Design of Ground-detect Equipment for Aircraft Electrical Anti-skid Braking System

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Abstract. According to the principal of aircraft electrical anti-skid braking system，a detection equipment was designed by integrity using PLC technology, LCD graphical displaying, measurement and control data processing, information storage and communication technology. The design schemes of hardware and software were given. The designed equipment was validated by practice with characteristic of veracity and reliability, simply for operation, and satisfying real requirement of aircraft maintenance.

Introduction

The electrical anti-skid braking system was the important component of modern airborne equipment. By utilizing the friction force between ground and tread, this component can realize brake and control when aircraft takeoff, land, taxi and turn. According to statistics, the 49.1% flight accidents happened at the takeoff phase [1]. Therefore, the performance of the anti-skid braking system affected the safe of pilot and sustaining combat ability. It was necessary to ensure the system operating safely and reliability by exactly and rapidly detection for anti-skid braking system.

System design

The control scheme of aircraft anti-skid braking system showed as fig.1.

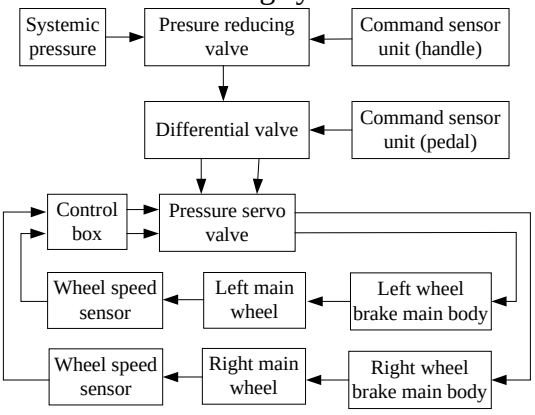

Fig.1 The control scheme of anti-skid braking system

The anti-skid braking system was composed of relief valve, differential valve, pressure servo valve, control box, wheel speed sense, braking main body, and command sensor. Thereinto, the function of relief valve was relieving the hydraulic pressure of main system to provide for braking system. The function of differential valve was balancing the braking moment of right and left wheel. When aircraft landing, wheel speed sensor will output an AC voltage signal with frequency direct proportion to wheel speed to control box. The control box received this signal, and then doing compare operation. When braking speed rate of aircraft less than the designed decreasing speed rate, the control box will not output electrical current to pressure servo valve. At this condition, the pressure servo valve just as passageway, the braking pressure was controlled directly under the instruction of pilot. When braking speed rate of aircraft more than the designed value, it shows that

the wheel being skidding. At this condition, the control box will output an electrical current to pressure servo valve, and then the pressure valve functioning as a reverse valve. The pressure force will enlarge direct proportion to electrical current to release the skidding. [2]-[5]

The test of Anti-skid Braking System is to find out whether its input-output relations meet the criteria requirements. Therefore, the hardware design of the system should be able to simulate the input signal of the control box, and the output signal of the control box can be measured. The input signal of the Anti-skid Braking System has two kinds of sinusoidal voltage and switching value. Among them, the sinusoidal voltage comes from the wheel speed sensor. the switching value comprises a landing gear landing, parking brake, main landing gear wheel load signal and so on. The output signal of the Anti-skid Braking System includes voltage, current and switching value. Thereinto, voltage includes internal power supply voltage, internal reference voltage and frequency discrimination voltage; the current is the control current of the pressure servo valve; the switching value indicates the various operating conditions of the Anti-skid Braking System.

The hardware components of detection equipment were shown in the figure 2, it mainly consists of detection module, display module and control module.

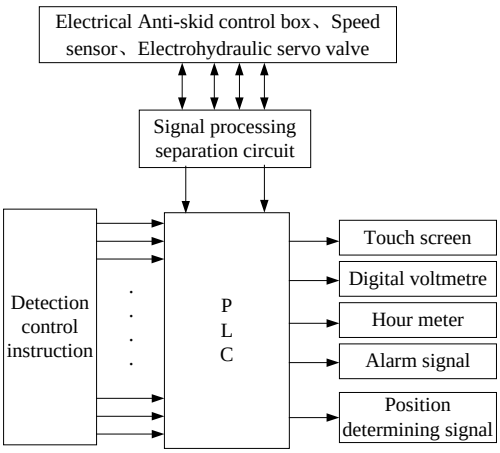

Fig.2 Configuration of the detection equipment

The aircraft maintenance crew conduct active and static test by selecting the control instruction of the Anti-skid Braking System, including: the self-test of the ground detecting device, the working voltage detection of digital anti-slip control box, the detection of anti-slip main channel, reference velocity voltage detection, the speed detection of airplane wheel, the detection of open and short circuit units in control box and airborne detection. After these detection, we can know whether the Anti-skid Braking System works well.

