Design and implementation of Vibration Detecting System of Ship-borne Radar

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Abstract. Although redundancy design has been adopted by measure angle computer (MAC), but the switches between the host and the backup were by mankind which can’t catch up with requirement of system real time. This paper analyses the task of primary-backup switching and confirm the time of auto switching are system fault and communication interruption. It proposes a new strategy by using the characteristic of dual -network of MAC by which add fault status words in net send data bags and changes the net send time series. This strategy doesn’t need change hardware and only last one frame data on switching process which great enhancing the reliability of MAC.

1. Introduction
During the survey ship's mission at sea, the shipborne measurement and control radar has been working in complex and severe sea conditions such as surge, heavy load, strong impact, fatigue, and corrosion for a long time, which puts forward higher requirements for improving the reliability of the radar system. The sky servo feed sub-system is the key equipment of the shipborne measurement and control radar. Its main task is to always effectively track the target, complete the effective reception and transmission of the radio frequency signal, and send the angle measurement data to the ship central machine in real time through the measurement and control system Ethernet. In the process of equipment development, the use of modular design and the selection of high-quality, high-stability, low-failure components are the guarantee of system reliability. The computer is the core component of the Tianwei feed sub-system. It is responsible for system control, status monitoring, signal acquisition, information transmission, and data processing. High reliability is one of the important requirements for the computer. Redundancy design is an important means to improve the reliability of the system. Some components of the system are repeatedly configured. When the system fails, the redundantly configured components intervene and assume the work of the failed components, thereby reducing the system's failure time. Redundancy includes hot backup and cold backup of the system. The cold backup of the system generally has problems such as long switching time and delayed task timing, which does not meet the real-time requirements of the Tianshi feedback system. Although the angle measuring computer in the current day servo feed sub-system adopts a redundant design, the switch between the main and standby machines is still carried out through the table control buttons. Therefore, the judgment of the fault state will affect the timing of the system's master-slave switchover. In view of this situation, this paper uses the existing equipment status of the radar system to transform the angle measuring computer to realize the automatic switch of the angle measuring computer and improve the reliability of the system.
2. Working principle of angle measuring computer
The angle measuring computer is an important part of the sky servo feed sub-system, it is the center of data acquisition, data transmission and data calculation in the sky servo feed sub-system, and one of the key equipments in the tracking and measurement system. The main functions include:

①. Complete the operation control and status monitoring of the Tian servo feed sub-system;
②. Receive center computer, system monitoring station / radar data processor, inertial navigation, low-light TV and other equipment data to realize real-time data reporting;
③. Complete the management and control of the antenna working mode, and realize the remote control of the sub-system;
④. Complete antenna polarization control, program control of program-controlled attenuator and power combiner;
⑤. Complete temperature detection, vibration detection and central body humidity detection of each monitoring point of the Tian servo feed sub-system;
⑥. Complete real-time display and recording of measurement data, post-event data processing and text printing in corresponding format; complete sub-system assisted automated testing.

The angle measuring computer switches the main and standby machines through the tabletop key switch. The output signal of the switch is divided into three channels: one to the dual-machine switching unit, which controls the relay on the dual-machine switching board to realize the external transmission of the host serial port information; the other two After the PCI-1712 boards in the two computers are collected, the status is judged in the software code. The software first judges the A / B machine. If it is the A machine, the collected switch state is assigned to the Isonline function; if it is the B machine, the collected switch state is inverted and assigned to the Isonline function to realize the host network data External transmission. It can be seen that although the current angle measuring computer adopts a redundant design, the dual-machine switching is still manually implemented, and the timing of the switching depends on the degree of recognition of the system fault status by the post staff. Once the host machine fails and cannot switch the standby machine in time, it will cause data interruption and loss of control instructions, which affects the continuity of task data and poses a hidden danger to the safe operation of the system.

3. Angle measuring computer interface signals and classification
The angle measuring computer is the data center of the sky servo feedback system. There are many types of data and different interface forms. It is necessary to classify the interface signals and perform different forms of processing for different signal forms or sources when switching between two machines. For convenience of description, the two angle measuring computers are called A and B respectively. When the system is working, two computers receive data at the same time, according to the online status of A or B, the host sends data externally, but the standby does not send data.

4. Key technology of dual-machine switching
When the system is running, the master and backup machines switch because the host has failed or the host communication is interrupted and the standby machine works normally. In order to avoid unnecessary switching or the main and standby machines compete for priority, repeated switching causes the system to be unavailable. Real-time and accurate monitoring of the equipment status of the master and backup machines, and at the same time report their respective status to the other party. Therefore, the key technologies for dual-machine switching include fault monitoring and status reporting.

