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A WORD IN DEFENSE OF THE DISCRETE CONTROL SIGNAL

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Abstract: In the structure of automatic regulators are still widely used astatic electrical constant speed actuators. An alternative solution is the use of electrical constant speed actuators, but the proportional action. The comparative evaluation of the both version of the actuators. Attention is drawn to the importance of determine the amount of time the full move electrical actuators. It is argued that the most accurate way to determine this is to use simulation modeling. The advantages obtained in case to ensure proportionality of the action of traditional electric constant speed actuator.

Key words: Automatic control system, simulation model, executive mechanism.

Introduction

Juergen Müller, the employee of Siemens, concerning influence of the actuation mechanism on the SAR loudspeaker has spoken quite definitely [4]: "In practice it often happens that the executive link has the greatest influence on a general characteristic of the site of regulation, and the regulator is mainly loaded by "correcting" the influence of an executive link. Unfortunately, at design often save on an executive link (that is in the false place), and "economy" on the equipment and then it is repeatedly eaten at installation and start in operation".

Keywords in this, quite long, the quote: **the regulator is mainly loaded by "correcting" the influence of an executive link.**

Unfortunately, the author haven't explained in what the reason of such **typical** situation and what actuation mechanisms so negatively influence on work of SAR. Therefore we will try to understand independently an origin oa a specified, urgent not only for Germany, problem.

To the middle of the 70th years in case of creation of SAR on the electrical automation equipment, in option of application of the linear algorithms of regulation, the electrical executive mechanisms (EEM) of constant speed equipped with asynchronous electromotors of an alternating current were used, as a rule. Such EIM type required use of an impulse width modulated signal of control. The matter is that on dynamic properties the specified EIM belong to astatic links. Moreover, they have a constant speed of movement–! Peculiar "payment"for it inevitable entering of distortions into a regulation algorithm was peculiar "board".

The beginning of application of such EIM belongs to the twentieth years of the last century. As requirements to quality of

regulation were not really strict, use of such executive mechanisms a long time was quite admissible with all their features about which the speech will be lower.

Entering of distortions into a regulation algorithm, in view of inevitability of application of a pulse signal of management, is yet not main "evil". Considerably their more serious shortcoming consists in features of their dynamics: in the closed SAR contour inevitably there was an integrating (!) link, though specific. Here is a basic reason of the fact that the regulator, so to speak, constantly "fights" against the executive mechanism, and the inventory of stability of such SAR is small. And when also subject to regulation had astatic properties, creation of steady SAR became not a feasible task. It is one of the reasons that electric SAR were applied for more than half a century quite restrictedly.

Appearance in the mid-seventies of microprocessor programmable controllers caused prompt, with an acceleration, growth of SAR using only electrical technical means of automation. Here it is pertinent to mark that in the USA, in the homeland of microprocessors, till 80th years the majority of SAR were pneumatic.

Thus, there was very serious objective contradiction between those, really huge opportunities which have appeared owing to the invention of digital control facilities, and the scandalous shortcoming inherent in the released EIM. This contradiction managed to be eliminated partially with emergence (in a segment of EIM of low power) oa mechanisms of proportional action. It was reached by means of embedding in EIM of a microprocessor system of positioning – spanning of the integrating link by proportional negative feedback. So, with delay almost for 100 years, some of the released EIM, like pneumatic executive mechanisms, became susceptible to an analog signal of control.

With an appearance in the 80th years of EIM of proportional action with monopoly of impulse regulators among electrical SAR was finished. More and more broad application in electrical SAR of an analog signal of control 2 is watched... 10 V of a direct current. However there is a question: how really it is always necessary to aim at use of analog signal of control? And whether there are no problems? And if they are, then how is it possible to overcome them?

Main part

Rather objectively it is possible to answer these questions if comprehensively to consider all pro et contra, that is all pluses and minuses of use of traditional EIM of constant speed and EIM of proportional action with an analog signal of control. This question has several aspects, so to speak – edges. First, it is necessary to estimate the significance for quality of regulation use of the continuous signal of control. That is quantitatively expressed estimates of decline in quality of regulation when using a pulse signal of control in comparison with the continuous are necessary if it so. To answer this question rather easily by means of comparative imitating modeling of SAR using according to the EIM model of proportional action with a continuous entrance signal of management and EIM of constant speed with a pulse signal of management. Such opportunity is available [3] now. Moreover, there is an opportunity by means of runs of the SAR imitating model to determine the optimum size of time of a full speed of EIM.