Through communication between PLC and HMI, HMI real-time displays the content which the air maintenance crews are detecting. By watching the digital voltmeter and calculagraph, we can find out whether the digital anti-slip control box functions well. The on and off of the guard lamp and fault location lamp can provide accurate fault message for the testers.

PLC is the core of the ground detecting device. It accepts all kinds of testing signal and output all kinds of controlling signal. With the help of the initial pulse of PLC, HMI displays the initial interface every time it turns on, after the software interlock of PLC, all detection content can be free from conflicts. Signal processing and separation circuit comprises a sensor analog circuit, an open and short circuit fault location unit, a servo valve analog circuit and a power supply circuit. It plays the role of conditioning, it not only gives signal to the control box, but also gets signal form it. The control box can accurately locates the fault of open and short circuit by several simulated cell. Moreover, the ground detecting device can display the specific location of faults, and provide the faults message of the Anti-skid Braking System for testers.

Hardware electrical circuit design

The hardware control logic of system show as Fig.3.

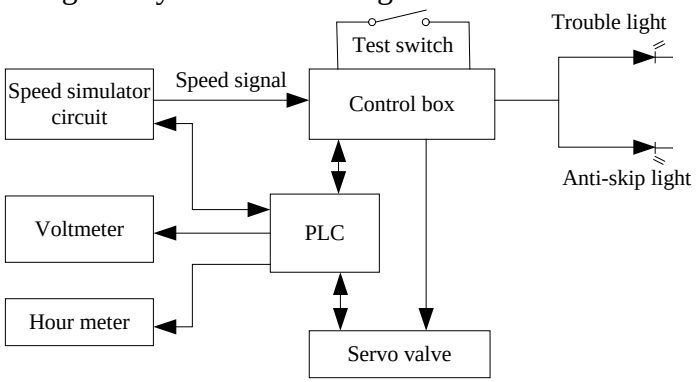

Fig.3 Control logic scheme of detection equipment

Speed analog circuit: the wheel speed signal is approximated an alternating sine wave, in the a simple and effective principle, we choose sine signal generating circuit using 555 timer as the basic components to simulate 4 wheel speed signal.

Servo valve analog circuit: Servo valve is a current type element, and it is simulated by a certain power resistor.

Digital voltmeter, calculagraph: press-loose the test switch, and use PLC to choose a brake channel. The detection device voltage meter real-timely measures the corresponding channel voltage, and the calculagraph times. We can watch the voltage meter, calculagraph and the state of control box anti-slip lamp to decide whether the anti-slip function works well.

Open and short circuit detection unit circuit: the test of open and short circuit detection unit mainly check whether open and short circuit detection unit in the control box works well, the detection device simulates the condition of speed sensor and the open and short circuit of servo valve. Fault-detection unit of control box detect faults in real time, and the faults are reflected by the guard lamp, trouble light and fault-location lamp of open and short circuit.

Software design of the system

Communication parameter set:

The RS-485 serial interface standard was employed as system communication type. The RS-485 with two-line mode realized the real multi-point bidirectional communication. The communication between HMI and PLC was realized by 9-pins serial interface.

The communication between HMI and PLC was set up by correct parameter configuration. There were three different menus in HMI. These menus keep consistent with control display by PLC. The different detection content could be displayed in HMI.

Detection content display:

The two text label stores of HMI were defined with different color and different text type. After selecting these labels, the content displayed in ‘content’ label was the content of text label. The text type was the selected type in the label stores. The displayed text content changed according to deferment PLC address. Under the control of PLC, the different content can be displayed in different zone of the main menu. The detector can know the tested content at the real time. The current data of the anti-skid system can be provided by the equipment.

The Scheme of PLC main program show as Fig.4.

According to the main program structure chart 4, we can see that if a link of 9 aspect of detection contents which are controlled by PLC and include 16 small items test goes wrong, the person who checks it will know the fault and exchange the accessory and then checks it again until there isn’t any fault after the initial interface being showed by initial pulse on HMI. So we can guarantee the reliance of the state of the electronic anti-skidding braking system before taking off is all right.

The system saves 3 types of different checking contents into 3 data registers and uses

transferring order to invoke the data in the registers when it operates. PLC checks anti-skidding system in 9 main aspects according to the operation order and shows corresponding words information on the screen. PLC also checks the thoroughfare of the anti-skidding system according to the operation order and shows corresponding words information on the screen when 4 anti-skidding thoroughfares should be checked. PLC checks the working state of the 12 accessories respectively according to the operation order and shows corresponding words information on the screen when the working state of the 12 accessories should be checked.

