The Design and Realization of C Band Spare Parts Checkout Systems in the Shipboard

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Abstract. The detection and rotation of spare parts is a very important work for the unified measurement and control system of shipborne C frequency band. In addition to the routine maintenance work that needs to be carried out regularly every six months, it is also necessary to conduct targeted testing of spare parts before the implementation of test tasks. As a complex measurement and control system, big body of spare parts, short test rotation period, complex detection process, a direct result of the spare parts inspection process is difficult and long time consuming, and frequent removal of equipment can damages to the system electrical performance, precision microwave components, so the development of a set of effective spare parts detection system is of great significance. In this paper, a design scheme of rapid spare parts detection system is proposed, relevant application tests are carried out, 56 percent less time than traditional methods, which is successfully applied to onboard equipment.

1. Introduction
The shipborne C-band unified measurement and control system is an important part of China's third-generation ocean-going space survey ship measurement and control system.⁴ Because the marine monitoring and control is affected by multiple environmental stresses such as humidity, salt spray, vibration, and rocking, in order to ensure the normal operation of the equipment, it is necessary to test and maintain the on-board equipment and spare parts every six months.⁵ Due to the lack of the necessary interface environment under the machine, the spare parts are tested by on-board testing. The wide distribution of equipment, large spare parts, and cumbersome test procedures make the on-board detection difficult and time consuming, and some important modules such as low noise field effect amplifiers and D/C devices on the receiving channel. Machine detection will result in a series of adjustments to equipment parameters. At the same time, frequent disassembly of equipment can also damage the electrical performance of precision radar microwave components and systems. Therefore, it is extremely urgent to develop a spare parts inspection system to solve the above problems by innovating spare parts detection methods.

2. Design and verification of the simple test device under the machine
2.1. Overall design ideas
The high-frequency microwave receiving component adopts the on-board spare part detection mode, which is because the on-board detection can provide the interface environment required for the high-frequency microwave receiving component to work. The interface environment here mainly refers to the hardware interface environment, including the electrical interface environment and the monitoring
interface environment. The electrical interface environment mainly refers to the power supply environment. All high-frequency microwave receiving components are low-voltage DC drives, and the differences between different components lead to different specifications of the DC power supply interface. For example, LNA and D/C usually require a group of +12V. DC power, frequency synthesis requires +15V, +5V two sets of DC, RF ammeter attenuator needs +5V, -5V two sets of DC power supply. The monitoring interface environment refers to a hardware support environment in which the external input and output information of the high-frequency microwave receiving component can be correctly processed. The external input and output information includes various control commands and parameter setting information for component operation and status information reported by the component. Therefore, the first thing to achieve under-machine detection is to provide the same hardware interface environment as on-board.

2.2. Hardware interface combing

In order to realize the same hardware interface environment under the machine detection, the project team comprehensively combed the function interface definition of the C-band measurement and control radar high-frequency microwave receiving component, and complied with these definitions, with the frequency synthesis module, LO amplifier, single-point frequency lock phase The three microwave receiving components of the source are the devices to be tested, and a simple test device under the spare parts machine is designed. The device is used to test the three key parameters of phase noise, spurs and third-order intermodulation of these three components. The test results are compared to verify the matching between the provided interface environment and the on-board state, which fully proves the feasibility of the test under the component machine. The combing table of the functional interface is shown in Table 1.

| Component name                      | Pin         | Functional interface definition | Type of interface |
|-------------------------------------|-------------|--------------------------------|-------------------|
| Frequency synthesizer               | 1 RXD+      | DE-9S                          |
|                                     | 2 RXD-      |                                |
|                                     | 3 TXD-      |                                |
|                                     | 4 TXD+      |                                |
|                                     | 5 GND       |                                |
|                                     | 6 LD        |                                |
|                                     | 7 +5V       |                                |
|                                     | 8 +5V       |                                |
|                                     | 9 +15V      |                                |
| Single point frequency lock phase source | 1 +15V     | DE-9S                          |
|                                     | 2 GND       |                                |
|                                     | 3 +8V       |                                |
|                                     | 4 GND       |                                |
|                                     | 5 Locked state |                        |
|                                     | 6 Signal output status |                |
| LOA                                 | 1 RXD+      | DE-9S                          |
|                                     | 2 RXD-      |                                |
|                                     | 3 TXD-      |                                |
|                                     | 4 TXD+      |                                |
|                                     | 5 GND       |                                |
|                                     | 6 LD        |                                |
|                                     | 7 +5V       |                                |
|                                     | 8 +5V       |                                |
|                                     | 9 +12V      |                                |
It can be seen from Table 1 that the function interface definitions of the frequency synthesizer module and the LO amplifier component are the same except for pin 9 (DC power supply pin), and the function interface can be shared. Therefore, for the simple test equipment that is only used to detect the frequency synthesizer module, the LO amplifier and the single-point frequency lock phase source, only two sets of functional interfaces need to be designed, that is, the frequency synthesizer/LO amplifier function interface and the single-point frequency lock phase. Source function interface. The panel design of the simple test device under the component machine is shown in Figure 1.

