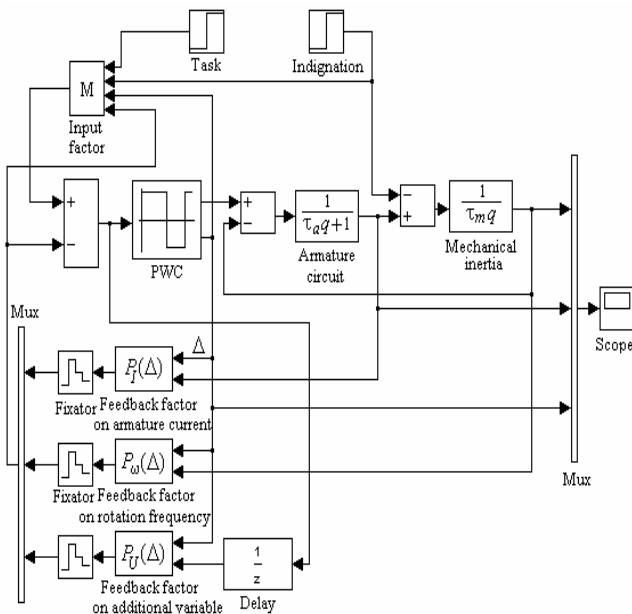


Fig. 2

The block diagram of a model will consist of connected in series model PWC and parts of a control object of a direct current electric drive system, where q is a dimensionless Laplace operator. The variable factors of feedback dependent on value Δ given out by the PWC which are switched N times for IP are included in models. Relative constants of time τ_a и τ_m are N times less than θ_a and θ_m [4].

To correct the static mistake caused by the application of a load moment an adjustable input factor M was introduced into the structure. Its size depends, apart from everything else, on the value of a load moment. As it is known, the measurement of the latter is inconvenient, therefore below a variant of absence of such dependence is considered. An input factor is calculated according to the formula:

$$M = 1 + \sum_l \frac{x_l \cdot p_l}{x^*}$$

where l is the amount of state variables, x_l is an instant value of l -variable at the end of IP, p_l is the value of a feedback factor on l -variable, x^* is the sum of values of master control and a reference signal.

It should be noted that an input factor for a reference signal which was introduced to provide a zero static mistake depends on the size of pure delay as the factors of a characteristic polynomial of a closed system transfer function will change together with the change of vector P .

The size of a delay θ_{PWC} represents the factor of PWC filling β which is calculated according to the formula [3]:

$$\beta = \frac{\omega^* + i_f + 1}{2},$$

where ω^* is a preset value of an engine speed, i_f is the static current accepted as a disturbing signal for a system.

In fig. 3 one can see the curves of transients of the described system which have a typical for a binomial spectrum aperiodic character and a preset speed. Along the horizontal axis there are values of global relative time. The presence of pulsations can be explained by a pulse character of armature current. Disturbance compensation provides a zero static mistake. The size of computing delay introduced by a microcomputer is equal to 0.1. The maximal control signal and EMF of a voltage source of the PWC are both equal to 1. The signal of the task is a jump from a level of 0.1 up to 0.2 with displacement on three IP (for clearness). A static current step from 0.05 up to 0.1 is displaced on 25 IP to provide the established mode in a system after performing the task.

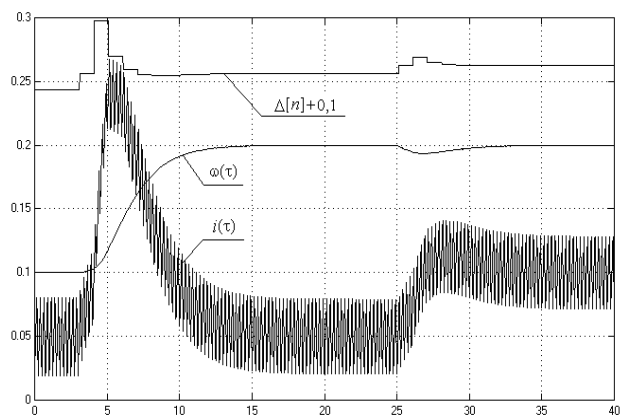


Fig. 3

As it has already been mentioned the actual size of pure delay can vary rather widely and under its significant deviation from the calculated value transients can be completely unacceptable. The developed technique of modal regulators synthesis allows to exclude subharmonic oscillations typical for high-speed systems with a part of pure delay in the control channel. Subharmonic

oscillations are oscillations the period of which exceeds the IP by an integer of times [3]. Fig. 4 shows schedules of processes in a digital electric drive system for two cases:

