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ACTIVE VIBRATION ISOLATION AND POINTING SYSTEM FOR HIGH-PRECISION LARGE DEPLOYABLE SPACE ANTENNAS

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Abstract. *The paper is concerned with the problem of providing required precision parameters of high-precision large deployable space antennas (HLDSA) small stiffness of antennas entails its high sensitivity to microdinamical factors arising in the orbital flight. To provide necessary precision of geometrical characteristics, one have either to diminish microdinamical factors or to implement active or passive vibration protection systems.*
In this paper we concentrate on the second problem. Detailed analysis has shown that, in condition of orbital flight, the precision parameters of HLDSA mainly depend on low-frequency vibration with frequencies from 0,01 Hz to 10 Hz and with acceleration magnitude from 0,6 to $10^{-4} \div 10^{-6}$ *g. This low frequency vibration is usually induced by external and internal perturbations. Since the passive vibroprotection is ineffective for low-frequency vibration, we decide to solwe the problem with help of active vibroprotection systems.*
Comparative analysis of existing and perspective facilities of active vibration isolation with regards to HLDSA structural features has proved the effectiveness of active vibroisolation of "the kinematic type". In this systems an object is attached to the base with actuators controlling relative position and velosities of the object and of the base via the information from sensors.
External perturbations leading to reduction of the precision characteristics may also include structural thermo-deformation. As a result, the antenna's optical axle deviates from its theoretical position. This requires its periodic high-precision pointing (up to 1 second of arc) in the real-time mode.
We present the concepts of the active system of structural control that provides:
1) *vibration isolation of spacecraft from elastic oscillations of HLDSA, which were caused by its opening on orbit;*
2) *suppression of oscillations of elastic structure of HLDSA, which were caused by its opening and external factors;*

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3) *vibroisolation of the structure from microdinamical effects caused by the functionning of the spacecraft systems;*
4) *periodic high-precision angular pointing of the HLDSA optical axis.*

Problem of granting of required precision characteristics of geometry high-precision large deployable space antennas (HLDSA), distinguishing, as a rule, small acerbity and as an effect, sensitivity of microdinamics influences in condition of orbital flight, is actual. Possibilities of deciding this problem are involved on the one hand - with reducing of the microdynamics influences on the HLDSA and spacecraft from external and internal outraging are factors, on the other hand - with using of active and passive facilities vibration isolation the HLDSA and spacecraft in conditions of using in the regime of real time [1].

Reduction of the microdynamics influences on the HLDSA and spacecraft from external and internal outraging factors is guaranteed by corresponding develop-technological deciding and the organizing actions on all stages of designing, making and using HLDSA and spacecraft and in this reporting is not considered.

Conducted analysis has shown that in conditions of orbital flight essential influence on the precision characteristics of geometry HLDSA render low-frequency the oscillations in the range of frequencies from 0,01 to 10 Hz and amplitudes from 0,6 to $10^{-4}\ldots10^{-6}$ g from the rest microacceleration, causing by the action external and internal outraging factors. In this connection, using in the system of vibration isolation of HLDSA passive facilities - ineffective but decision of this problem possible by means of active facilities of vibration isolation only.

Comparative analysis of existing and perspective facilities of the active vibration isolation with provision of particularities of HLDSA vibration isolation has shown that the most effective - the active vibration isolation systems of "kinematic" type, in which communication of object with base are hard mechanisms, controlling relative position of object and base by information from sensors of relative positions and speed of object and base.

External outraging factors, leading to reduction of the precision characteristics of HLDSA geometry consist of also thermodeformation of form structure, arising from its nonuniform heating in conditions of cosmos. In consequence real optical axle HLDSA coinciding with the diagram of direction, some move asides from different is swayed away theoretical and is required its periodic high-precision pointing (to 1 angular second) in the necessary direction in the regime of real time.

Presented conception of system of active vibration isolation and pointing (SAVIP) HLDSA, which secures:

1) vibration isolation of spacecraft from elastic oscillations of HLDSA, which were caused by its opening on orbit;
2) suppression of oscillations of elastic structure of HLDSA, which were caused by its opening and external factors;
3) vibration isolation of structure of HLDSA from microdynamics influences, which were caused by the work systems spacecraft in the process of using;
4) periodic high-precision angular pointing optical axle of HLDSA.

Offered conception SAVIP may be realized, for example, in space radio telescope (SRT) (Fig. 1).

