Remote Sensing Camera Automatic Test System Based on Ethernet

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Abstract. With the rapid development of high-resolution remote sensing camera and the rapid increase of the number of remote sensors, telemetry data and image data have the characteristics of large amount of concurrency and high real-time. These characteristics bring great challenges to the test, interpretation and processing of massive data, which requires a lot of manpower and time resources, meanwhile, it is easy to cause repeated test work because of the errors occur during operations and interpretations. In order to improve work efficiency, test coverage, test accuracy, comprehensiveness, and human resources, developing automatic and intelligent test equipment is becoming much more particularly urgent and necessary. The test system proposed in this paper uses the on-line monitoring and diagnosis system to analyse the running state of the equipment in real time, find out the system fault in time, locate and eliminate it. The system can put forward the network protocol of data processing and storage, command control, real-time analysis and transmission of telemetry information and display the realization way of the test system workflow. It is expected that the system test efficiency will be increased by more than 5 times. In addition, the efficiency of fault diagnosis and data processing will be increased by more than 3 times. The automatic test system can solve the conflicts between test quality and human resources, moreover, the architecture patterns based on Ethernet is easy to expand and reconstruct.

1. Introduction
In recent years, the research of high-resolution remote sensing satellites has been widely used in civil, emergency, emergency, disaster relief, military and other fields due to the characteristics of high spatial resolution, high temporal resolution, hyperspectral resolution and high radiation resolution [1-3]. With the growth of the remote sensing cameras, high resolution and wide coverage, the amount of data has been increased multiply, in addition, the complexity of cameras is becoming higher and the research cycle is constantly shortened. This paper presents a system test and solution based on Ethernet. It is expected that the system test efficiency will be increased by more than 5 times. In addition, the efficiency of fault diagnosis and data processing will be increased by more than 3 times. Traditional manual inspection and maintenance methods have been unable to meet the requirements of modern equipment. Automatic test system has become a necessary guarantee for the reliable operation of complex systems and equipment [4].

2. Design of Automated Test System

2.1. Design Objective and Difficulty of Automatic Test System
At the present stage, the independent analysis function of test system equipment and the ability of collaborative work cannot meet the current research requirements. The lack of data and information interaction with environmental test equipment and expert diagnosis system causes inefficiency and takes up more human resources.

2.1.1. Design Objective of Automatic Test System
- Optimizing and expanding the functions of electronic comprehensive test equipment which include data analysis and calculation function.
- Standardizing the interfaces between electronic comprehensive test equipment, optical test equipment and environmental test equipment.
- Establishing and solidifying the mode of electronic automatic test and system automatic test.
- Establishing an automatic test system of remote sensing camera which covers single machine test, environmental test and system test.

2.1.2. The Difficulties in System Design
- Actualizing the high integration and cooperation between test equipment.
- Building an efficient system architecture and actualizing the rapid data acquisition and transmission [5].

2.2. Network Architecture of ATS
The remote sensing camera electronic integrated test equipment is the core of the automatic test system. The electronic integrated test equipment equipped with a general network interface which communicate with other computers and test equipment. The network connection architecture of automatic test system is shown in Figure 1.

![Figure 1. Remote sensing camera the network connection architecture of automatic test system.](image)

Ethernet control application equipped with abundant protocols and good compatibility. Electronic integrated test equipment, optical test equipment and other equipment are linked together through Ethernet, which has good stability, long transmission distance, and advantages for system expansion.
and reconstruction [6]. Efficient automatic test could be achieved by linking different network connection which according to different test projects.

