Paper ID: 17547
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MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures - Dynamics and Microdynamics (3)

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A.M.LYAPUNOV METHODOLOGY IN MODELLING DYNAMICS OF GYROSCOPIC STABILIZATION AND ORIENTATION SYSTEMS

Abstract

This work is devoted to specific problems of avia-, aerospace systems, with reference to problems of mathematical modelling, analysis and synthesis for systems of stabilization and orientation with gyroscopic controlling elements (with using two-degrees gyroscopes). The research is developing the reduction principle, solving the decomposition problem for such systems by elaborated approach, with dividing original system on the subsystems of different times scales. Nonlinearity, high dimensionality, multi-connectivity are causing the difficulties in obtaining solution by analytical and analytic-computer methods, in designing and control. It leads to the necessity of simplifying of original model, with the revealing of main freedom degrees of system, with subsequent transition to decomposed systems, to reduced submodels with idealized physical properties. These problems are important both for general fundamental theory and for engineering applications; it is connected with the working-out of systematical methods for constructing correct reduced models and for determining acceptability domains in engineering practice. In regard to peculiarities of stabilization and orientation systems with gyroscopic controlling elements, it leads to complex singularly perturbed problems, with different singularities types, with critical cases, with nonlinear singular generating systems as reduced systems. The principal questions: the scientific methodology of reduction-decomposition for stability problems; the substantiation of reduced models in dynamics and control problems; the determination of conditions for qualitative equivalence and correctness of reduced models. Here formulated problems are solved by strong method, based on stability theory ideology. General approach of A.M.Lyapunov, N.G.Chetayev is extended here. The understanding of these problems via singularly perturbed systems points gives new ideology of perspective results. Developed method gives the efficient algorithm for modelling complex multidisciplinary systems. The constructiveness of this approach is illustrated on concrete examples (systems of one-axis gyrostabilization, bi-axis gyrostabilization, ...). New results are revealed: considered systems in cases with small satellites and big stabilized objects (space stations) should be treated from different classes points; for ones different conditions should be required for positive solving decomposition problem. Two principal tenets (stability postulate and singularity postulate) are accepted here as fundamental axioms. It allows to establish strong methodical aspects for modelling dynamics and decomposition of spatially developed mechanical space systems, including space manipulators (multiple-link mechanisms),with dividing on different channels of control in nonlinear statements. Advanced approach, worked out here, is generalizing the classical results (A.H.Nayfeh, L.K.Kuzmina, A.A.Voronov, A.Yu.Ishlinskiy, B.V.Raushenbakh ...), with revealing minimal approximate models (on N.N.Moiseev).