Design and Implementation of UAV’s Flight Control System Test Platform

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Abstract. For the test requirements of UAV flight control system, using the virtual instrument, dynamic configuration of software and hardware and database technology, a flight control system test platform with more flexible manual and automated testing platform was designed. This paper describes composition and working principle of the system. Some key technology such as ICD data management, flight instrument simulation displaying, and flight control actuator loading is analyzed and discussed. Through actual use, the platform can satisfy comprehensive testing requirements for the development and production.

1. Overview
Based on the analysis of the principle and external interface relationship of the flight control system [1] of the UAV, a flight control automatic test [3] platform based on the virtual instrument [2] technology is designed. The test platform uses advanced computer testing and the control technology establishes a platform for automatic and manual testing, test data storage and fault injection analysis of all components of the flight control system. At the same time, it can meet the changes in the onboard equipment model and interface through software and hardware dynamic configuration technology. Adapt to the expanding needs of test changes. The test platform can maximize the test efficiency and improve the test reliability. Depending on the information equipment, the aircraft flight control system output information can be detected, and then the calculation and analysis can be used for fault detection and isolation. It is not necessary to require the tester to have a very rich system. Knowledge, you can quickly test and quickly determine the point of failure for unqualified items.

2. Platform composition and working principle
The test platform realizes the functions of installation, loading, connection, excitation and testing of the UAV flight control system. The composition principle of the test platform is shown in Figure 1. It can be seen from the figure that the signal excitation and display system, the complete tester, the bar force displacement test system, the servo loading table, the balance loading table and the system test cable were tested. The components of the flight control system are connected to the test platform by a complete set of testers. In the complete tester, the signal transfer and distribution unit completes the connection of the various components, and the wiring relationship of each component is connected according to the actual wiring relationship of the aircraft; the signal transfer and distribution unit is At the same time, the connection lines of the components of the flight control system are completed, and the signal lines are simultaneously connected to the detection and control interface of the whole system tester panel to
facilitate manual control, detection and state observation in the system test; in addition, the flight control test requires a computer. The bus signal, discrete signal and analog signal for excitation and monitoring are connected to the specific PXI function board of the signal excitation and display system by the whole system tester, and the signal excitation and signal monitoring are controlled by the computer. During the system inspection process, the test platform also provides test bench and loading table to complete the test installation and fixing of each component, and the test loading of the servo and related trim components.

This universal test platform can check multiple types of flight control systems. Because the models, components, power supply and wiring methods of each type of flight control components are different, this universal test platform is equipped with multiple sets of complete testers to adapt to different flight control systems. Different types of flight control systems use different sets of testers for system signal connection, signal interface adaptation and system power distribution, ensuring that all flight control systems can be tested and tested under this test platform.

The test platform is equipped with common test and test resources, that is, the signal excitation and display system and the power supply system are common in the test and test of each flight control system. In the specific test, the difference test between the flight control systems is completed through software configuration and selection. Testing, the realization of the maximum use of resources and the general operation of the software [4].

During the flight control system inspection, the test platform supplies power to the components of each flight control system. The platform checks the self-test information of each flight control component. When the power-on self-test is working normally, the avionics are simulated by the excitation unit, and the control is stabilized. And the signals of the system such as the flap control are given to the flight control computer, and the loading platform is controlled to load the servo and the trimming system, and then the flight control working state is set on the operation of each flight control console and the handle in combination with the simulation excitation signal and the loading situation. The control system enters the corresponding working mode to work normally. The test platform collects the working data of the flight control system. After the ICD analysis, it is output to the software interface of the experimental system. The test personnel can observe whether the flight control system works on the flight monitoring and data monitoring interface. Normally, the test software can also judge the test results of each test item, and finally save all test data to the database.