Comparison of both main types of EIM on their technical characteristics (reliability, a time between failures, durability and survivability) is complicated as there are no statistical data on these categories, and SAR developers are forced to use instead of quantitative estimates qualitative type: "better" – "worse", "more" – "less", etc.

In the beginning we will mark the strong and weaknesses of SAR with EIM of each of two types.

The main advantages of EIM of constant speed with the asynchronous electromotor variable that:

1. The minimum cost in group of electrical means (it is caused by simplicity of their construction).
2. Very high noise immunity (use of the discrete signal of control of 220 V is possible) in case of signal transmission of control from the controller to EIM in case of long distances in between.

Their objective shortcomings:

1. Bring distortion in a regulation algorithm.
2. The technical resource of the actuation mechanism decreases. It is caused by the fact that the most part of time of transition process in real SAR EIM is in the mode of so-called "sliding" which characteristic sign is his repeated inclusion in work and movement of a lock of regulator in the same direction. Such operating mode results in the increased wear of isolation of windings of the electric motor, as well as tooth gearings of a reducer. However long-term (more than semicentennial!) experience of practical use of such EIM shows their very high reliability and durability. Complaints of operators on them aren't enough.
3. The principal shortcoming – in the dynamic properties marked above.

The main merits and demerits of the modern EIM of proportional action having the built-in microprocessor positioners are directly opposite on comparing with traditional EIM of constant speed. Therefore let's not list them. It is necessary to add however to number of their objective shortcomings that use of the continuous signal of control (2... 10) V doesn't create problems only in case of electromotors of especially low power.

The available prejudices concerning the under quality of reproduction of an algorithm of regulation by traditional EIM of constant speed partly it is caused also, according to the author, by the wrong choice of value of time of a full speed Tim (more precisely, no calculations of this characteristic even are made) and value of time of pulse of the slidings mode of EIM. The task of determination of value of time of a full speed of EIM is not trivial, and dynamic, the similar task of determination of parameters of an algorithm of regulation as it, in total with parameters of an algorithm of regulation and an object, defines quality of regulation. Therefore in case of simulation modeling of SAR surely it is necessary to include in group of optimizable parameters Tim and, so the simulation model of SAR shall contain as a subsystem, the EIM model.

In the best case of the decision of the task of determination of a constant of time Tim of EIM SAR developers use formulas which cornerstone is single parameter – a constant of time of T of a static object of first order [1, 2]. It is quite obvious that these formulas are approximate and can't satisfy requests of SAR developers now. Here pertinently to mark that in option of EIM of constant or proportional speed with an analog signal of control the developer is in a bigger uncertainty.

The easiest and bystry way of finding of answers to two questions, namely:

- what type of EIM is the most suitable for use in the specific project of SAR (with a pulse, analog or discrete signal of management)?;
- what has to be time size Tim of a full speed of EIM?
- can give only imitating modeling of SAR. The obligatory requirement to the SAR model – it has to use also the models adequate real, and this task as already it has been noted above, in rather full volume, is solved.

Now three options of creation of SAR using EIM are possible:

- traditional – still to continue to put normal EIM of constant speed in projects, using a width modulated signal of control of the controller;
- to apply EIM of proportional action (in case of their existence) with the system of positioning which is built in them (the analog unified signal of control of the controller is used);
- to apply traditional EIM of constant speed (the discrete signal of control of the controller is used instead of a pulse signal). On belief of the author this option is the best. However this statement requires clarification. It was for this purpose necessary to develop the research virtual bench which structure is given in fig. 1.

