Equipment of infrared earth sensor for testing EMC performance

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Abstract: In different model tasks, the antijamming ability of swing scanning infrared earth sensor in electromagnetic interference environment needs assessment. The structural design of overall structure and the main parts of portable swing scanning infrared earth sensor's whole machine electromagnetic compatibility test dedicated performance testing were introduced in detail. This device is able to assess the performance of the whole earth sensor indicators, gives infrared radiation signal, comprehensive assessment on the optical, mechanical, electrical properties of products. The earth simulator in this paper adopts a project of replaceable earth diaphragm for two orbit heights 35 786 km and 21 500 km, and can afford two earth angles (17.46° and 26.54°). In this paper, test equipment achieve simulating the earth of satellites in space have seen on the ground, for the satellite components infrared earth sensor testing performance on the ground.

Key words: EMC; infrared earth sensor; hot earth

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红外地球敏感器整机 EMC 试验测试设备

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摘 要:在不同的型号任务中,对摆动扫描式红外地球敏感器在电磁干扰的环境中所达到的抗干扰能力需要进行考核。详细介绍了便携式摆动扫描式红外地球敏感器整机 EMC 试验专用性能测试设备的总体结构及主要部分结构设计,该设备能考核地球敏感器的整机性能指标,给出红外辐射信号,全面考核产品的光、机、电性能。所设计的地球模拟器针对卫星 35 786 km 和 21 500 km 两个轨道高度,采用可更换地球光阑的方案,提供 17.46°和 26.54°两种地球张角,所研究的测试设备实现了在地面上模拟卫星在太空中所看到的地球,供星上红外地敏在地面上测试性能使用。

关键词:EMC; 红外地球敏感器; 热地球

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0 Introduction

The infrared earth sensor is typically used for measuring pitch attitude angle and roll attitude angle of spacecraft [1-2]. According to the different ways of working, the sensor can generally be divided into the following several infrared earth sensors, cone scanning type, swing scanning type, boundary tracking type, static infrared type, etc. The infrared earth sensor generally consists of an optical system, bandpass filter, thermal detector and information processing circuit [3]. According to the information processing mode, it also can be divided into digital and analog infrared earth sensors. Generally we most choose to use cone scanning infrared earth sensor in the medium low orbit spacecraft attitude measurement, use swing scanning infrared earth sensor in high orbit spacecraft attitude measurement [4-5]. The earth simulator is on the ground simulation satellite view of earth from space for special performance test machine electromagnetic compatibility test, it supplies for the satellite components infrared earth sensor testing performance on the ground.

1 Overall design of machine performance test equipment

In order to simulate the scene of satellites in 35 786 km and 21 500 km orbit seen the earth on the ground, we achieve different orbit altitude through two earth apertures which from the earth sensor window 200 position respectively. Simulate the earth angular 17.46° and 26.54°, achieve luminance difference of the simulator between earth and space radiation through thermostatic control system to adjust the temperature difference between the hot earth and earth diaphragm. Machine performance test equipment mainly consists three major components: the earth simulator main body, thermostatic control system and installation accessories. The overall structure of machine performance test equipment as shown in Fig.1, the physical map of test equipment as shown in Fig.2.

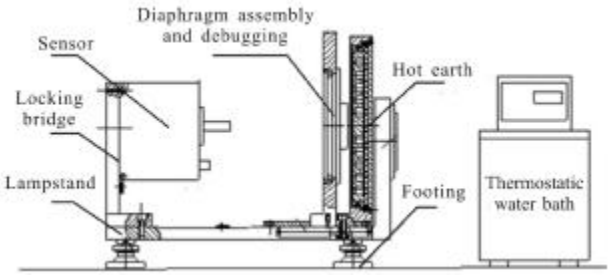

Fig.1 Integer structure of earth simulator for whole machine capability testing

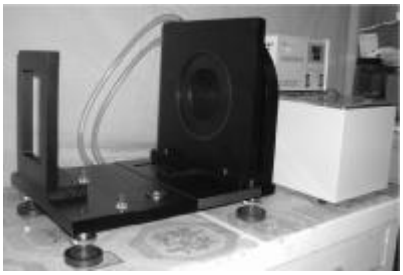

Fig.2 Picture of earth simulator for whole machine capability testing

2 Main parts structure design scheme of maching performance test equipment

2.1 Earth angular simulation principle

The earth angular principle in the machine test equipment as shown in Fig.3.

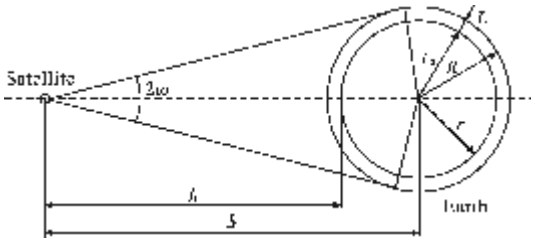

Fig.3 Count sketch map of earth angular

In Fig.3, 2ω is the earth angle; r_0 is the earth's equatorial radius; **r** is the average radius of the earth; **L** is the thickness of CO_2 layer; **R** is the radius of CO_2 emission band; **h** is the height of the satellite from the ground; **S** is the distance from satellite to the center of the earth.