2.3. Hardware Structure of Automatic Test System

The hardware structure of automatic test system includes the following eight parts:

- Remote monitoring and control system mainly completes on-line fault monitoring and diagnosis, real-time operation status analysis and monitoring of the system [7,8].
- Expert diagnosis system mainly completes the remote processing and analysis of calibration data, spectrum test and other big data.
- Optical test equipment mainly including integrating sphere and blackbody for radiometric calibration.
- Optical test control computer is used as the main control equipment of optical test items. When conducting other test items, the electronic integrated test equipment serves as the master control equipment.
- Environmental test equipment mainly includes vacuum tank and temperature circulation box. The vacuum tank is used to provide the vacuum degree and high and low temperature environment required by the experiment. The temperature circulation box is used to provide the specified temperature for experiments.
- Single board test equipment mainly including oscilloscope, electronic load, etc. The oscilloscope is used to measure the shape of alternating current and pulse current wave. The oscilloscope can accurately detect the load voltage and adjust the load current accurately. At the same time, it can realize the short circuit of simulated load. The simulated load is inductive resistance and capacitance as well as the rise time of capacitive load current.
- Electronic integrated test equipment mainly completes command sending, telemetry acquisition and interpretation, power supply and distribution control, image display and storage, image and auxiliary data interpretation, etc.
- Network switch.

![Diagram](image)

**Figure 2.** The hardware structure of automatic test system of Remote sensing camera.

According to Figure 2, there are four information flows in the hardware structure diagram of automatic test system.

**Flow 1. Regular electronics joint test, test and general function inspection of camera**

The electronic integrated test equipment connects with the camera. The external equipment is generally the light source. Start the automatic execution of the test process, The test process could be automatically operated which including power on and power off, command sending, auxiliary data and image receiving and interpretation.

**Flow 2. Electronic environment test**
Electronic integrated test equipment is connected with camera, external equipment, vacuum tank and corresponding test equipment. The test equipment starts the test process according to the requirements of the test program. During the process, the environmental parameters of the camera are obtained through the communication with the test equipment, so as to call the test sub templates under different working conditions.

Flow 3. Environment test of camera subsystem
Generally, the environmental test equipment of subsystem are vacuum tank and corresponding measurement and control equipment. During the test, the collimator is used to check the function and performance according to the test template. The test equipment starts the test process according to the requirements of the test outline. During the process, the environmental parameters of the camera are obtained through communication with the test equipment, so as to call the test sub templates under different working conditions.

Flow 4. Optical system test
The communication between electronic integrated test system and optical test equipment is based on Ethernet communication protocol. Through the comprehensive scheduling of test program, the automatic operation of optical test, data interaction, remote processing and fault location could be achieved.

2.4. Workflow of Automatic Test System
Automated testing mainly solves the problems of test cases and criteria, instead of manual implementation of closed-loop test process. Therefore, automated test is a closed-loop test centred on electronic comprehensive test equipment. The whole process is highly automated. After the test process started, there is no need for manual intervention except for equipment failure, abnormal image and telemetry data. At the same time, compared with manual test, automatic test has better accuracy and reliability, and can complete more tests in limited time [9].

2.4.1. Interaction Protocol between Electronic Integrated Test Equipment and Other Equipment
- The network protocol uses the windows system. Each computer is located in the LAN, and the network address can be changed.
- Optical test control equipment, environmental test equipment, stand-alone / single board test equipment, expert diagnosis system, remote network monitoring terminal and other equipment computers (hereinafter referred to as other test equipment) have directories that can be obtained through the network (shared). When other test equipment requests, the electronic integrated test equipment records the file in the subdirectory of the directory.
- The electronic integrated test equipment starts the TCP server to connect with the listening port. After other test equipment connected, the handshake signal could be established.
- The electronic integrated test equipment facility accepts the name of the network directory and storage path in directory determined by the dedicated configuration instruction.
- The exchange between electronic integrated test equipment and other test equipment is completed in text mode. Command and replies are (data) lines ending with the symbol \(<\ CR > <\ LF>\) sequence (symbol code #13#10). Electronic integrated test equipment must send a reply line to answer requests from other test equipment.
- The command (reply) and command (reply) are separated by tabulation symbol (code #9).
- File names are stored and transmitted as required.
- The data transmission rate is 1Gbps, and the transmission order is low byte in the first and high byte in the last. Data transmission need not be subcontracted.
- In order to avoid overheating of camera focal plane during long-time operation, the switch on / off command group is specified in advance.

