Remote diagnostic capability of aircraft special equipment

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Abstract. The article presents the methods of remote diagnostics of special aircraft equipment. The methods of remote diagnostics used on aircraft are analyzed. Based on an analysis it is proposed to create a new method of remote diagnostics of special equipment of aircraft.

Currently, avionics is one of the main aircraft navigation systems for aircraft. Avionics refers to the entire complex of electronic equipment that is installed on board aircraft. The basic elements of electronic equipment are navigation, communication and control systems. As for the control equipment, it is a very large number of systems, ranging from searchlights to modern radars. [1]

Equipment for aircraft control:

- navigation system;
- display system;
- communication system;
- flight control system of FCS type;
- The system responsible for collision prevention in the air, type TCAS;
- general control system;
- meteorological surveillance equipment;
- equipment to record all flight parameters. These are in-flight recorders and controls.

Onboard equipment is a set of functionally connected systems, devices, sensors, computing devices. Examples of on-board equipment complexes are pilotage, navigation, radio and data communications, power supply system, etc. [2]

One of the main aircraft systems installed on board is special equipment (avionics). The composition of avionics is different for different aircraft classes and represents the following groups:

- primary information systems,
- radio navigation systems,
- radio communications systems,
- automatic piloting systems,
- board information systems,
- other piloting and navigation systems.
The main feature of modern avionics is a completely new architecture of electrics, first of all avionics. The aircraft is equipped with a new automated flight stabilization system in turbulence conditions.

Nowadays, it is important to determine the state of avionics so that it can be used properly. At the same time, it is necessary to have diagnostic systems. That is why foreign developers of aviation equipment currently offer various remote diagnostic systems for special aircraft equipment.

The main feature of modern aircraft is the new architecture of avionics, which is equipped with an automated system of flight stabilization in conditions of turbulence, as well as a complex of electric remote control (fly-by-wire). The cockpit differs considerably from analogues of the previous generation, where the interface represents five large multifunctional liquid crystal (LC) displays, as well as two indicators on the windshield (IW) - the display is already in basic configuration. [3]

From all the variety of avionics, the following main groups can be distinguished, each of which is characterized by a specific functional purpose.

Electrical equipment (power supply system) provides generation of electricity and its distribution among consumers. Electrical equipment includes electric power sources and converters, power supply system, lighting equipment and electric drive.

The radio coherent equipment provides bilateral external and internal communication. For bilateral external communication with planes and land stations it is used short-wave radio stations. Their prominent features are: high stability of communication and remote control by stations. Intraplane communication between crewmen and information transfer to passengers which provided with plane trunk-call and loud-speaking devices.

The avionics systems include radio communications equipment designed for transmitting and receiving information. With the help of this equipment is carried out inside - aircraft communication between the crew members, two-way radio communication between the crew and the flight manager (airport traffic control dispatcher), as well as between crews of individual aircraft. Radio communication equipment is used practically at all stages of the flight and during the aircraft movement on the flight field. [4], [5]

A distinction is made between simplex, duplex and half duplex methods of communication between correspondents. In simplex communication, messages are transmitted alternately in the forward and reverse directions (i.e. messages are transmitted alternately by the correspondents). In case of duplex communication, it is possible to transmit messages in forward and reverse directions simultaneously. For this purpose, independent forward and reverse communication channels are included in the communication system. In half-duplex communication, independent forward and reverse channels are also organized, but messages are transferred through them alternately, just as simplex mode of operation is implemented.

Depending on the flight distance, two types of radio communications are different: near and far.

For short-range radio communications the CF range (with frequencies 100-150 MHz) and the DCMV range (with frequencies 320-440 MHz) are used.

For long-distance radio communications, the GCMV (with frequencies of 0.3 - 1.5 MHz) and DCMV (with frequencies of 3-30 MHz) bands are used. Such use of wave bands is conditioned by the conditions of radio wave propagation.

Depending on the applied wavelength range, the stable communication range for MV and DCMV ranges depends on the lifting height of the antennas (at 10 km lifting height, communication range - up to 400 km); for DCMV range - communication range limit - 2000 - 6000 km.

The radio station providing close communication is called command radio. A radio station providing long-distance communication is called a liaison radio. In addition to communication and command stations, there are also emergency and retransmission radios.

Radio communication equipment of the Armed Forces is characterized by a number of parameters: frequency range, number of communication channels, frequency difference between channels, receiver sensitivity, power and others.

