COMPUTING RESOURCES DYNAMIC OPTIMIZATION OF DIGITAL MULTICHANNEL CONTROL SYSTEMS

A.I. Frid, A.K. Enikeev, B.A. Novikov
Ufa State Aviation Technical Univ.
12 K. Marx str.
Ufa, 450000, Russia
E-mail: admin@vtizi.ugatu.ac.ru

Abstract. The new view on digital multichannel control systems design is considered. The suggested method provides an optimal reallocation of calculating resources according to quality criterion including its sensitivity to sampling period variations and the risk degree of inspected coordinate approaching to critical value. Reallocation of calculating resources is based on the results of pre-calculated response surface which represents the solution of the system of non-linear equations by the Lagrange undetermined multipliers method.

Keywords. Dynamic optimisation, calculating resources, reallocation.

Introduction. Nowadays the digital control systems development frequently comes across the problem of optimal computing resources allocation. The growth of productivity of calculators considerably exceeds growth of capacity of input/output channels . Therefore it is necessary to mind, that the free resources of a computing part can be used for optimization of periphery resources during operation.

In multichannel systems there are situations, when mismatch between required and actual stream of the information from the object during transmission of the measuring and managing information through the channel linking set of objects exists. With limited capacity of a data channel it can result that the information from one objects will actunexculpately frequently, while the information from others will be unsufficient to support correct regulation. For solution of a similar problem the system is represented by a mathematical model as the system of a queuing. For each object the stream of the applications is determined, in view of limitation of capacity of the channel and requirements to a degree of importance of that the assignment of priority to each object of the system is made. After that the way of processing of priorities by the central calculator is set. The probable methods of allocation of priorities are given in (J.Martin, 1985; V. A. Valkovsky, 1989).

Common fault of similar systems is that the characteristics of stream of the applications are determined and are set with construction of the system. The dynamic linking between an actual state of the object and the calculator schedule of operation is absent. There are extreme acceptablis states of the object characterized by values of parameters, with which achievement there are critical situations (from the output out of operation up to full destructions of the object). With designing the system of regulation all possible methods lowering possibility of occurrence of these situations are used: handle with the help of logical devices, installation of various restrictors etc.

In case of the digital multichannel system, one of such methods is the adaptive correction of sampling rate of the control systems (Vasilyev V.I. et al, 1997). The above frequency of interrogation, the process of control better.

In multichannel control system with the multiplex channel the decrease of sampling period of one channel of the system carries on to necessity rising sampling periods in other channels. Therefore we develop a complex criterion connected to an estimation of a control system quality depending on sampling rate.

The criterion of quality consists of two components:

- Integrated estimation selected on the basis of the comparative analysis on a degree of sensitivity to change of sampling period. This estimation characterizes behaviour of the system "in small" and is removed beforehand;
- Degree of risk. Characterizes a degree of risk of inspected coordinate approaching to limiting value.

For example, the first component of criterion is illustrated on fig. 1.

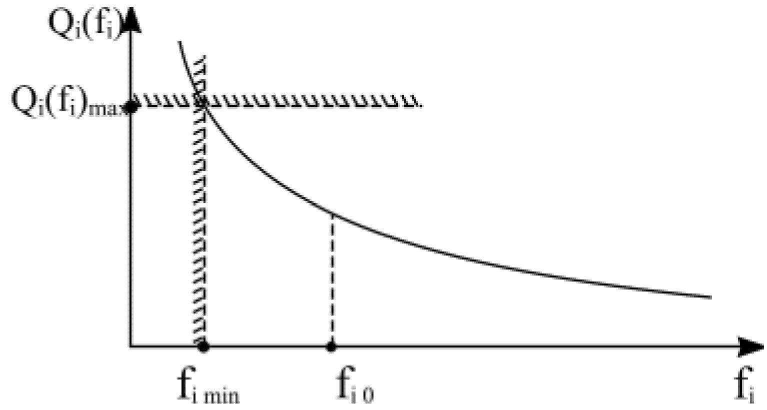

Fig. 1.