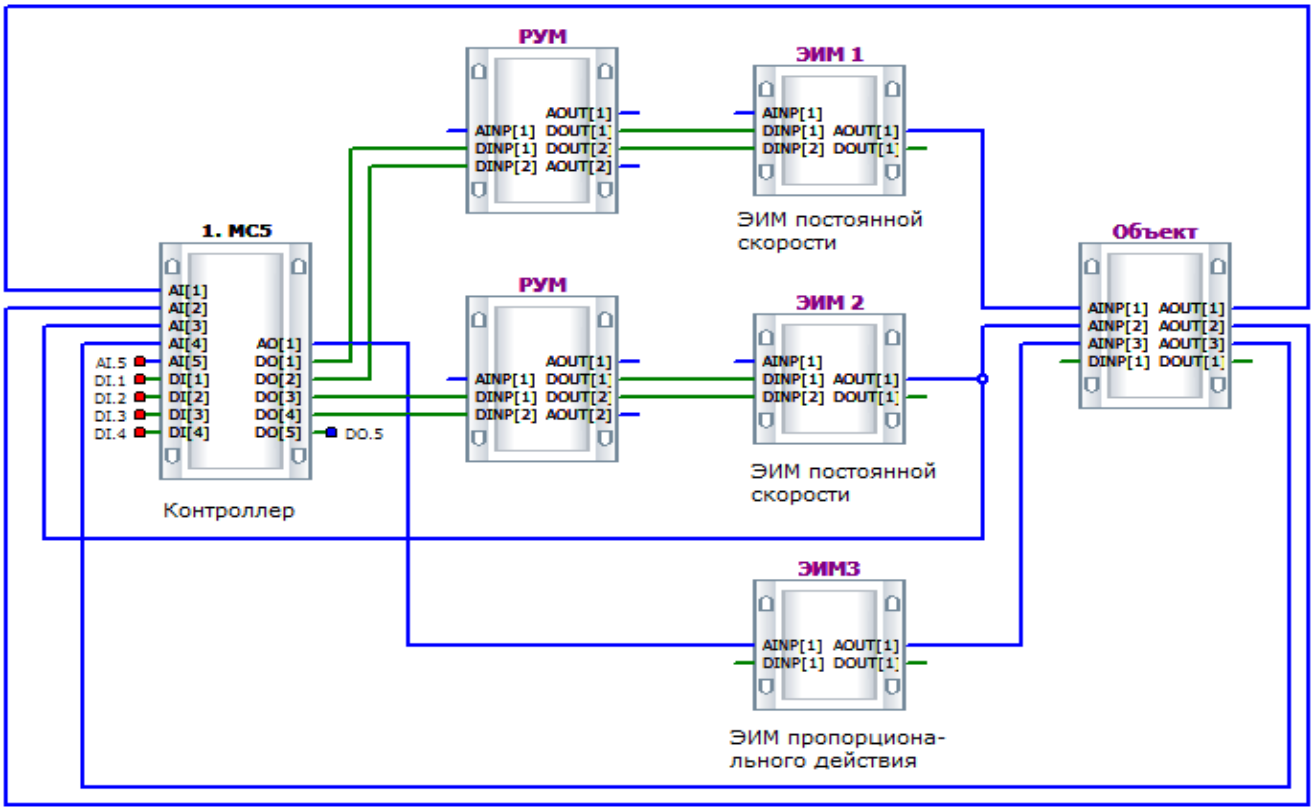

Fig. 1 – Virtual stand

Use of such bench realized with use of the programming system of Kongraf allows to analyze rather objectively features speakers SAR with the signals of the regulating controller called EIM and listed. RUM are relay amplifiers of power of signals of control. Besides they provide the galvanic isolation of electrical circuits of EIM and the controller. Dynamic properties of control links of a subject to regulation correspond to an aperiodic link of the second order with transport delay: T_o =0,75; τ=4s; T=20 s. As the most close to optimum value of time of a full speed of EIM the constant Tim of =45 s is accepted.

In fig. 2 the software modules used in structure of the MC5 controller providing formation of signals of control are shown. So, the Regulator 1 is PI-impulse, and the Regulator 2 and the Regulator 3 are a PI-analog regulating program units. By means of the program unit Positioner the analog signal of the Regulator 2 will be transformed to the discrete. Its structure is provided in fig. 3. The positioner allows to scale EIM sensor signal (to change transmission ratio of negative feedback), provides a possibility of filtering a signal and allows to set up value of a zone of nonsensitivity of this input of the controller.

