AUTOMATIC CONTROL SYSTEMS

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MEASUREMENT SYSTEM OF LOW-ALTITUDE FLIGHT UNMANNED AERIAL VEHICLE

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Abstract. *The necessity of creating automatic control unmanned aerial vehicle low altitude flight is substantiated. Brief analyses existing means of measurement of geometric altitude of the aircraft is given. The principle of action capacitive transducer with open inhomogeneous field and its characteristic properties are considered. Analyzes the characteristics of the geometric capacitance meter altitude are given. The results of experimental and theoretical investigations of the characteristics of a capacitive transducer are showed. The systems of electrode capacitance meter height are proposed.*

Keywords: low-altitude flight; the geometric height; capacitive measuring of height.

Introduction

Review and analysis of unmanned aerial vehicle (UAV) shows that the vast majority of problems solved UAVs, (completing in mode) made during a low-altitude flight. Unmanned aerial vehicle flight control, usually by the operator remotely. Estimation of flight parameters is performed visually. The probability of mistakes is high enough by the lack of information about the parameters of the flight and the inertia operator actions. Obvious need for the introduction of automatic flight control UAVs.

Statement of the problem

One of the essential factors for the implementation of the system is the information about the true (geometric) altitude. A brief overview of modern avionics aircraft shows that the most common gauges are true altitude radio altimeters. At present, foreign aircraft are widely used laser altimeters. In these devices, the method of the location is used, which is having the following disadvantages. Quality of the information signal essentially independent from the shape and properties of the reflective surface. Typically, the reflected signal is noisy enough. To obtain useful information acceptable accuracy is necessary filtering the signal and its corresponding treatment. This leads to a delay of the useful signal, which can be unacceptable. Besides, the measurement error increases with decreasing altitude.

According to the author, more acceptable means of obtaining information about the height is an electrical capacitance way to measure the height. In this device uses dependence of capacitance between planar capacitor plates disposed on approaching them a conductive surface (land, water, etc.). The approximations of the earth's surface call the capacitance increases. This property is a capacitive transducer significantly increases the accuracy of the measurement of geometric altitude. Thus, measurement of altitude capacitance method is to measure the capacitance between the receiving and emitting electrode capacitance transducer in the form of plates mounted on the surface of the aircraft.

Search for solutions

Interelectrode capacitance of the capacitive transducer has a very small value. Methods for measuring ultra small described in [1; 2]. There are some descriptions analog circuits and devices implementing these methods. Unlike radar techniques, the capacitive method of measuring the height gives the integral estimation of height. If on way of the UAV will appear separate projecting above the terrain object (hump, failure, forest), this will change the configuration of the electromagnetic field of a capacitive transducer and will provide proactive information on changing terrain.

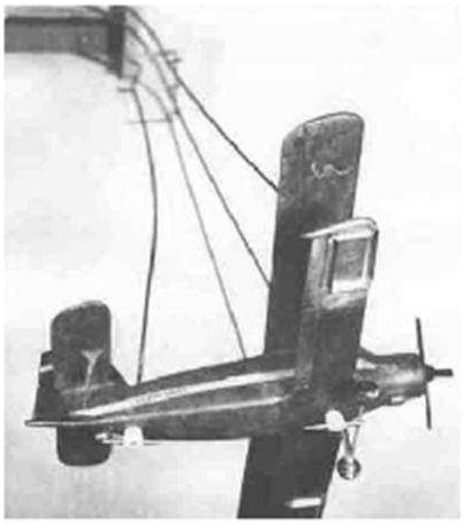
This is called to the following properties. The electromagnetic field of a capacitive transducer interacts with the Earth's surface at a certain spot, which gives an integrated assessment of the relief within the area of the spot interaction

Experimental studies on a scale model of the An-2 (fig. 1, *a*) showed that the low-altitude meter, built on the capacitive principle of operation is efficient and can be broadly applied. The results of the first test flight on an An-2 proved the applicability of the method of measurement of the capacitive low-altitude flight. However, the static characteristics of the meter had mixed views. (fig. 1, *b*).