On fig. 1: f_i — frequency of interrogation in channel number *i*;

$f_{i\,0}$ — frequency of interrogation in stalled mode;

$f_{i\,min}$ — minimum limiting value of frequency of interrogation;

$Q_i(f_i)$ — criterion value;

$i = 1...n$, where *n* — number of channels.

By us it is offered to characterize a degree of risk by the following functional:

$$\Psi_i = \frac{1}{x_{i\,max} - x} + \tau_i \dot{x}_i = f_{ri}, \qquad (1)$$

that is associated with required frequency of interrogation f_{ri} in channel number *i*, and in which first addend describes a degree of approaching to limiting value, second — dynamics of approaching.

This expression has a disadvantage, that with $x \to x_{max}$ the expression tends to infinity, therefore, with technical implementation of the system, the unit of limitation by some reasonable value is put. It is useful to compare this criterion with a certain function, which is limited with $y \to \infty$, for example *arctg(y)*. In this case, the degree of closeness to dangerous boundary can be characterized by an angle of turn of some vector. The achievement of critical value of the parameter will correspond to the value $\pi/2$.

The nonlinearities ensuring physical sense of operation of the system are included in logic of a criterion of quality manufacture. The calculated value compares with desirable frequency of quantization of the system in the given channel. In common functional of an estimation of quality which is necessary for minimizing the square of a difference f_{ri} and f_i (current frequency value) is included

$$\varphi_i = \beta_i \frac{(f_{ri} - f_i)^2}{f_{io}^{\ 2}} + Q(f_i). \qquad (2)$$

The common criterion of quality of the channel represents the sum of metrics of quality.

The possibility of organization of such criterion follows from this, that with exceeding some critical value on any of addends the system fails, i.e. these addends have identical physical sense.

Mathematically task of reallocation of computing resources is formulated as follows:

$$\Phi_\Sigma = \sum_{i=1}^{n} \left(\beta_i \frac{(f_{ri} - f_i)^2}{f_{io}^{\ 2}} + Q(f_i) \right) \to \min \qquad (3)$$

It is required to minimize functional Φ_Σ with limitation $\sum f_i = F$, where F — common calculating resource.

The task of such type is solved by a method of uncertain factors by Lagrange, where

$$\Phi = \sum_{i=1}^{n} \beta_i \frac{(f_{ri} - f_i)^2}{f_{io}^{\ 2}} + \sum_{i=1}^{n} Q_i(f_i) + \lambda\left(F - \sum_{i=1}^{n} f_i \right), \qquad (4)$$

$$\frac{\partial \Phi}{\partial f_1} = \frac{\partial \Phi}{\partial f_2} = \ldots = \frac{\partial \Phi}{\partial f_n} = 0 . \qquad (5)$$

In result the system of the nonlinear equations turns out which can be solved only by numerical methods.

$$\begin{cases} 2\beta_1 \dfrac{(f_{r1} - f_1)}{f_{10}^2} + \dfrac{\partial Q_1}{\partial f_1} = 2\beta_2 \dfrac{(f_{r2} - f_2)}{f_{20}^2} + \dfrac{\partial Q_2}{\partial f_2}; \\ \ldots\ldots\ldots\ldots\ldots\ldots \\ 2\beta_1 \dfrac{(f_{r1} - f_1)}{f_{10}^2} + \dfrac{\partial Q_1}{\partial f_1} = 2\beta_n \dfrac{(f_{rn} - f_n)}{f_{n0}^2} + \dfrac{\partial Q_n}{\partial f_n}; \\ f_1 = F - \sum\limits_{i=2}^{n} f_i . \end{cases} \qquad (6)$$

The solution algorithm of the system provides the following: the parameters f_{io} are set with designing the system and characterize a working point of sampling rate of each channel. This point is determined from the system of the equations (6) with all $\beta_i = 0$. It is equivalent to an installed mode, when all inspected coordinates are precisely equal f_{i0}. If one of frequencies f_i will turn out less limiting value during solution of the system, value $f_{i\,min}$ is assigned to it, and the frequencies reallocation performs again, but f_i is eliminated, and value F-$f_{i\,min}$ is used instead of F. Essentially, the system of the equations can contain an unlimited amount of the equations on number of channels, however really there is a certain limitation $i=N$, which exceeding can result in overload of the central processor.