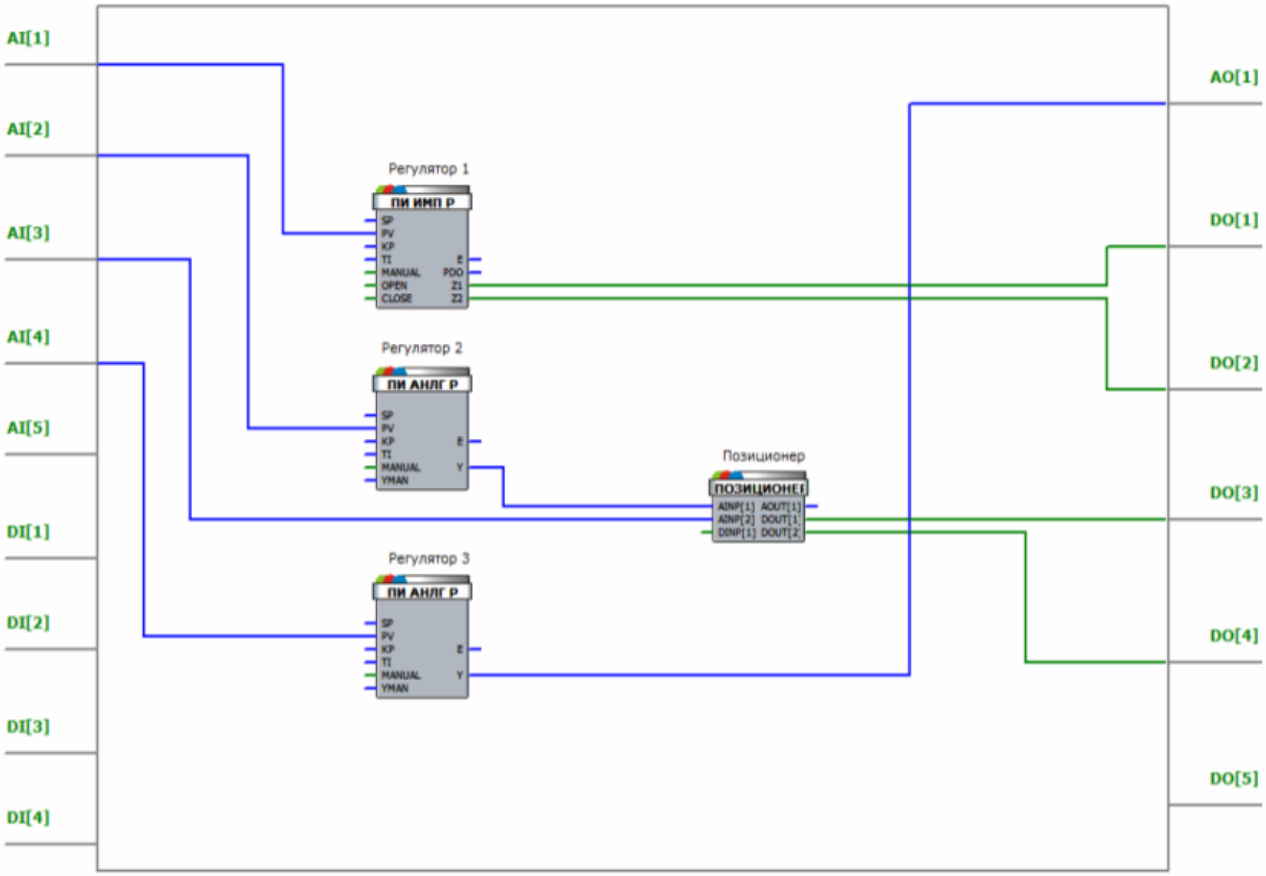

Fig. 2 – Regulating Controller MC5 of the complex "КОНТАР"