The signal exciter and display system test consists of signal exciter/test control computer, EFIS/EICAS interface simulation computer, data monitoring, database server, PXI exciter/test unit; The complete tester consists of system power supply, power distribution and monitoring unit, signal switching and distribution unit, switching unit. The servo loading station table is mainly used to simulate the hinge torque of the air acting on the rudder surface of the model aircraft during the actual flight to verify the operating efficiency of the servo. The load torque consists of three parts: hinge torque, inertia torque and damping torque. The balance loading station is mainly used to install the trim parts and simulate the torque acting on the trim servo and motor-drive mechanism to test displacement.
3. ICD data management design
ICD refers to the avionics interface control file, which defines the data format for input and output between devices. Due to the large number of avionics and the huge amount of data, ICDs are often very complex, making it difficult to query and use. Therefore, the design uses a database to store ICD data and builds ICD management software to manage all ICD data. Use the database to manage ICD definitions for various onboard electronic devices. The ICD definition in this database should be mapped to the platform hardware. After entering the corresponding ICD, the test platform can access the database, call ICD related information, complete the data grouping and parsing functions. The ICD is packaged and decoded by the program according to the information in the database, and the ICD information needs to be standardized.

The ICD database adopts a three-tier access method, which means that there is an application service between the client and the database. When the client accesses the database, it directly communicates with the application, and the application communicates with the database. In this way, the application server is accessed by the client, and the client does not directly operate. Therefore, the client does not need to understand the deployment of the database, nor does it need to deploy the client related to the database, which brings convenience for deployment and data security.

4. EFIS/EICAS picture simulation design
During the test, it is necessary to simulate EFIS, EICAS display, simulate PFIS interface of EFIS, provide graphical ADI and HIS interface, fault interface; simulate EICAS and flight control related screen; EFIS and EICAS screen split screen display, and It can switch the parameter screen that needs to be displayed; it can display the attitude and heading of the aircraft on the ADI and HIS interfaces of EFIS under the control of the handle; the angle resolution of the trim system displayed on EICAS is 0.1 degree, and the test resolution of the rod force is 0.001V, discrete test resolution is 0.1V.

The EFIS/EICAS screen simulation interface is designed using the SCADE Display tool, which is a stand-alone module. The data processing module was developed using the VS2010 tool to interface with the simulation interface. The design of this part uses a modular processing method to separate the data processing [5] from the simulation display, and complete the data interaction between the data through the data mapping table to achieve a more reliable software architecture [6].
5. Loading station design

In the flight control system test process, it is necessary to add a certain torque to the servo and the trim motor mechanism of each rudder surface to simulate the force of the aerodynamic force acting on the rudder surface during the flight. Therefore, the flight control system needs to design the loading platform for each the actuator [7] is energized, here the torque motor is used to directly drive the loading scheme. The system consists of mechanical structure, loading control device, sensor, etc. Figure 2 is a block diagram of the loading platform system.

![Figure 2. Loading station system block diagram](image)

The torque load simulator is an electric servo system whose torque is adjusted. It is a typical passive torque control system. The servo loading system generates a control command output driving voltage through the control device, and the driving torque motor works. The torque motor is connected to the magnetic powder clutch through the rotating shaft, the output shaft of the magnetic powder clutch is mounted with a torque sensor, and the loading connecting device is rigidly connected to the servo. The load is transmitted to the servo via the magnetic powder clutch. To simulate the servo load, and collect the load torque value through the torque sensor of the magnetic powder clutch output shaft and display it. When the load increases, the speed of the motor can be automatically reduced, and the output torque is increased to maintain balance with the load. The speed measuring device is added to the motor shaft, coupled with the controller, and the voltage output by the speed measuring device and the controller are given. Compared with the voltage, it automatically adjusts the terminal voltage of the motor to make the motor stable. It has low speed, high torque, strong overload capability, fast response, good linearity and low torque fluctuation.

The electric loading mechanism is composed of a loading channel assembly and a sliding table substrate. The loading channel assembly moves forward and backward along the positioning keyway of the sliding table substrate through a high-precision guiding key, and the servo mounting seat is also fixed on the sliding table substrate by a guiding key, so as to ensure loading. The torque output shaft of the channel is concentric with the rudder shaft. At the same time, T-shaped grooves are arranged on the sliding table base to facilitate the installation and fixing of different sizes of servos, which makes the loading channel more widely used.

6. Conclusion

The flight control test platform adopts advanced testing technology and modular and standardized test instrument design, and has achieved system configuration optimization, reasonable structure, perfect
function, high degree of automation and strong adaptability, which can meet the development and production of various series of aircraft. The aircraft flight control comprehensive test requirement in the process is a test platform with high reliability, excellent cost performance, strong practicability, simple operation, convenient maintenance and strong testing ability.

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