2.4.2. Spectrum Test Automation Process
In order to understand the workflow of the automated test system, the following is an example of the automatic workflow of spectral testing [10]. The test process consists of remote sensing camera, spectrum test equipment, spectrum test control equipment, network switch, electronic comprehensive test equipment, expert diagnosis system and remote monitoring equipment. The automation process of camera spectrum automation system is as follows:

- At the beginning of the test, the electronic integrated test equipment software starts the automatic acquisition mode of spectrum test, and establishes the handshake signal with the main control program of spectrum test.
- After the test equipment is set up, the switch-on command is sent.
- Communication flow and instruction set between main control computer of spectrum test and integrated test equipment of electronics. The command list between main control computer of spectrum test and integrated is shown in Table 1.

| Command | Use | Reply |
|---------|-----|-------|
| On      | The camera subsystem is switched on | Ok-normal |
|         |                 | Error-abnormal |
| Off     | The camera subsystem is switched off | Ok-normal |
|         |                 | Error-abnormal |
| Path    | Specifies the storage path | Ok-Path setup is normal |
|         |                 | Arguments-abnormal |
|         |                 | Ok-Data transmission is normal |
|         |                 | Arguments-Failed |
| Getn    | A list detector Numbers obtained by optical test control equipment or expert diagnostic system | Ok-Completed in a specified format and the next wavelength information can be sent |
|         |                 | Eaccess-Data is not stored in the specified path |
|         |                 | Error-Other errors |
| Start+  | When the spectrum test control equipment sends wavelength information, the integrated test device names the data file in terms of wavelength | Ok-Accepted, Camera start-up switch on / off command group |
| Wavelength | When the camera operating temperature exceeds the limit, the electronics integrated test equipment sends “Temperature high” string to the spectrum test control equipment | Error |
| Temperature | When the spectrum test control equipment sends "wavelength" information to control the comprehensive test equipment to store and send data files. Storage file naming format < date > < time > < matrix > < wavelength >. Raw, where < date > - refers to the |

- Inventory data, if the storage path does not exist, try to create a directory. If the directory cannot be created, EACCESS is returned.
- Starting data acquisition, the spectrum test control equipment sends "wavelength" information to control the comprehensive test equipment to store and send data files.
shooting date, the format is yyyyymmdd, < time > - shooting time, the format is hhmmss, < matrix > - the first digit of detector number is 01, < wavelength > - wavelength. For example: 20200824-164025-01-352.raw. Internal structure of time information segment is shown in Table 2.

| Displacement | Size (byte) | Message segment |
|--------------|-------------|-----------------|
| 0            | 2           | Year            |
| 2            | 2           | Month           |
| 4            | 2           | Day             |
| 6            | 2           | Hour            |
| 8            | 2           | Minute          |
| 10           | 2           | Second          |
| 12           | 4           | Microseconds    |

• When the main control equipment of spectrum test is abnormal, the "wavelength" information part of the instruction sent to the comprehensive test equipment is "error". After receiving the information, the integrated test equipment will return to "understand" and pop up an error dialog box in the spectrum test control software interface.

• When the remote sensing camera works for a long time and the operating temperature exceeds the limit, the electronic comprehensive test equipment sends the "temperature high" string to the spectrum test equipment to start the camera the switch off command group.

• When the main control equipment of spectrum test judges that all the states are collected, the finish information is sent to the comprehensive test equipment to start the switch off command group.

• The expert diagnosis system can obtain the spectrum test data at any time, and it process and analyse the data in real time.

3. Conclusion
In this paper, according to the requirements of remote sensing camera system automatic testing, an implementation method of automatic test system based on Ethernet is proposed. The test system architecture and test flow are established. It is expected that the system test efficiency will be increased by more than 5 times. In addition, the efficiency of fault diagnosis and data processing will be increased by more than 3 times. The number of testers will be greatly reduced, and the expected target is basically achieved. The automatic test system makes the camera test process standardized, and it improves the work efficiency, test coverage, test accuracy and comprehensiveness. It liberates human resources, and provides reliable guarantee for remote sensing camera development. The results show that the system has the advantages of high data transmission rate, strong remote data processing and analysis ability, and good real-time performance, which can better meet the test requirements of remote sensing camera.

Acknowledgment
The author would like to thank the following people for their mentorship, advice, and support during this phase of the project: Li Yongqiang, Guo Yongxiang.

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