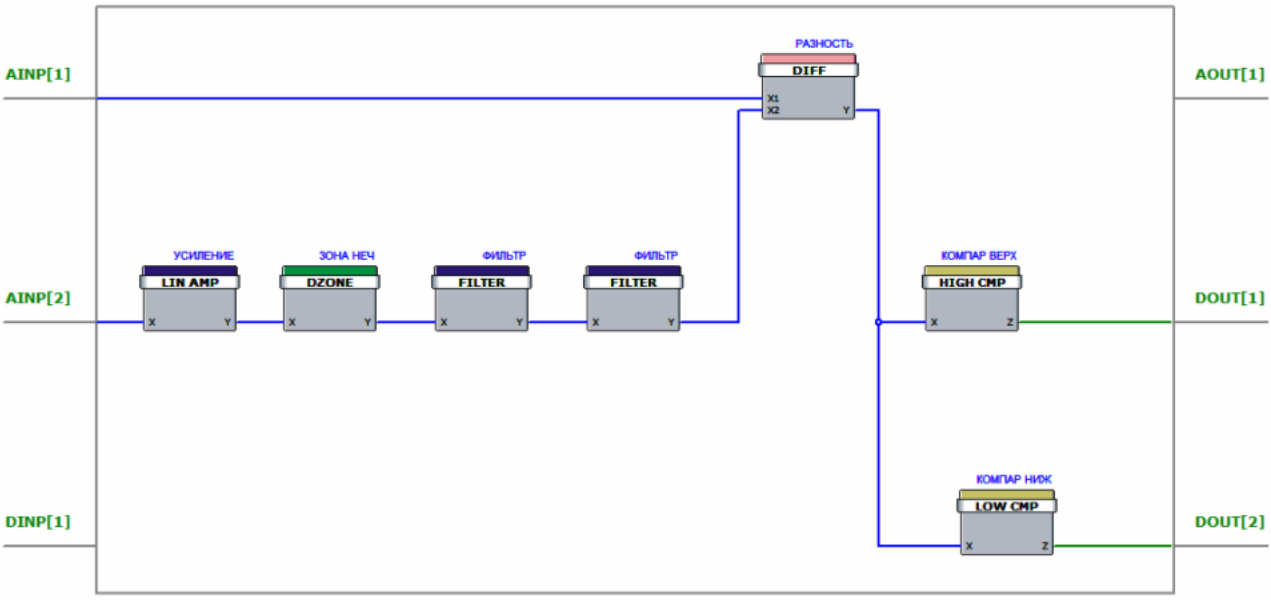

Fig. 3 – Block diagram of a positioner

In fig. 4 and 5 the EIM imitating models according to constant speed and proportional action are presented.

