2018 Eighth International Conference on Instrumentation and Measurement, Computer, Communication and Control

Design of Satellite Automatic Test System Based on Data Transmission

Zhaoyang Wan, Hongjue Li, Chunyang Zhao
School of Astronautics
Beihang University
Beijing 100191, PR China
wanzhaoyang@buaa.edu.cn, lihongjue@buaa.edu.cn, cyzhao1994@163.com

***Abstract*—With the rapid development of aerospace technology, the satellite is becoming more and more complicated. The satellite test tasks are facing with serious challenges, such as complex test requirements and long test cycle. Also manual test cannot guarantee the adequacy of test requirements, completeness and reusability. In this paper a satellite automatic test system is designed based on the data transmission feature in satellite components. This automatic test system contains a formal language to describe the process of satellite test, a way automatically generates the test process and automatically interpret the results. The design has certain guiding significance to the industrialization of satellite automatic test.**

Keywords—satellite test; automatic test system; data transmission

I. INTRODUCTION

The traditional manual test mode is facing huge challenge as the launch missions increasing. To avoid test accidents caused by human factors and to improve test efficiency, automated testing is the only way to develop satellite test technology [1]. Automated test systems should be versatile and automated. The versatility requirement is to meet the basic needs of various types of satellite testing and cover the important test cases of the satellite. Automatically execution of the test process and automatically interpretation the test results can effectively save manpower, avoid many uncertainties caused by human reasons, and then improve the effectiveness of the test results [2].

Simulation technology is an important vehicle to support the development of satellites. It has the advantages such as Controllability, safety, non-destructive, not subject to environmental conditions and can repeat many times. It plays important role in the design, performance evaluation and design improvement of spacecraft [3]. The Dynamic Satellite Simulator is a satellite built up by component simulators based on real satellite. The satellite Simulator is running in a software-simulated space environment, which mode and parameter is in consistent with real satellite. The satellite simulator can simulate the various subsystems and their components of satellite, shows the condition of the satellite system and reveal the working principle of subsystems and the mutual cooperation in each other [4].

The designed satellite automatic test system is based on data transmission among components of different subsystems. The system records the component model and the component data transfer protocols. After the testing process is determined, this system can execute the process automatically and judge the test result based on the response from the tested equipment. The satellite automatic test system also considers versatility. It not only can be applied in test of a satellite, but also effective in test of satellite components, not only can be used to verify the communication protocols of the real satellite, but also can be used to test digital satellite simulators.

II. SYSTEM DESIGN

During the test process of satellite, the most important is sending and receiving data through the telemetry and telecontrol links [5]. The basic process of any test involves sending an excitation signal to the satellite, such as telecommand, injected data, and component power supply signal [6]. And then collect the satellite response signal and judge whether the response signal is correct according to the specified rules. Any test, manual or automatic, follows this basic process. And a test is made up of several basic processes. The basic process of satellite test is shown in Fig. 1 below.

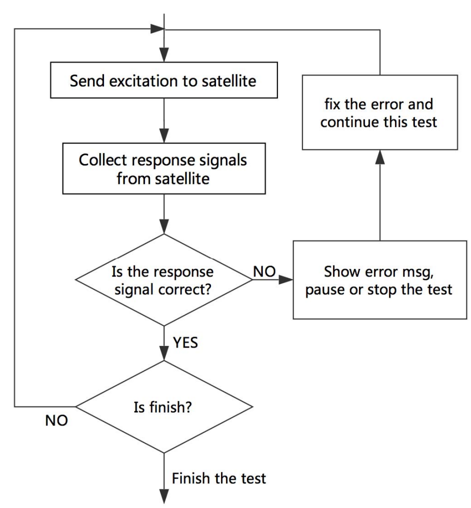

Fig. 1. The basic process of satellite test

Compared with manual test, automated test is characterized by tasks are preformed machine instead of human being. The tasks mainly include the transmission of the excitation signal, the acquisition of the response signal and the interpretation of the test results. Based on the above considerations, the

978-1-5386-8246-3/18/$31.00 ©2018 IEEE
DOI 10.1109/IMCCC.2018.00037

automated test system must define a standardized data format that describes what interfaces the under test device own, what kind of data it can deal with and what response should be made after receiving the corresponding data. Automatic test system can automatically perform processes in a certain order, a standardized test process should be defined. At last, the data format should be clearly defined to automatically interpret test results.