The operating frequency range is the area of radio frequencies within which a radio station can be tuned up smoothly or discretely.
Sensitivity is the minimum EMF at the radio’s input, which ensures normal operation of the terminal unit. Sensitivity is measured in microvolts and characterizes the ability of the radio to receive weak signals.

High sensitivity can be realized only if the level of useful signal at the receiver input exceeds the noise level by a given value determined by the nature of the received signal.

Transmitter power is the power of electrical vibrations transmitted by the transmitter to the antenna, usually between 5 and 400 W. It depends on the purpose of the radio station and the operating frequency range.

The reasons that limit the power are:

• The impossibility of placing large-size and highly efficient antennas on the aircraft;
• mutual influence of REO;
• impossibility of separation of receiver and transmitter antennas;
• flight altitude, which affects the performance of RFMOs, etc. [4], [5]

Communication distance is the longest distance between endpoints of a communication line, where stable two-way communication is carried out. A communication is considered stable if the commands are legible during ground-to-board negotiations when pronouncing a phrase once.

Radio navigation and radar equipment make it possible to perform flights under any weather conditions day and night. For navigation purposes, azimuthal-dalomer near-field navigation systems, radio stations, radio altimeters, Doppler navigation systems, instrumental landing equipment, etc. have been widely used. [3]

The proportion of radio engineering systems on aircraft is constantly growing. For example, satellite navigation systems can be installed on aircraft, which with a high degree of accuracy can determine the coordinates of the spatial position of the aircraft. Therefore, microtitration of equipment elements, wide application of semiconductor devices, film and solid radio systems are of great importance.

A large group of instruments, sensors and systems is united by the so-called pilotage and navigation complex. The main purpose of the complex is to bring the aircraft to the designated point on a given trajectory and at a strictly set time.

In order to save time on maintenance and ensure regular flights, a remote diagnostic system is proposed. The remote diagnostics system includes hardware and software that allows setting test signals and obtaining test results of on-board systems not from the aircraft but from a workstation located in control rooms. The systems testing do not start after passenger’s disembarkation and customs clearance of an aircraft, but immediately after its landing. [6]

There are well-known remote diagnostic systems that are used in modern airfields of developed countries, in particular, in Germany:

• AiRTNM (Airbus Real-Time Health Monitoring) is a development of Airbus;
• AIMS (Airplane Information Management System) - development by Boeing and others.

The listed systems are software and hardware for remote control and diagnostics of aircraft systems. [7]

The AiRTTM system developed by Airbus includes real-time system parameter tracking and troubleshooting. Data are transmitted to the ground point by means of ARINC-42 communication and reporting system - a system for transmitting data on the condition of aircraft systems to the ground.

The AiRTHM monitors the parameters of seven aircraft systems: fuel, engines, oxygen, pneumatic, hydraulic, air conditioning, landing gear release and cleaning systems.

If a fault is detected in any system, by means of ARINC-42 system via VHF - radio station additional information is requested or the system is diagnosed. Diagnostic results are sent to a special center where they are processed, analyzed and, if necessary, the information is sent to the airline.
Well-known systems allow to simultaneously diagnosing more than 10 aircraft located at a distance of up to 10 km from the diagnostic point and have a very high price. However, the use of the existing systems is practically unsuitable for airlines with small fleets. For such airlines, simpler and cheaper remote control systems are more suitable. On the territory of CIS the means of remote control of parameters and testing of air systems are not currently developed and produced. [8]

Therefore, it is relevant to develop a new diagnostic system, which should meet the following requirements:

- the ability to work in all weather conditions;
- the ability to work at any time of day or night;
- the quality of communication should not change when working;
- all data must be securely protected.

For this system, you must first select the operating frequency range. The optical frequency range is most suitable for diagnostics. According to physical properties of radiation, methods of its generation and registration, the optical range is conditionally divided into ultraviolet, visible and infrared.

The proposed system is designed to operate in the infrared frequency range. In the presence of meteorological phenomena (fogs, snowfalls and rain) it should be considered that fogs are the most dangerous for the infrared range. The frequency range for remote diagnostics over the atmospheric optical channel is between 780 and 1600 nm. The frequency selected for use in atmospheric optical lines is 900 nm. Data transmission is implemented in accordance with IrDA (Infrared Data Association) standards and protocols. [9]

As a result, the proposed system saves time for aircraft maintenance and prevents flight delays, which lead to increased flight regularity.

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