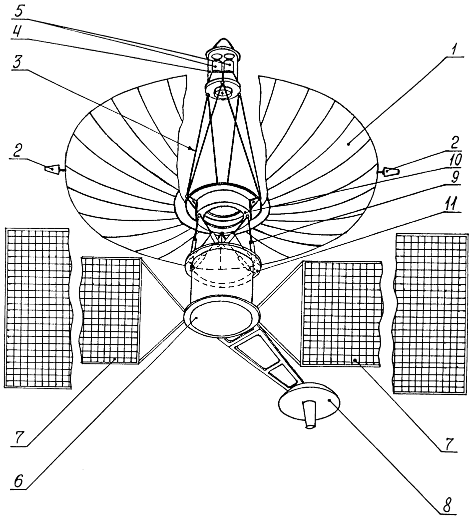

Fig. 1

In addition, the construction SRT and spacecraft have elastic elements, which have small rigidity and concentrated masss. The elements require vibration isolation from insignificant oscillations. SRT consist of HLDSA 1 with small – directed antennas 2 and support system 3. The system 3 supports focal block 4 and star transmitters 5. SRT was established on supporting construction 6 spacecraft by transition truss 9. This construction has solar power arrays 7 and TM – antenna 8. The platform 10 and the base 11 of transition truss 9 regidly append to knots of interface SRT and supporting construction 6.

Executive organ of SAVIP presents the platform of Stewart's [2] and is installed between HLDSA and spacecraft and sends by the switching wires off mechanical start loadings in the process of disappearing of spacecraft by the rockets-carrier of on tasking orbit, combining own base functions with functions of transition truss 9 of spacecraft. Stewart's platform (Fig. 2) was accomplished as l-coordinate manipulator [3]. The platform provides six degrees of freedom to output link (platform 1) with high-precision angular pointing with respect to the base 2. Platform 1 and base 2 are linked by closed kinematic chain. Each connective link of the chain has line drive 3 and two spherical kinematic pairs 4 with constraint from rotation of connective link with respect to lengthwise axis or combinations of kinematic pairs, which are equivalent to its, which provide relevant number of degrees of freedom. Coordinating work drives of platform of Stewart's guarantees six degrees of freedom and corresponding spacing vibration isolation, and also possibility angular pointing of HLDSA.

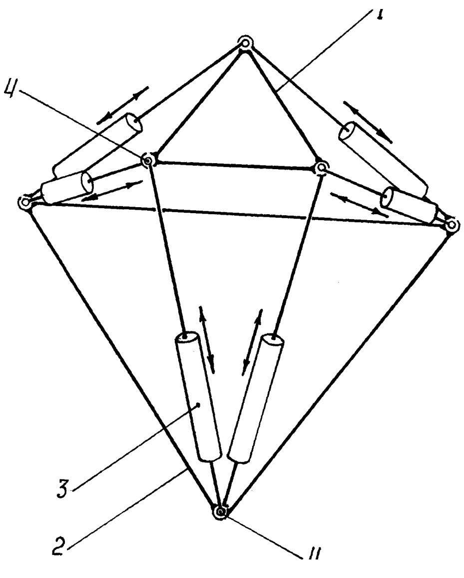

Fig 2.

The control of SAVIP SRT is realized from neurocomputer. High-precision angular pointing HLDSA is realised by star transmitter 5 (Fig. 1). Realized in SAVIP special software-mathematical granting guarantees a mode of performing the problems a real-time, as well as possibility to process vector information from sensors of by the way parallel data processing, organized in the base of an neural network processor and shaping the facilities and using a knowledgebase.

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AKTIVNA VIBRACIONA IZOLACIJA I SISTEM PRECIZNOG USMERAVANJA ZA VELIKE RASKLOPNE ORBITALNE ANTENE

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Ovaj rad se bavi problemom obezbeđenja parametara preciznosti za visoko precizne rasklopive orbitalne antene (HLDSA). Mala krutost antene ukazuje na visoku osetljivost na mikrodinamičke uticaje u orbiti. U cilju obezbeđenja preciznosti geometrijskih karakteristika, potrebno je da se umanje mikrodinamički uticaji ili da se ugrade aktivni ili pasivni sistemi zaštite od vibracija. U ovom radu mi smo se usredsredili na drugo rešenje. Detaljne analize su pokazale da u uslovima orbitalnog leta parametri preciznosti za HLDSA uglavnom zavise od nisko-frekventnih vibracija od 0,01 Hz do 10 Hz sa ubrzanjem od 10^4 do 10^6 g. Ove niskofrekventne vibracije su obično izazvane eksternim i internim perturbacijama. Pošto je pasivna vibro-zaštita neefektivna za nisko-frekventne vibracije, mi smo se odlučili da problem rešimo pomoću sistema krute vibro-zaštite.