The basic types of data for the test system include byte, long, unsigned long, int64, unsigned int64, double, and string. In addition to the above basic data types, you can also define composite data. For example, the size of a pulse signal of the accelerometer in the data transmission is only 1 bit. 8 pulse signals can be stored in 1 byte. So the bit parameter is defined. The bit parameter is measured by bit. And the length of bit parameter is not less than 1 bit and not longer than 7 bit. The composite data is constituted by bit parameter. The way bit parameters constitute a composite data is same as assemble a packet. The difference is that the bit parameter can be added from any position of the composite parameter, while data can only be added to the packet by ascending order. Fig. 2 shows that the 2 bytes long composite data contains three bit parameters. They are assembled in intermittent position of the composite data.

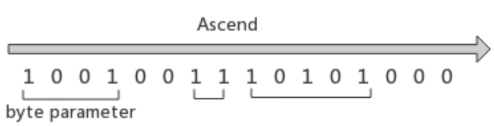

Fig. 2. Byte parameters in composite data

The data used in the test process must be defined in advance. The test data is assembled in a packet to transmit to another component. By inducing the process of satellite test, we define 5 kind of base test process, they are open device process, close device process, send data process, receive data process and test process control process. Each test case is consisting of several base test processes. The base test can set multiple parameters, which is similar to functions in the advanced programming languages. The base test process is related to the test case contains it by the parameters. Also a low level test case can be an element of a high level test case just as the way the base test process is. At last, one test case can be defined as the executed process. Fig. 3 illustrates the relation between base test process and test case.

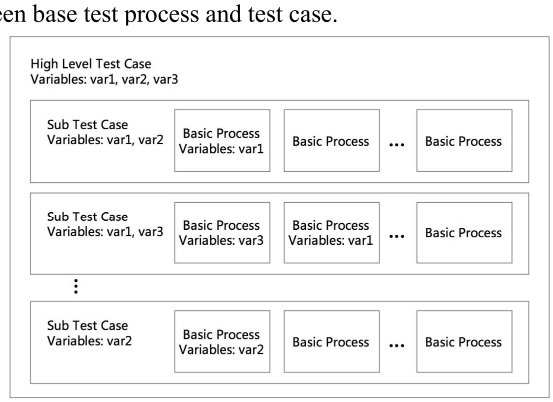

Fig. 3. The relation between basic test process and test case

The test device receives data from the DUT and save it to database. The data is also needed to display on real time to show let the tester know the schedule and current status of test. So the automatic test system needs to design 2D-display system to display data from the DUT. Fig. 4 shows the data transmission logic of 2D-display system. It is a totally independent system, which can receive data from not the test system, but also data even from the satellite, as the data received can be analyzed.

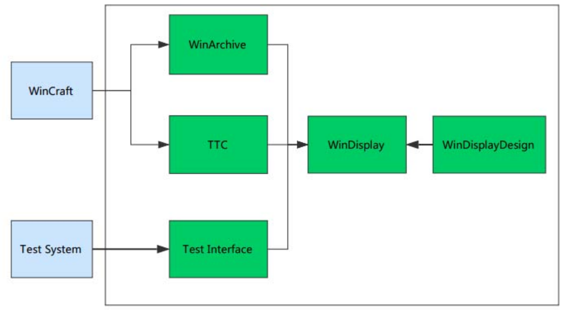

Fig. 4. Data transmission logic of 2D-display system

In addition, the displayed data is different as the DUT is different, which requires the 2D-display system support customization of the displayed data. So the design of 2D-display system should consider the binding of data and display controls. The 2D-display system can be designed and the tester can decide to use which control to show data. For example, the attitude information should be continuous and a line chat is suitable to display it. By referring to the types of controls supported by other display programs, the 2D-display system can provide a series of virtual instruments controls, including line chart, list, progress bar, indicator, slider, and so on.