**Figure 1.** Simple test device panel design

XS1 is a serial communication interface, XS2 and XS3 are respectively frequency synthesizer/LO amplifier function interface and single-point frequency lock phase source function interface, and XS4–XS7 respectively provide +15V, +12V, +5V DC power supply by external regulated DC power supply. And signal ground (GND) interface. The definition of the monitoring between the function interface XS2, XS3 and the serial port XS1 and the definition of the DC power between the XS2, XS3 and the electrical ports XS4 to XS7 are shown in Table 2.

**Table 2.** Simple test device interface definition table

| Functional interface | Pin | Electrical interface / serial interface | Pin | Function definition |
|----------------------|-----|----------------------------------------|-----|--------------------|
| XS2                  | 5   | XS7                                    | Single pin | +15V/+12V   |
|                      | 9   | XS4                                    | Single pin | GND          |
|                      | 1   | XS1                                    | 2   | RXD+            |
|                      | 2   |                                        | 4   | RXD-            |
|                      | 3   |                                        | 7   | TXD+            |
|                      | 4   |                                        | 9   | TXD-            |
| XS3                  | 1   | XS4                                    | Single pin | +15V        |
|                      | 4   | XS7                                    | Single pin | GND          |
|                      | 5   | XS1                                    | 3   | Locked state    |
|                      | 6   |                                        | 5   | Signal output status |

### 2.3. Experimental verification

We will connect the frequency synthesizing module, LO amplifier, and single-point frequency lock phase source to the device for testing, which can be normally powered and controlled, as shown in Figure 2. Tests have shown that the device can provide the same hardware interface environment for the
above three components when testing on the machine, as long as the corresponding instrumentation is
connected to complete the same test as the onboard test.

![Test connection diagram under the frequency machine](image)

Figure 2. Test connection diagram under the frequency machine

3. Design and verification of integrated inspection system

3.1. Design ideas
In order to meet the practical requirements of more than a dozen component inspections, a more
centralized under-machine detection system must be designed. The system must be able to provide
centralized power and centralized monitoring of all components under test. The most common form of
design is a plug-in test system with a uniform port. According to the electrical characteristics of the
tested components, multiple power modules can be used to provide multiple sets of DC power. The
monitoring and processing aspects are designed in the test box. The bus interface design is used to check
the monitoring information of all the tested components. The pin definition, thereby determining the
cable connection relationship between the bus interface and the test port of each component of the sub-
box, so as to form an independent test system with compact structure and uniform interface as a whole.

3.2. Bus design
Since the monitoring process of the test system requires centralized acquisition of the status data of the
component under test and control of the component in response to the user's operational settings, the
system must have a bus controller and peripherals for inputting user control information and display
status information. Looking at the monitoring information of various components, we can see that they
are all low-frequency switching information. Therefore, using the single-chip microcomputer as the
monitoring processing unit, equipped with portable display terminals and keyboards and other
peripherals, it can fully realize the bus control of various switching quantities.

3.3. Internal and external interface relationship

3.3.1. External interface
The communication mode between the monitoring processing unit and the external is serial port, and
the communication protocol adopts RS-422A. The communication parameters are: baud rate 19200, 8
data bits, 1 stop bit, no parity. The communication needs to be connected to the serial server. The
network communication IP address, port and serial communication parameters on the serial server can
be set. The main communication content of the interface is the query and response, attenuation setting
command and response, and rejection response sent by the monitoring software.

3.3.2. Internal interface
We combed the interface relationship of core spare parts such as low noise amplifier and frequency
synthesizer. The communication mode of each module is serial port, and the communication protocol
adopts RS-422A, as shown in Figure 3.
Figure 3. Internal interface relationship diagram

a). IF_MCP_TTL_O / IF_MCP_TTL_I: Interface between the monitoring module and the TTL level output and input. The monitoring interface is TTL level. The maximum number of output channels of the control signal design is 80 TTL levels, and the 8 outputs are a group, which are configured as input and output in units of groups;
b). IF_MCP_Uart: Interface between the monitoring module and the standard Uart. The maximum number of interfaces is 10, of which 2 RS-232 and RS-422 interfaces can be configured, and 8 RS-422 interfaces, including the interface with the outside;
c). IF_MCP_DA: interface between the monitoring module and the analog signal output. The interface is an analog voltage output with 12-bit analog signal control. The range is -2V to +2V or 0V to 5V.
d). IF_MCP_AD: The interface between the monitoring module and the analog signal input. The interface is 6 analog signal inputs with an accuracy of 12 bits and a range of 0V to 5V analog signals.

3.3.3. DC power supply relationship. The following spare parts are included in the test system test range: low noise amplifier, D/C, frequency synthesizer, single point frequency lock-in source, LO amplifier, RF attenuator, IF attenuator, IF equalization amplifier, T-U/C. According to the module status parameters, the module power supply relationship can be summarized. The low noise amplifier, D/C and LO amplifiers are all +12V, the frequency synthesizer and the single point frequency lock phase source are +8V/15V, RF attenuator and IF attenuation. The device is +5V/-5V and the TU/C is +12V/-5V.