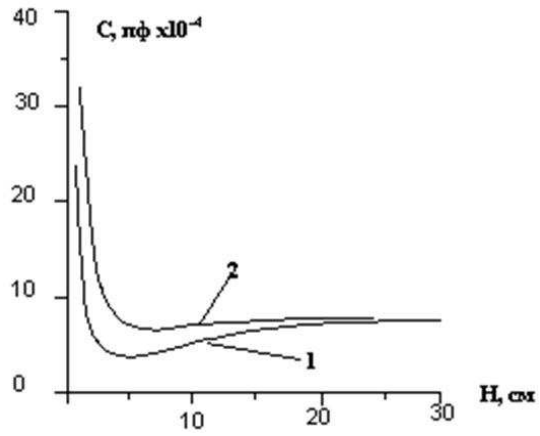
Character change is determined by the sizes of the electrodes capacitance altimeter and their relative positioning on the surface of the body of the aircraft. The electrode system and given potentials form the

electromagnetic field of a certain configuration, parameters behavior is approaching the Earth's surface and determines the character of the information capacity of the height.

For elucidation the mechanism of interaction of electromagnetic fields meter with the Earth's surface, finding ways to create the desired straightforward static characteristics performed a study that was carried out by means of mathematical modeling of the electrostatic field meter [3].



a



b

Fig. 1. *a* – Large-scale physical model of the An-2 (M 1:50); *b* – Dependence of the inter-electrode capacitance of the height above the sample surface: 1 – sheet metal; 2 – wet sand

Mathematic modeling is completed with of several variants of placement elements of an electrode system. Most revealing in the sense of the uniqueness of the static characteristic was emitting electrode placement on the top surface of the wing. As can be seen from the graph (fig. 2), is obtained the simple static characteristic.

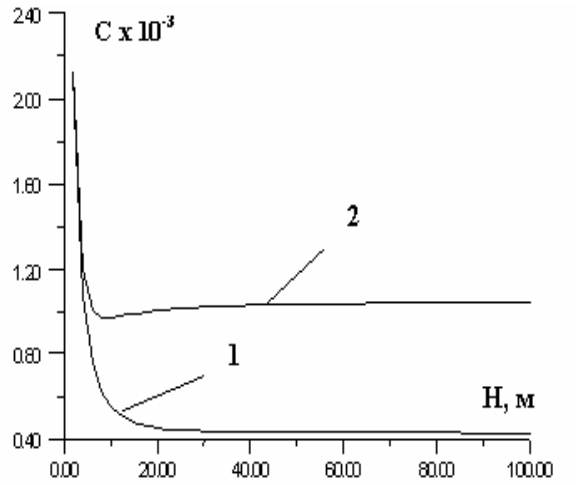


Fig. 2. Static characteristics of the meter to the upper (1) and lower (2) the placement of the radiating (high potential) electrodes

Development of an electrodes system capacitive transducer

For stabilization of the geometric altitude of the UAV is suggested to use an electrode system with a receiving electrode, which is placed middle bottom of the fuselage, and four radiating electrodes that are placed on wings and front and rear surfaces of the fuselage. In order to obtain the unique characteristics of the emitters are located on the upper surfaces of the body and wing UAV (fig. 3).

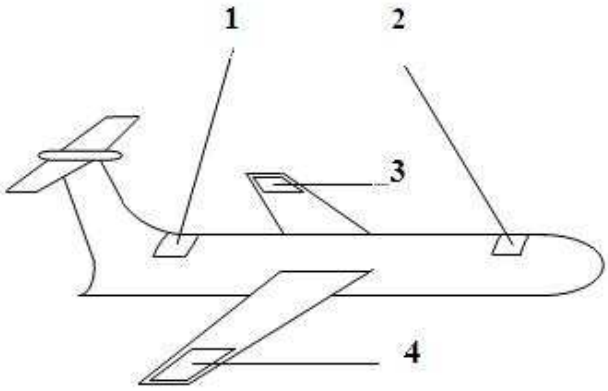


Fig. 3. Placement of electrodes on the body of the UAV: 1, 2 – longitudinal high-potential electrodes (HPE); 3, 4 – Cross HPE Vehicle

Structure of the control system

The structure of the stabilization system of geometric altitude UAV is developed. Capacitive measuring geometric altitude (CMA) outputs a signal in accordance with a static characteristic of the particular system of electrodes placed on the body of the UAV. To use the well-known standard structures stabilize the geometric altitude must be entered into the system unit linearization characteristics CMA. This can be realized digital system unit. In the

memory block is entered static characteristic CMA, placed on the UAV. Input data are determined experimentally. The input signal is digitized by the analog-to-digital converter and then processed according to the entered program. On the way out get a signal corresponding to the measured geometric height. The output signal for introducing it into the control system is converted into analog by the digital-to-analog converter. Designed digital unit is introduced into the set point height – corrector. The process of stabilization height is performed on the previous known algorithm.