The test results are displayed in real time to the interface for real time viewing by the tester, and the test result display program is developed according to this requirement. After the test is completed, a detailed test report is required based on the results of the test. During the test, the results of the packets and test results received from the DUT are saved to the database. The data is read and the test report is generated automatically according to the relevant contents of the database.

III. Test Process Control Model

No less than one basic test process will be executed after previous basic process. By default, the test process is a serial model, which means after previous basic process executed, there is only one basic test process that will be executed. When the result of current basic test process is wrong, the test process will be terminated and the cause of the error will be checked manually. In addition to the serial model, there are two more models, which are the divergence model and the aggregation model.

A. Serial Model

The serial model is the simplest and easiest to understand model. It refers to the execution of the node is in accordance with the scheduled order. The next figure illustrates the way the serial model works. In Fig. 5, the process is executed follow the sequence from A to B and then C. Failure of each basic process will terminate the test process.

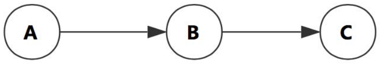

Fig. 5. Serial Model

B. Divergence Model

The divergence model will lead to executing more than one basic process. And these basic processes will be executed synchronously. In Fig. 6, after the success of basic process B, there are three basic processes, which are C, D and E will be executed.

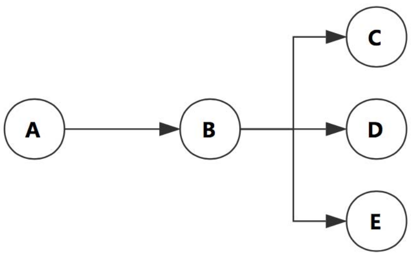

Fig. 6. Divergence Model

C. Aggregation Model

In the subsequent process, the divergence model will eventually come together, which is the aggregation model. In the aggregation model, the previous basic processes must all be executed and the judgment of the previous basic processes should all be right. Fig. 7 shows the execute pattern of the aggregation model.

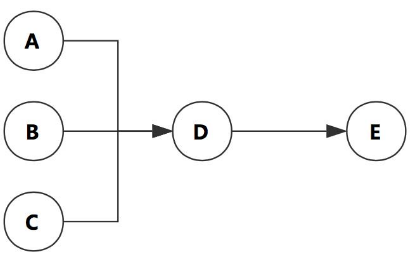

Fig. 7. Aggregation Model

IV. VALIDATION

The automated test system is written in Visual C++ and C#. It includes the test environment configuration program, the test task design program, and the test process control program. The test environment configuration program is used to record the basic status information and connection information of the test devices and under test devices. The information will eventually save to the Inter Center Database(ICD). The relation of data tables to save configurations and information is showed in the figure below.

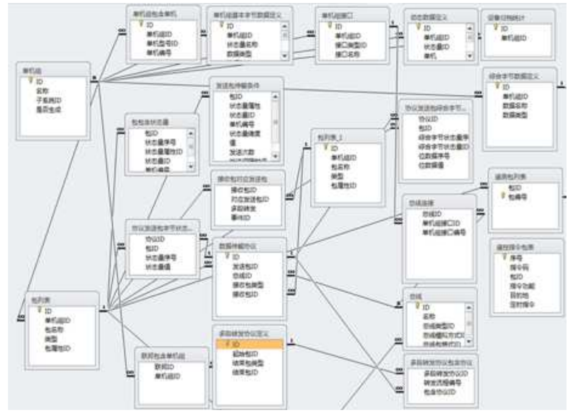

Fig. 8. Relation of data tables

In this test case the satellite dynamic simulator is our tested device. The connection of our test devices and the satellite dynamic simulator is showed in the figure below.