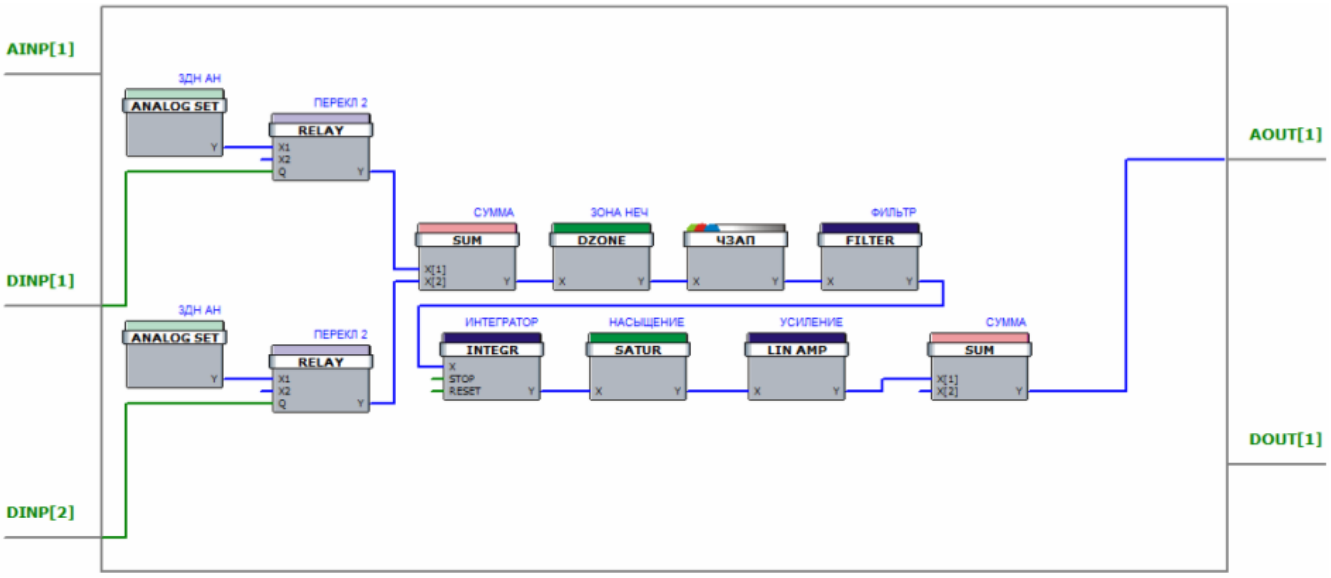

Fig. 4 – EIM imitating model of constant speed

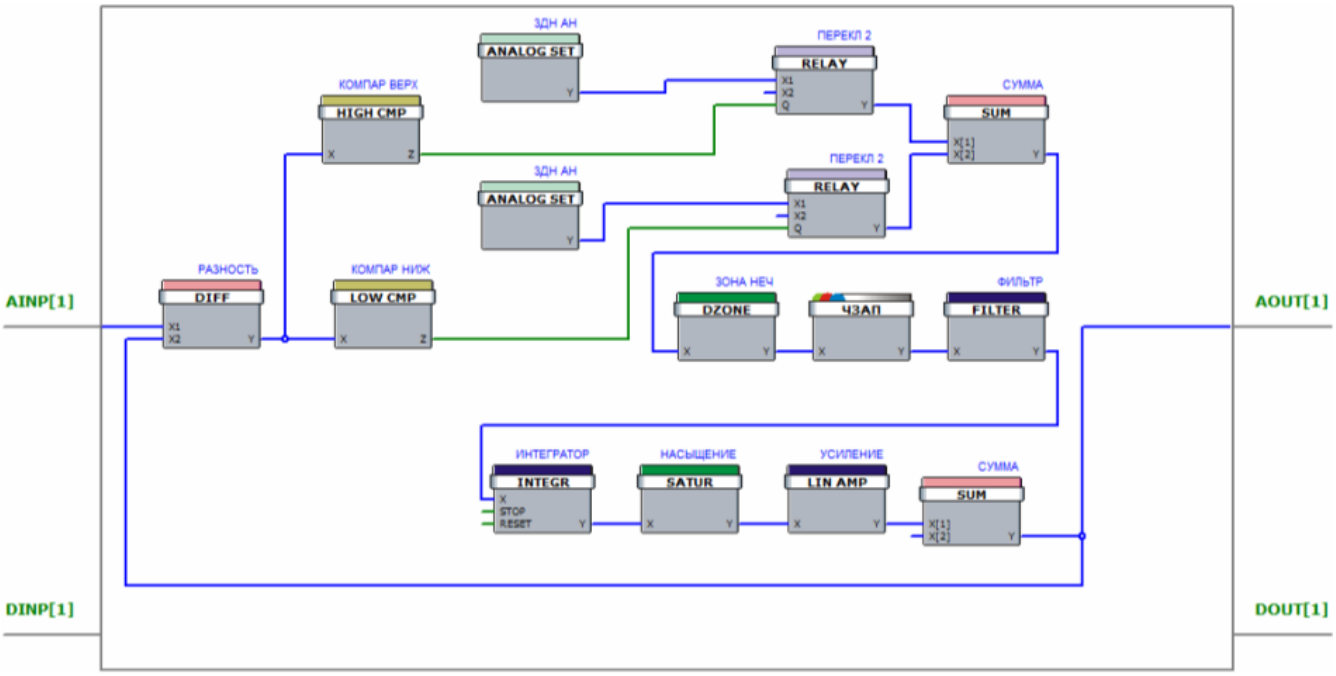

Fig. 5 – EIM imitating model of proportional action

Graphic results of imitating modeling of SAR are presented in fig. 6. The top window of the simulator displays dynamics of errors of regulation in each of three contours of SAR. In the lower window change, so-called, external impacts on the SAR models is shown (changing task by sine low and coordinate indignation). The worst results, as one would expect, correspond to the SAR model with the pulse regulator. To quoted at the beginning of the article "… the regulator is mainly loaded by "correcting" the influence of an executive link" difficult and to think up the best illustration: SAR actually shows the not working capacity. The pulse regulator hasn't mastered the astatic executive mechanism. He couldn't correct" influence of an executive link (at simultaneous and rather strong external impacts on SAR).

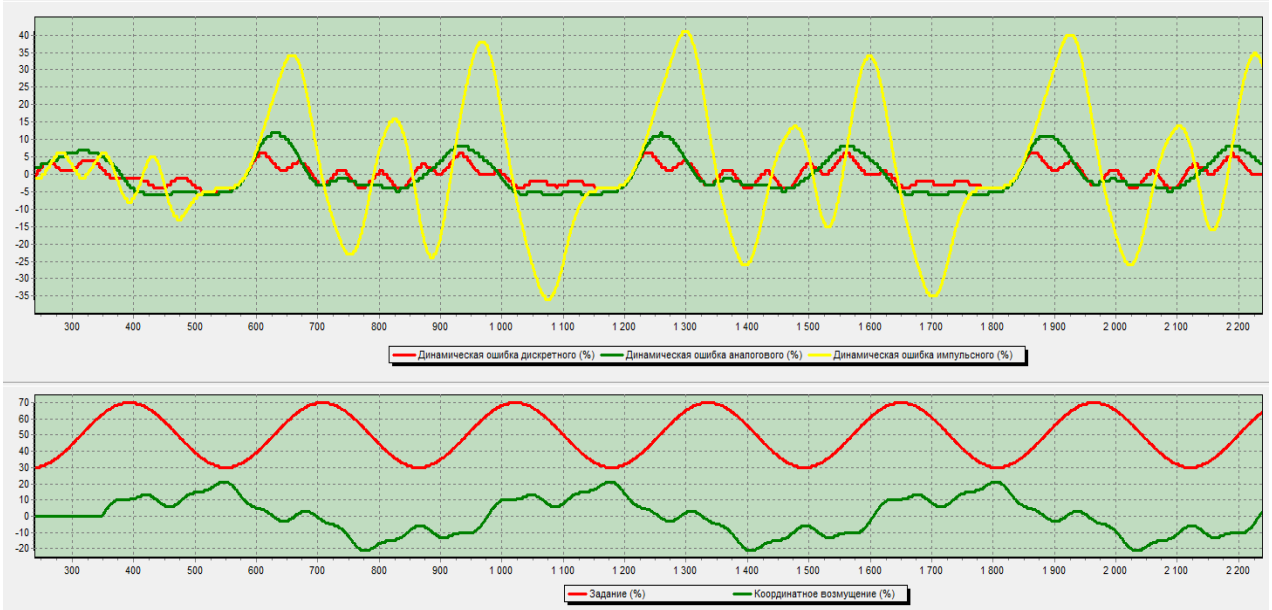

Fig. 6 – Graphic results of modeling of SAR

The best results of modeling correspond to SAR in which the discrete signal of management is used (are provided with setting up the program of a positioner).

Conclusion

Opinion that time of EIM of constant speed has passed – wrong.

It isn't necessary to hurry with replacement in real SAR EIM of constant speed (provided that size Tim is determined correctly). Moreover, there are strong reasons to recommend to put in the SAR projects such EIM, however with obligatory performance of a condition that **they have to be transformed to EIM of proportional action**. But this requirement is very easily feasible as all EIM are equipped with analog sensors of situation. And it means that in a software environment of the regulating controller it is possible to construct a positioner that allows to use the regulating software modules of its library in real SAR PID-analog, and also to use not classical technologies of formation of signals of control – a fuzzy logic, neural networks and their hybrids. **At the same time the control signal on an output of the industrial controller will be the discrete, having stopped being impulse.** Scoring from such decision is big. First, EIM slidings mode is softened ("rovings" of EIM disappear and, therefore, the longevity and faultlessness of SAR raises. Secondly, the high noise immunity of transmission channel of a signal of control of the controller inherent in impulse regulation remains. Thirdly, such "external" (in relation to EIM) the positioner, very easily implementable (and its structure, if necessary, can be considerable more difficult, for example, regarding filtering an input signal of the sensor EIM), allows to provide proportionality of action of EIM **of any power.** And it is very important! Fourthly, quality of regulation will be almost higher or, at least, same, as well as in option of EIM of proportional action with the positioners which are built in them (products, for example, than Siemens, Belimo). It is necessary to refer impossibility of modification of program structure of the positioners which are built in them to number of shortcomings of EIM of the specified producers. Besides, at them "nomenclature" of sizes of time of a full speed is very small. Therefore "binding" of such EIM in this parameter to features of a specific subject to regulation, to change of its characteristics is impossible.

It should be noted, at last, once again the low original cost of EIM of fixed speed, simplicity of their servicing and, so small costs in case of operation.

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