One of the candidate solutions of the task of reallocation with an amount of channels, greater than N, is the ranking on groups of all inspected coordinates. For example, the first group units the channels with most rigid requirements on frequency, $f_1 = f_{11} + f_{12} + ... + f_{1n}$, $f_2 = f_{21} + ... + f_{2n}$ etc., so number of frequencies decreases for rather fast solution.

Allocated in that way resources of data transmission channels should be ordered by the requests controller based on the queueing theory.

Numerical example. The simulated system consists of three subsystems united with common central processor. Each of them is the serial connection of isodromic, aperiodic and delay units with feedback. The criterions for them are:

$$Q(f_1) = 0.526 + \frac{0.214}{f_1} + \frac{0.427}{f_1^2};$$

$$Q(f_2) = 0.437 - \frac{0.998}{f_2} + \frac{5.869}{f_2^2};$$

$$Q(f_3) = 0.721 + \frac{0.406}{f_3} + \frac{0.386}{f_3^2};$$

Let:

$\beta_1 = \beta_2 = \beta_3 = 1$;

$F = 50$ Hz; $f_{10} = 29.668$ Hz; $f_{20} = 9.111$ Hz; $f_{30} = 11.221$ Hz;

The solution of the set (6) is shown on fig. 2 (surface A).

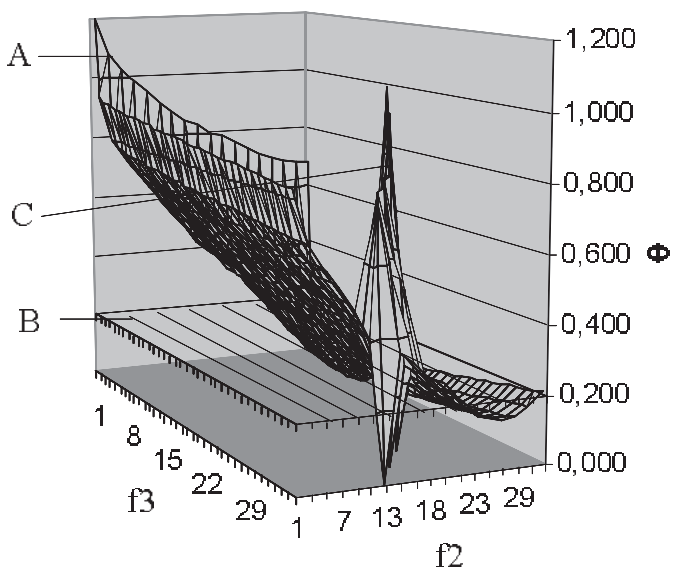

Fig. 2

It has a lot of local extremums. Using special logic procedure one can exclude the throw out zone (surface C). The surface B establishes the required level of criterion calculating accuracy.

Conclusion. The problem of calculating resources dynamic optimization in multichannel control systems is solved using complex criterion that includes integrated quality requirements and degree of risk.

Referenses.

1. J.Martin, Computer networks and distributed processing. M.: Finansy and Statistica, 1985, 256 p.

2. V. A. Valkovsky, Paralleling of algorithms and programs. Structural method. M.: Radio and Svyaz, 1989, 176 p.

3. Vasilyev, V.I., Ilyasov B.G., Doersam, Th., Adaptive digital control of robot manipulators with variation of sampling period and use of fuzzy logic, Proc. of III Asia Conference on Robotics and Its Applications, Tokio, Japan, Oct. 1997, pp. 100 — 105.