Earth angular under different orbital altitude is calculated by the following formula:

$$2\omega=2\times\arcsin\left(\frac{R}{S}\right)$$

In the formula, in synchronous orbit (35 786 km), $R=r_0+L$, $S=h+r_0$; in orbit (21 500 km), $R=r+L$, $S=h+r$. The calculated results of earth angular under different orbital altitude as shown in Tab.1.

Tab.1 Earth angle on different orbits

Orbit altitude/km	Earth angular/(°)
35 786	17.46
21 500	26.54

2.2 Earth aperture structure design

Earth aperture adopts plate type structure, material is aluminum plate, black surface anodic oxidation treatment, the inner circle boundary is the horizon. It is formed integrally with the aperture seat and leave mounting positioning hole behind aperture seat for the cross reticle components which is used for debugging. Earth aperture structure as shown in Fig.4.

When the requirements of different orbits earth at different aperture, we can refit different **ØD** sizes of the earth aperture. The aperture end face should be perpendicular to the optical axis, to ensure that the optical axis of the simulator through the center of the **ØD** hole and perpendicular to the aperture plane.

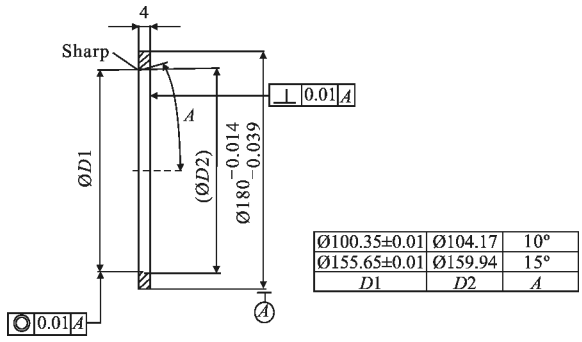

Fig.4 Structure of earth aperture

2.3 Structure design of hot earth

The hot earth using aluminum disc structure, it's front surface is the soaking plate, black surface anodic oxidation treatment, provided with a cycle waterways and the inlet and outlet, and each install a valve in the inlet and outlet, as shown in Fig.5. Hot water is supplied by a constant temperature water tank, the water temperature should keep at about 30-40 ℃. In order to ensure the constant temperature, it is need to add in the insulation layer around the hot earth.

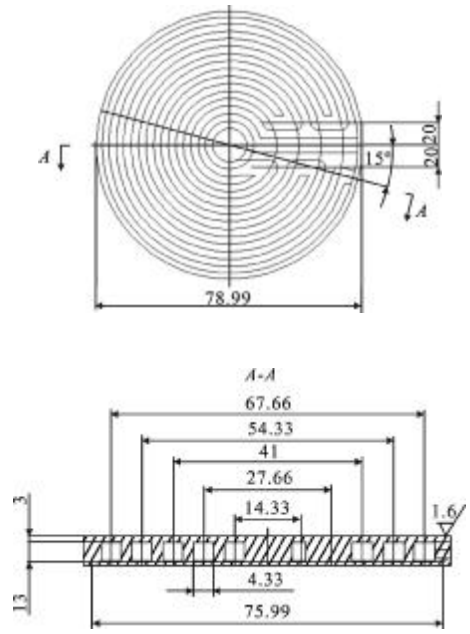

Fig.5 Structure of hot earth

Since the hot earth is so thin to only a dozen millimeter, the pipe joints of quick connector we buy on the market are coarser, therefore conducted pipe joint design, it's structure as shown in Fig.6.

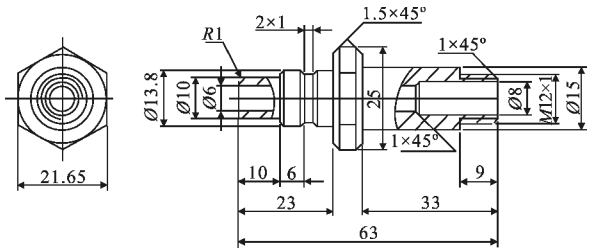

Fig.6 Structure of pipe connetion

3 Test results and analysis

Adopting infrared thermometer for testing the control accuracy of constant temperature water tank, as shown in Fig.7. When the temperature is set to 46 ℃,

select 5 points in the front surface of the earth simulator conduct temperature measurement. The test data and results of temperature uniformity in the front surface of the earth simulator as shown in Tab.2.

Fig.7 Hot earth's surface uniformity test device

Tab.2 Data and results for testing temperature uniformity for hot earth on 46 ℃

Measured value/℃	Temperature setting value/℃	Error/℃	Maximum error/℃	Requirements/℃	Conclusion
46.01 middle		0.1			
46.02 up		0.2			
45.99 down	46	-0.1	0.2	0.5	Up to standard
46.02 left		0.2			
46.02 right		0.2			

By adopted infrared thermometer for testing the control accuracy of constant temperature water tank, test results reached the technical requirements, satisfied the design requirements of earth simulator.

4 Conclusion

The test equipment design developed in this paper is reasonable, stable and reliable performance, this equipment used integration of structural design, the structural design of the major part has given is reasonable, test results is believable. According to the test instances, it can be seen that the designed test equipment satisfies need of swing scanning infrared earth sensor for the whole machine EMC test dedicated performance testing.

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