Chapter 40
Automated System of Stabilization and Position Control of Aviation Equipment

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ABSTRACT

In this chapter, the author presents the problems of design of the robust automated system for stabilization and control of platforms with aircraft observation equipment. The mathematical model of the triaxial stabilized platform is developed. The procedure of synthesis of robust stabilization system based on robust structural synthesis is represented. The above-mentioned procedure uses loop-shaping approach and method of the mixed sensitivity. The matrix weighting transfer functions are obtained. The optimization programs in MatLab are developed. The developed procedures are approved based on the results of simulation by means of the appropriate Simulink model. The obtained results can be useful for unmanned aerial vehicles and aircraft of special aviation, which are used for monitoring technical objects and aerial photography. The technical contributions are procedures of the robust controller design represented as the flowchart. The proposed approach is validated by application of the theoretical suppositions to the concrete example and appropriate simulation results.

INTRODUCTION

The motivation of the proposed work is to fill gaps in solving conflict requirements such as accuracy and robustness to the aviation automated systems of stabilization of systems with observation equipment.

Nowadays the robust control is widely used in the design of automated aviation systems. Such an approach is well studied and widespread in the design of aircraft control systems. A novelty of the presented research is the application of the known methodology of design of the robust automated control systems in a new area such as the development of inertially stabilized gimballed platforms operated on aircraft. Respectively, the new type of moving vehicle (platform) and the new area of the application (inertial stabilization) require new special researches. The new mathematical models and design procedures

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based on the H_∞-method including loop-shaping and method of mixed sensitivity, which is given in this chapter, present the theoretical contributions. The technical contribution is an improvement of accuracy of observation processes, which take place on aircraft during mapping, monitoring of terrain and so on.

The necessity to provide stabilization of airborne observation equipment is one of the important problems of modern aviation. The typical observation equipment operated on modern unmanned aerial vehicles (UAVs) and special aircraft includes television camera, digital camera, and laser scanner. Above listed types of observation equipment allow solving problems cartography and aerial survey by means of the digital photogrammetry and aerial photography using television camera of the high resolution. The cartographic survey can be implemented by means of the laser scanner. Using of these devices provides development of the relief model by means of sending laser impulses and analysis of reflected signals. The high quality of an image can be achieved by means of the system for stabilization and control of orientation by line-of-sights of observation devices. These devices are mounted on UAVs and aircraft of special aviation to provide a solution of observation problems.

Functioning of observation equipment operated on UAVs and aircraft of special aviation is accompanied with parametric and coordinate disturbances. First of all, these disturbances are caused by object aerodynamics and the influence of wind. The modern trend of the design of stabilization systems operated in difficult conditions of real operation is using of robust control. Such an approach provides stabilization of observation equipment in conditions of aircraft angular motion caused by various disturbances.

It should be noted that approaches to robust control of aircraft motion are well developed and widely used in modern aviation. Robust control of systems, which carry out functions of observation equipment stabilization, has some features defined by a type of the vehicle, on which the observation equipment is mounted, and operating conditions (Sushchenko & and Tunik, 2013). So, development of procedures for the design of an automated system for stabilization of observation equipment is a very important and urgent problem of the modern aviation.

The main goal of the design of robust automated systems lies in a search of the control law, which can provide accuracy of stabilization in some given range under conditions of uncertainty. This uncertainty can be caused by many factors such as external disturbances, inaccuracy of the mathematical model and unmodeled dynamics.

The objective of the proposed work is to develop the design procedure of the discrete robust automated stabilization system, which implements an increase of quality of observation processes on the board of an aircraft.

REVIEW OF PREVIOUS LITERATURE

The main directions of the design of inertially stabilized platforms are given in (Hilkert, 2008). The problems of robust control are not mentioned in this publication although robustness is very important for aviation inertially stabilized platforms, which function in difficult conditions of real operation. The features of the design of aviation robust automated stabilization system depend significantly on the type of the researched vehicle. For example, papers (N. Wu & J. Yu. 2018) and (S. Kim, S. Cho & H. Him at all, 2018) are dealt with such different moving vehicles as the hypersonic vehicle and multirotor respectively.

It should be noticed that principles of the design of aviation automated control systems differ significantly for such objects as aircraft and moving platforms with a payload of the different type. For example, procedures of the design of the marine robust inertial platforms with navigation measuring

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