- feedbacks with variable factors in the function of pure delay (fig. 4, a);
- feedbacks with constant factors calculated in the assumption of an average value of pure delay equal to one IP [3] (fig. 4, b). It is obvious, that in the second case in the process of performing the task there appear converging subharmonic oscillations as a result of which the speed of a system decreases approximately in one and a half time. If the speed of a system increases considerably subharmonic oscillations can even increase. In any case their occurrence is extremely undesirable, as they are badly filtered by flyweights because of their low frequency and it leads to additional losses of energy.

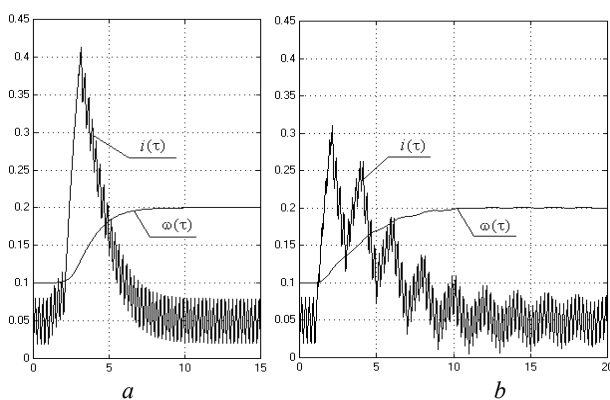


Fig. 4

Conclusions:

- the analysis of time delays introduced by a microcomputer together with the PWC is made and the principle of their account is established in the process of calculation of the discrete state equations of a control object;

- the technique of numerical calculation of modal state regulators is developed in view of the influence of variable pure delay in a microprocessor system with several periods of discreteness;
- the account of variable character of pure delay allows to remove subharmonic oscillations typical for high-speed closed digital systems;
- there is an opportunity to decrease a static mistake (to its full compensation) and to reduce a dynamic mistake significantly if disturbing influence in a system can be supervised and measured.

References

1. Volkov A. I. Algorithms and structures of microprocessor systems of high-dynamic electric drives control // Electrical engineering. 1999. № 8. P. 10–16.
2. Synthesis of microprocessor systems of asynchronous electric drives control applying the method of polynomial equations / I. Ya. Braslavsky, A. M. Zyuzev, Z. Sh. Ishmatov, S. I. Shilin // Electrical engineering. 1998. № 6. P. 20–24.
3. Zalyaleyev S. R. Design of microprocessor regulators of industrial electric drives : Tutorial. Krasnoyarsk : KSTU, 1995.
4. Zalyaleyev S. R., Pakhomov A. N. Equations of the state of a direct current electric drives microprocessor system taking into account pure time delay in a control channel // Proceedings of higher educational institutions. Electromechanics. 2002. № 3. P. 35–41.
5. Zalyaleyev S. R., Pakhomov A. N. Mathematical description of a control object of a digital system with two periods of discreteness and delay // Optimization of an operating mode of electric drives systems : Interacademic collection of scientific papers / editor-in-chief S. R. Zalyaleyev. Krasnoyarsk : KSTU, 2002. P. 157–168.
6. Kuo B. Theory and designing of digital control systems : translate from English. M., 1986.

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A METHOD OF IMAGE SEGMENTATION WITH THE HELP OF AREAS GROWING AND MULTISCALE ANALISYS

In this article we analyzed advantages and disadvantages of existing methods of image segmentation. The development of an original algorithm of segmentation which uses the method of areas growing and multi scale analysis is presented. The capabilities of this method in different images segmentation are researched.

Keywords: segmentation, image, growing, wavelet.

Segmentation means selection of homogeneous fields in original digital images. It is one of the most important problems in modern systems of computer vision, which are used in many scientific and industrial spheres: medicine, metallography, air-photography, robotics, safety systems and others. It is at this stage of processing

that conversion of an image from a set of pixels into a set of segments suitable for further recognition of scene objects takes place.

Nowadays there is a number of formalized methods of segmentation [1], which can be divided into two groups according to the basic principle of working: