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ANALYTICAL REVIEW OF AUTOMATED STABILIZATION COMPLEXES

АНАЛІТИЧИЙ ОГЛЯД АВТОМАТИЗОВАНИХ КОМПЛЕКСІВ СТАБІЛІЗАЦІЇ

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Abstract. *The article provides an analytical overview of automated stabilization complexes, which systematizes the following principles of construction of modern stabilizers: by stabilization object, by the number of stabilization planes, by the type of measured coordinate, by the function of the gyroscope, by the type of executive drive, by the type of regulation, by the type of schematic technical performance.*

The principle of operation of the digital stabilization complex is explained using the functional and structural diagrams of the channel of the automated stabilization complex.

Key words: *stabilizer, stabilization complex.*

Introduction.

Precision automated stabilization complexes can be used in modern moving objects (MO), performing the functions of speeding up the search, determining the coordinates of moving objects in extreme conditions; surveillance of ground, air and surface targets. It is also promising to use automated stabilization complexes in aviation gravimetry for the exhibition of sensitivity axes of navigation sensitive elements (gravimeters).

The analysis of the instrument composition, structure and dynamic parameters of blocks of well-known automated digital stabilization complexes [1-5] showed that there are no reserves for increasing stabilization accuracy and speed. Therefore, the requirements for the accuracy of the means and methods of measuring the mechanical values of the stabilizers defined above have become much higher.

Achieving high accuracy of such complexes became possible thanks to the high quality of modern elements of gyroscopic technology and significant development of the theory of gyroscopic devices developed by A.N. Krylov, B.A. Bulgakov, O.Y. Ishlinskyi, Y.M. Roitenberg, S.S. Rivkin, Pavlov V.A., E.H. Popov, A.I. Lurie, V.V. Solodovnikov and etc. The theory of linear and nonlinear guidance systems was developed by V.V. Solodovnikov, B.K. Chemodanov, N.A. Lakota. The theory of digital tracking drives was developed by V.A. Besekersky, S.M. Fedorov. The theory of gyroscopic stabilization complexes was developed by M.A. Pavlovsky, D.Z. Pelpor, A.O. Odintsov, B.B. Samotokin, G.F. Bublyk, O.M. Bezvesilna, O.V. Zbrutsky, L.M. Ryzhkov, P.M. Bondar, S.S. Ryvkin, Y.N. Roitenberg, E.A. Fabrikant, P.I. Saidov. The theory of optimal control systems - by R. Bellman, V.G. Polyansky, R. Grammer, V.I. Gostiov, D.I. Yeskov and etc. [1-4].

However, there are not enough works in the literature devoted to the analytical review of modern automated stabilization complexes (SC), which would solve the problems of increasing their accuracy and speed.

Therefore, **the purpose of this article** is to conduct an analytical review of modern automated stabilization complexes, which have significantly greater accuracy and speed than the known ones.

A characteristic feature of the development of modern technology is the improvement of the technical characteristics of all instrument complexes that are part of the control system of the moving objects, including the SC.

This process is due to the transition to a digital element base, the use of new information sensors, new optical and electronic devices for surveying the terrain and the development of new schematic and technical solutions for the construction of equipment, which, in turn, increases the level of speed of the equipment and its maneuverability due to a higher level of control automation.

On the other hand, the requirements for accuracy and speed of stabilization complexes are constantly increasing, which requires their improvement.

At the same time, it is necessary to take into account that modern moving objects have significantly higher speeds, they are subject to significantly higher overloads and uncontrolled mechanical disturbances: shocks, vibrations (table 1 [1]).

Table 1 - Average parameters of oscillations of the moving objects body during movement at a speed of up to 20 km/h

Types of oscillations	Angular oscillations		
	Amplitude, degrees	Speed, °/s	Frequency, Hz
Longitudinal	2,5	8,25	1,1
Horizontal	1,2	1,6	0,6
Transverse	1,8	6.3	0,8

Therefore, the requirements for the accuracy of the means and methods of measuring the above-defined mechanical values of SC have become stricter.

Scientific and technical progress in the field of automated SC requires the improvement of the components of the elemental base of SC, the use of modern digital devices for measuring angular velocities to improve the tactical and technical characteristics of SC, which should replace analog modifications.

In many scientific publications [1-3], separate directions of the principles of construction of SC are given. To understand the principles of construction, we present the main principles of their classification (Figure 1):

1) by object of stabilization:
- stabilizers of the main devices,
- stabilizers of additional devices,
- stabilizers of special devices;

2) by the number of stabilization planes:
– single-plane (stabilizers only in one, as a rule, vertical plane),
– two-plane (stabilizers in two vertical and horizontal planes),
– three-plane (stabilizers in the vertical, horizontal and roll angles);

3) by type of measured coordinate:
– positional (stabilizers of this type remember the given position (position) and measure the angular deviation of the horizontal and vertical channels from the given position with gyroscopic angle sensors);

4) by gyroscope function:
– force (with a stabilizing moment necessary to stabilize the object),
– indicator (with a gyroscopic device that performs the function of a deviation indicator),
– high-speed (stabilizers of this type measure only the absolute angular velocity of the moving objects being stabilized using a gyroscopic absolute angular velocity sensor – a gyrotachometer);

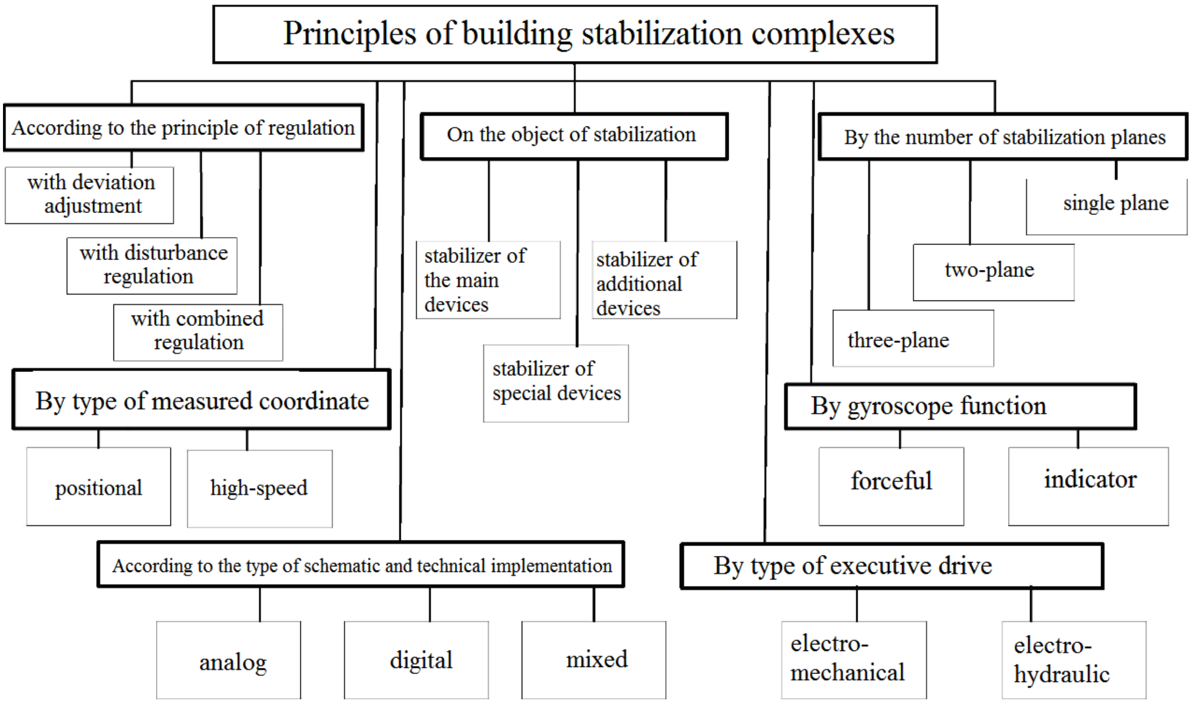

Figure 1 - Classification of automated SC

5) by type of executive drive:
– electric machines (with a stabilizing moment created by an electric motor),
– hydraulic (use a stabilizing moment that creates a hydraulic drive);

6) by type of regulation:
– by deviation,
– by perturbation,
– combined;

7) according to the type of scheme – technical execution:
– analog (made on transistors, resistors, diodes),
– digital (built on digital microprocessors with the possibility of

reprogramming without hardware modification of the equipment),
– combined (in which there are digital and analog circuit elements).

In addition, there is a separate type – field of vision stabilizers, which are divided into stabilizers with:

- joint stabilization (or "dependent"), in which the unit being stabilized is connected (rigidly or through kinematics) to the terrain observation device,
- autonomous stabilization (or "independent"). In them, a device with a stabilized field of view (SFV) or a stabilized line of sight (SLS) is introduced into the product management system (PMS).

Stabilizers, as objects of automatic regulation [3,4], are built according to the classical scheme, which includes the object of regulation and the regulator (Figure 2).

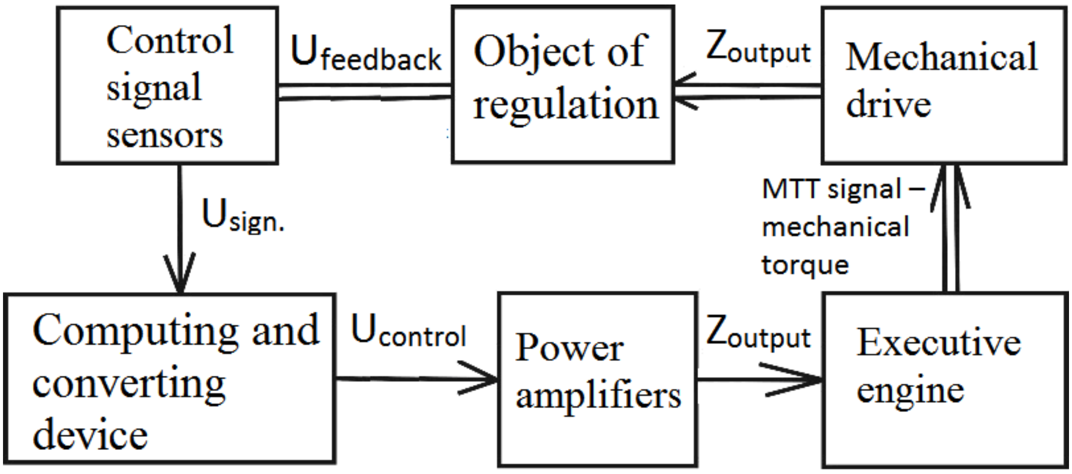

Figure 2 - Schematic diagram of the channel of the automated stabilization complex

Based on the scheme in Figure 2, let's consider how the main elements of this scheme are reflected in the schematic diagram of the digital SC (Figure 3).

Signal $U_{sign.}$ – signal from information sensors for the automated stabilization complex. This is the signal from the angular velocity sensors on the vertical guidance channel AVS-VG (GT46) and from the AVS-HG (GT46-01) on the horizontal guidance channel.

Signal $U_{control}$ – control signal from the stabilizer computer. This is a signal from the BU1022-04 control unit (Figure 3), which is sent to the BKD14-02 GN (VN) engine control units.

Signal Z_{output} – signal at the engine input. This is the signal coming from the BKD14-02 to the EDM20M GN(VN) engines.

MTT signal – mechanical torque transmitted from the engine shaft to the mechanical drive – turning mechanism (elevating mechanism) to eliminate the angle between the set position and the current position of the stabilization object.

The $U_{feedback}$ signal is a current or voltage feedback signal. Both current and voltage signals are used simultaneously in the stabilizer (Figure 3).

It follows from the above that the regulator is a complex of devices, sensors and mechanisms that works according to a given program and automatically compensates for mechanical effects on the moving objects. Moving objects regulation is a mechanism (unit of guidance on the vertical guidance channel and unit of guidance on the hortzontal guidance channel) in which the initial characteristics of the outputs are constantly adjusted.

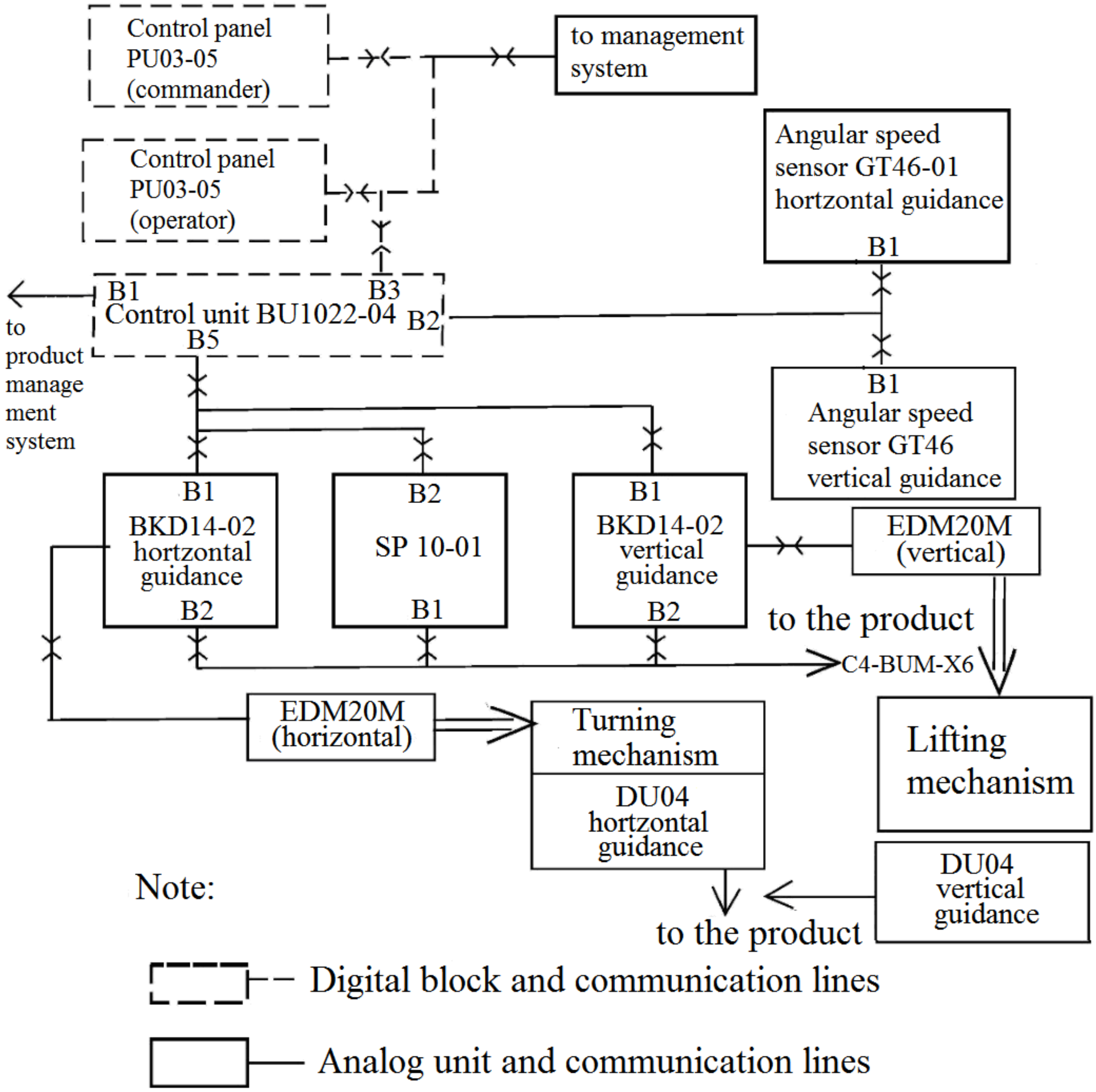

Figure 3 - Schematic diagram of a digital SC

Conclusions: on the basis of the above, we can say that a detailed analysis and classification of automated stabilization complexes has been carried out and the principles of modern stabilizer construction have been systematized. The principle of operation of the digital stabilization complex is explained using the basic functional and structural diagrams of the channel of the automated stabilization complex.

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Анотація. *У статі наведено аналітичний огляд автоматизованих комплексів стабілізації, який систематизує наступні принципи побудови сучасних стабілізаторів: за об'єктом стабілізації, за кількістю площині стабілізації, за видом вимірюваної координати, за функцією гіроскопа, по типу виконавчого приводу, по типу регулювання, по типу схемо-технічного виконання.*

Викладено принцип дії цифрового комплексу стабілізації за допомогою функціональної і структурної схем каналу автоматизованого комплексу стабілізації.

Ключові слова: *стабілізатор, комплекс стабілізації.*

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