The complexity of managing the UAV landing on the third phase is mainly determined by the fact that the touchdown should occur with minor deviations from the desired touchdown (especially in the lateral direction), with a small vertical velocity and with almost zero values of roll and deviation from the set course. When controlling the lateral movement and the crosswind at the end of the second phase the aircraft may have a significant roll angle and yaw. Therefore the objective of the system of lateral movement in the air landing phase of flight, above all, should be in alignment with the runway at the corners of the course and roll. Since the cross-wind in this case will take down the aircraft, the alignment should be possible to lower altitude just before landing. Recommended height of lateral movement of the UAV on the third phase consists of 5 ... 1m. The main task of the control system for the longitudinal motion of the air trajectory third phase is the alignment of the pitch. The variety of control laws in the alignment are used, as well themselves trajectory alignment.

Conclusions

The implementation of the automatic control low-level flight, the UAV will significantly expand their scope and reduce the cost of production.

References

1. *Hrynevych F. B., Grokholsky A. L., Sobolewsky K. M., Tsapenko M. P.* 1970. Transformer measuring bridges, ed. Karandeev K. B, Moscow, Energy. 280 p. (in Russian).

2. *Hrynevych F. B., Novik F. I.* 1987. Measuring compensatory and bridge devices with capacitive sensors. Kyiv. Naukova Dumka. 112 p. (in Russian).

3. *Kozlov A. P.* 2002. Control low altitude flying aircraft with capacitive transducers, dis. Candidate tehn. sciences: NAU, Kyiv. 151 p. (in Russian).

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А. П. Козлов. Система вимірювання на малих висотах польоту безпілотного літального апарата

Обґрунтовано необхідність створення системи автоматичного управління низьковисотним польотом безпілотного літального апарата. Наведено короткий аналіз існуючих засобів вимірювання геометричної висоти польоту літального апарату. Розглянуто принцип дії ємнісних перетворювачів з відкритим неоднорідним полем і його характерні властивості. Проаналізовано характеристики ємнісного вимірювача геометричної висоти польоту. Наведено результати експериментальних і теоретичних досліджень характеристик ємнісного датчика. Запропоновано систему електродів ємнісного вимірювача геометричної висоти для системи автоматичного управління низьковисотним польотом безпілотного літального апарата.

Ключові слова: політ на малій висоті; геометрична висота; ємнісний вимірювач висоти.

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Напрямок наукової діяльності: ємнісні перетворювачі з неоднорідним електромагнітним полем, ємнісні прилади вимірювання геометричних параметрів маловисотного польоту повітряного судна, використання ємнісних перетворювачів у системах автоматичного керування маловисотним польотом повітряного судна.
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А. П. Козлов. Система измерения на малых высотах полета беспилотного летательного аппарата
Обоснована необходимость создания системы автоматического управления низковысотным полетом беспилотного летательного аппарата. Приведен краткий анализ существующих средств измерения геометрической высоты полета летательного аппарата. Рассмотрен принцип действия емкостных преобразователей с открытым неоднородным полем и его характерные свойства. Проанализированны характеристики емкостного измерителя геометрической высоты полета. Приведены результаты экспериментальных и теоретических исследований характеристик емкостного датчика. Предложена система электродов емкостного измерителя геометрической высоты для системы автоматического управления низковысотным полетом беспилотного летательного аппарата.
Ключевые слова: полет на низкой высоте; геометрическая висота; емкостной измеритель высоты.

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Направление научной деятельности: емкостные преобразователи с неоднородным электромагнитным полем, емкостные устройства измерения геометрических параметров маловысотного полета воздушного судна, использование емкостных преобразователей в системах автоматического управления маловысотным полетом воздушного судна.
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