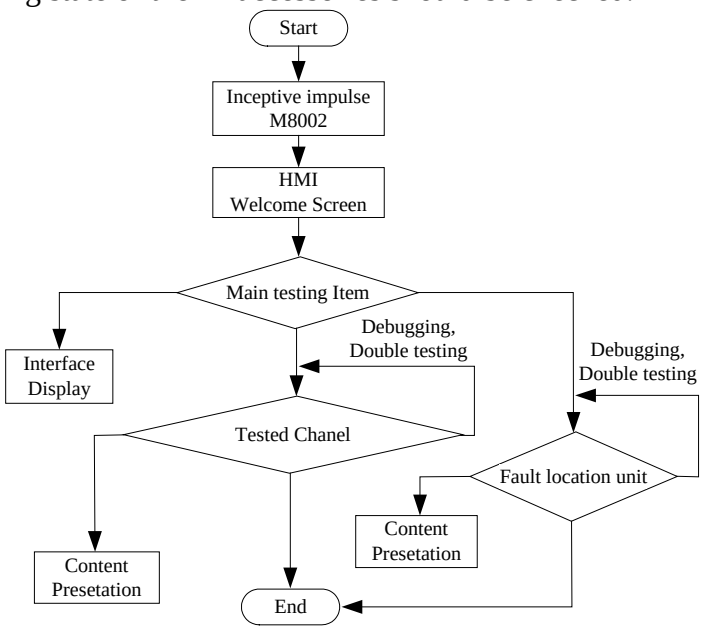

Fig.4 Scheme of system main program

Working principle

The working principle of the checking facility on the ground is producing checking signals to check corresponding accessory and circuit by the inner frequency producing circuit. The corresponding outputs of control box of checking facility collection in current time should be measured by voltage meter or analyzed by fault locating units.

The self-checking of checking facility:

The aim of the self-checking of checking facility is checking whether the circuit road of checking facility is normal or not. According to the fault locating units to check the outputs of frequency producing circuit, we can see that if the checking result is the change of the interval of high level and low level, the checking facility will work normally.

The checking of reference voltage:

When checks steadily, if the reference voltage is near to 0 volt and the voltage meter of checking facility is around 0 volt, the reference voltage in steady state is normal, otherwise, it isn't. When checks actively ,the checking facility is divided into 4 thoroughfares to provide control box with one speed artificial signal, then break it, and voltage meter checks the changing trend of voltage in current time.

The checking of the speed of airplane wheel:

The checking facility sends the simulative airplane speed to the control box, and checks the amount of the speed of airplane wheel voltage which control box outputs.

The checking of open circuit and short circuit checking units in the control box

The checking of open circuit and short circuit checking units mainly checks whether the open circuit and short circuit checking units in the control box is all right or not, the situation of checking facility of simulative speed sensor and the open circuit and short circuit of servo valve, the checking of circuit fault in current time of checking units of the checking of control box. The fault information is showed by the light of anti-skidding, the light of fault, and the light of fault location of open circuit and short circuit.

In-situ detection:

At the condition of In-situ detection, the working socket of control box interface with airborne system, and landing gear being laid down to ground. The control box provided the power to detection equipment by detection cable. At this mode, the detection equipment can detect entire fault, locate and detect sensor open circuit fault, locate and detect servo valve open circuit fault, detect system matching.

a. Entire fault detection

Press-release examination button, observing the anti-skidding light and fault light in the equipment panel to judge digital anti-skidding control box whether operation well.

b. Location and detection of open and short circuit fault for sensors and servo valve

When fault light illuming, it shown that corresponding sensor circuit was in open or short circuit fault condition. The 8 sensor circuits and 4 servo valve circuits can be detected by detection selecting switch in the detection equipment. If the switch being selected to corresponding circuit, fault location light would be illuming, it shown that this circuit in the fault condition.

c. System matching detection

The checking of matching of sensor corresponding channel:

When the speed sensor was being checked on matching, the plug of checked speed sensor should be completely pulled out and the connection of other speed sensors' plug and jack is all right. The fault location button should be switched to corresponding speed sensors, which can make the checking equipment check the situation of corresponding circuit in current time. The result can be showed by the fault light and the fault location light.

Matching detection of corresponding channel for servo valve:

Given some speed sensor simulation signal, normal braking system being selected, jammed on the pedal, the correctness of servo valve installment can be judged by measurement of pressure meter in the cockpit.

Conclusion

The designed electrical anti-skid braking system detection equipment based PLC-controlled had some merits such as electro circuit designing simplify, little volume, portable, high reliability, good real time performance, roundly function, humanism interactive panel, easy operation. The test results show that this designed equipment can shorten the prepare time for re-flight with high automation, short test circle, and total and selected test function. The designed equipment can advance the unit battle effectiveness at some meaning.

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