In order to optimize the power supply system composition, according to the power supply relationship of each module, the project team decided to adopt the 4NIC-Q3L41 power supply module (V1:15V/3A, V2: 8V/3A, V3: 5V/2A) and 4NIC-Q3L39 type produced by a certain company. The power modules (V1:12V/2A, V2: 5V/2A, V3: -5V/2A) form a DC power supply system.

3.4. Monitoring processing unit

The main function of the monitoring and processing unit is to control the working parameters and the working status of each module unit in the device. The monitoring processing unit includes six functional requirements: main control module (MCPS_Main), monitoring mode processing module (MCPS_MonMode), human-machine interface processing module (MCPS_UI), parameter control processing module (MCPS_Param), and device module status detection processing module (MCPS_Status), the control data processing module (MCPS_MCS). After investigation, we decided to use the PHILIPS single-chip 32-bit microcontroller LPC2214 based on real-time simulation and embedded tracking as the core of the printed circuit board as the monitoring processing unit.

3.5. Software writing and operation interface drawing

3.5.1. Software editing. The software design is carried out on the embedded system hardware platform based on the microprocessor LPC2214, and adopts the coding format and naming principle unified with the shipboard C-band unified measurement and control system. The supporting software is mainly Keil
uVision3 and Developer Suite 1.2. Keil uVision3 is responsible for the editing of the software, and compiles the software developed by Keil uVision3 into a binary file that can be recognized by the microprocessor LPC2214 through Developer Suite 1.2. Finally, the Keil ulink2 debug adapter is connected to the monitoring processing unit through the USB port of the PC. Program debugging.

3.5.2. Interactive interface. The human-machine interface is touch-type, and the main function is to provide the operator with display of device parameters and status, and provide effective and convenient operation. The interface is drawn with Photoshop graphics software. When a certain position is pressed in the operation interface, the I2C interrupt bus is started, the key value is read, the main control sub-module is notified to perform software call, the key value is processed, and the corresponding interface is displayed.

4. Spare parts detection system function realization

According to the previous design plan, the project team completed the pre-assembly and basic commissioning work of the spare parts inspection system. The power-on condition was good, the operation interface was normal, and the state feedback information was accurate. After the development and debugging of the spare parts inspection system, the project team conducted on-machine testing for important spare parts. The project team members tested the LNA module, D/C module, CNC attenuator, LO module, TU/C, LO amplifier and other spare parts in two ways: the average spare part inspection working time of the spare parts inspection system was 17.6 minutes. The average test working time was 40.3 minutes. After the data comparison, the spare parts inspection system has a good test effect, and the working time is greatly shortened, and the effect is remarkable. The specific test situation is shown in Figure 4.

![Figure 4. Spare parts inspection system LO spare parts inspection diagram](image)

![Figure 5. New and old method spare parts test time](image)
5. Conclusion

The spare part detection system of the shipboard C-band unified measurement and control system has innovated the spare parts detection method, which has changed the limitation of the traditional spare parts detection. Through the development of the system, spare parts for important microwave devices such as low noise amplifiers and down converters used in the C-band unified system can be used. Perform fast power-on and detection without removing the installation in the radar link for online testing, shortening the inspection time of spare parts and improving the reliability of the equipment. At present, it has been successfully applied to the measurement ship C-band unified measurement and control system, and has been promoted and applied in the development process of the new measurement ship, bringing good economic benefits and practical effects.

References

[1] Gu Jihui, Li Ming. Radio Frequency and Microwave Electronics [M]. Beijing: Publishing House of Electronics Industry, 2011.

[2] Di Chang, Xia Zhang, Qiong Liu, Ge Gao, Yue Wu. Location based robust audio watermarking algorithm for social TV system. In Pacific-Rim Conference on Multimedia 2012 Dec 4 (pp. 726-738). Springer, Berlin, Heidelberg.

[3] Di Chang, Xia Zhang, Yue Wu. A Multi-Source Steganography for Stereo Audio. Journal of Wuhan University (Natural Science Edition). 2013; 3: 277 - 284.

[4] Zhang Xia, Chang Di. Sonic audio watermarking algorithm for cable-transmission. The 2nd International Conference on Information Science and Engineering, Vol. 7, 2010, pp. 5395-5398. IEEE Catalog Number: CFP1076H-PRT, ISBN: 978 - 1 - 4244 - 8096 - 8.

[5] Zhang Xia, Chang Di, Huang Qian. An audio digital watermarking algorithm in DCT domain for air-channel transmitting. Journal of University of Science and Technology of China, Vol (41), 2011.7, pp: 642 – 650.

[6] Zhang Xia, Chang Di, Guo Wei, etc. An Audio Steganography Algorithm Based on Air-Channel Transmitting. Journal of Wuhan University (Natural Science Edition), 2011, 57 (6): 499 – 505.

[7] Qi Jingwei. Experimental Research on Computer Software Programming Based on C Language [J]. Technology and Enterprise, 2015 (01): 73.