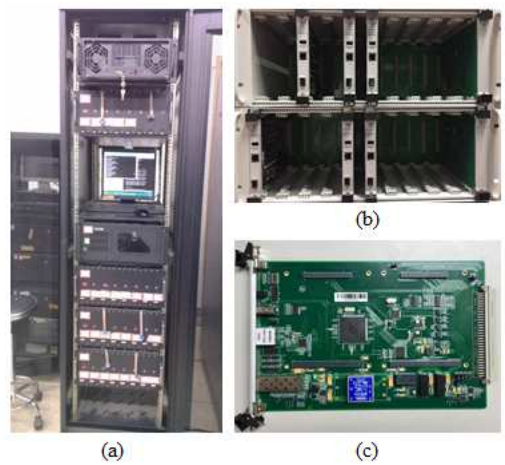

Fig. 9. Device under test: (a)test cabinet, (b)case in the cabinet, (c)card in the case

Satellite dynamic simulator includes Attitude and orbit control, thermal control, propulsion and TT&C subsystems. Data is transmitted in different subsystems through CAN bus and UART interface. The satellite dynamic simulator supports Whole satellite simulation as well as simulation of individual components of satellite. The test of satellite is based on test of individual components. When a single component is under test, the component is connected to the automatic test system via interfaces for data transfer with other components.

The satellite automation test system supports a variety of device interface types, which includes CAN, RS422, 1553B, AD, DA, DI and DO. The devices under test can be a cabinet in Fig. 8, or a case in the cabinet, or even a card in the case.

The output file of the custom 2D-display design system is a XML file, which contains common properties of controls such as layout, size, data binding, and unique properties of different controls. Fig. 10 shows the properties of the output XML file.

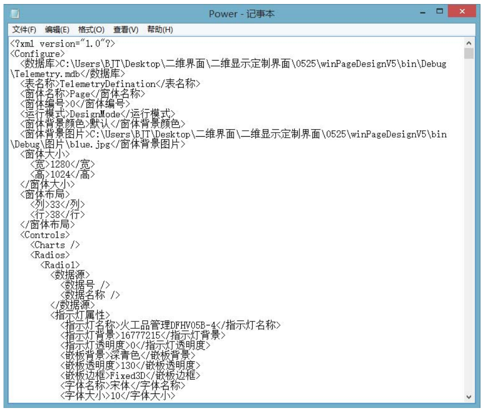

Fig. 10. Output XML file of custom 2D-display system

After the connection of the devices is ready, the test process is executed. The custom 2D display program can show the data returned by the DUT, and the test monitor program shows the progress of the automated test process execution and test execution results.

(a) (b)

Fig. 11. Test monitor and display system: (a)realtime datas from tested device, (b)test results of each basic test process

The monitor and display system showed in Fig. 11 can be used by the tester to watch the test process on real-time. After each test basic process executed, a colored result will displayed and the tester can easily tell result of current test case. Also by grabbing test data from ICD database, the auto test system can playback former test cases. In this case, the automatic test system is very helpful to let the test staff familiar with the test environment.

V. CONCLUSION

In this paper, based on the analysis of the requirements of the integrated test system, a design scheme of satellite automation test system is introduced. The automated test system uses a centralized monitoring and management of the distributed architecture. It has the characteristics of integration, automation and versatility. At present, the system has been successfully applied to the testing of hardware equipment of semi-physical simulation equipment of satellite dynamic simulator and the testing of each system of satellite dynamic simulator. The practical application shows that the system has strong engineering practicability.

REFERENCES

[1] S. Thibault, A needed evolution in automated satellite testiing[J], Autotestcon, IEEE, Vol.17, pp.425-434 , 2007

[2] C. Lansdowne, P. McCartney, C. Corringe, Experimental applications of automatic test markup language(ATML), Proceeding of 2012 IEEE Autotestcon. Piscataway, NJ: IEEE Press, pp.318-323, 2012

[3] M. Esteve, J. Katoen, VP. Nguyen, et al, Formal correctness, safety, dependability, and performance analysis of a satellite, Proceedings of the 34th International Conference on Software Engineering, ICSE. Piscataway, NS:IEEE, pp.1022-1031,2012

[4] B. Kizzort, Progressive automation in aerospace system[J], Aerospace Conference Proceeding, Vol.07,pp.116-118, 2002

[5] D. Yu, M. Shilong, Design and implementation of spacecraft automatic test language, Chinese Journal of Aeronautics, Vol.24, pp.287-298, 2011

[6] B. Wendler, Establishing minimum environmental test standards for space vehicles, Proceddings of the 21st Aerospace Testing Seminar, Washington D. C. , NASA, 2003