4.1. Fault monitoring
Simply monitoring the fault state of the computer has no practical significance for the operation of the sky servo system. Since the angle measuring computer is the center of data interaction between the
equipment of the sub-system and the data transmission channels are not the same, the angle measuring computer can be divided. The fault monitoring result of the system is used as the fault state of the computer to determine the timing of the two-machine switching. The main function of sub-system fault monitoring is to monitor the working status of each replaceable unit. When a fault occurs, it can quickly and accurately locate the fault location and the smallest replaceable unit. At the same time, it sends an alarm through sounds and indicators to remind the user to handle in time. The fault monitoring function is implemented by means of unit self-inspection, mutual inspection, and reporting. All faults and status information are collectively collected to the angle measuring computer for centralized processing and display. Failure monitoring technologies include: ①. The built-in test (BIT) function is set in the circuit unit of the B code shaft angle encoder and the polarization controller, and the status bit is set in the digital communication with the angle measuring computer. Through these methods, the operating status of each replaceable unit can be monitored. ②. Mutual inspection logic is set between the units to ensure the accuracy of fault monitoring. ③. Check the data continuity by adding the packet sequence number in the unit communication protocol. Therefore, real-time and accurate monitoring of various transmission information of the angle measuring computer can be realized.

4.2. Status report
Although the angle measuring computer can realize fault monitoring, only after the monitoring results are reported to the other party can the other party’s fault status be known, so as to decide whether to switch the master and backup machines. At present, "heartbeat" technology is generally used to monitor the working status of the other party. The A / B machine regularly sends the fault status, "heartbeat", through a dedicated channel, and then the two parties judge whether the other party is working properly based on the received heartbeat or whether enough heartbeat signals are received within a certain time. Since the angle measuring computer needs to receive and send data to the internal network and the external network at the same time, and the reception and transmission of data are completed in the same time period, the fault status can be sent to the same network at the same time (status), by analyzing the data received in the same cycle, the fault status of the other party can be known, and then the online status of the A / B machine can be automatically switched.

5. Implementation method of dual-machine switching

5.1. Network timing
Intranet data exchange is carried out at a frequency of 20 Hz. The timer sends interrupt signals such as 1 Hz, 20 Hz, 20 Hz transmission, and 20 Hz reception to the computers on the network. The 20 Hz transmission signal is different for each network node, and each node is at the corresponding 20 Hz Send a data message when the transmission interruption time comes. The 20Hz reception interrupt signal indicates that all network node data has been sent. The 20Hz interrupt and 1Hz interrupt are used for time synchronization and generating the number of beats required in the network data. At present, the angle measurement computer first judges the online status of the main and standby machines, and then sends the number of the network. Therefore, the number of angle measurement computers sent to the intranet is arranged at the 21ms of the 50ms repetition period. In order to ensure that the two computers send numbers simultaneously without causing data loss, the timing of the two computers sending numbers must be adjusted to different times, which can be achieved by connecting the reserved timing signal of the timing board to one of the angle measuring computers.

5.2. Data transmission
In the internal network, each sub-system device sends data packets through broadcast or multicast through SOCKET, and performs data exchange according to a fixed time sequence. The exchange frequency is 20 Hz. In order to report the fault monitoring results to the intranet, it is necessary to modify the format of the data frame sent by the network and add the fault status word to the original data frame. The length of the data frame sent by each device on the internal network is 256 bytes. By querying the
internal information transmission convention, the format of the data frame is shown in Table 1. Because the maximum length of the data content of each device is only 192 bytes, there is enough space in the padding part to add the fault status word.

**Table 1. Intranet data frame format**

| Unified message format | Message length | Subsystem number | Data length | Data content | Filled part |
|------------------------|----------------|-----------------|-------------|--------------|-------------|
| 6bytes                 | 2bytes         | 1byte           | 2bytes      | N bytes      | 245-N bytes |

The angle measuring computer already has the functions of fault monitoring and system inspection, so it is only necessary to convert the monitoring results into fault status words. The fault status word is defined as follows (here only represents the received data), filled to the 253-256 bytes of the data frame. Since the total length of the data frame is not changed, it will not cause any impact on the transmission and reception of network data.

- Bit0: voltage signal failure, 0 means no failure, 1 means failure;
- Bit1: Pulse signal failure, 0 means no failure, 1 means failure;
- Bit2: Serial information failure, 0 means no failure, 1 means failure;
- Bit3: Network data failure, 0 means no failure, 1 means failure.

5.3. **Data reception**

Each device in the internal network adopts an event-driven mechanism to receive data, and stores all received data in the receive buffer. When the receive interrupt signal sent by the timer arrives, it means that all devices have been sent. The data is processed. In order to detect the data transmission status of each device, you can define the first 2 bytes of the receive buffer to indicate the status of the received data packet. The corresponding relationship is as follows. In each bit, 0 indicates that the data is invalid and 1 indicates that the data is valid. Among them P3 represents the data transmission situation of A machine, P4 represents the data transmission situation of B machine.

**Table 2. Packet status**

| Bit | 15–11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-----|-------|----|---|---|---|---|---|---|---|---|---|---|
| Node| Stain | P4 | P23 | P22 | P21 | P15 | P12 | P9 | P7 | P3 | P2 | P1 |

5.4. **Two-machine switch**

After the system is running, the angle measurement computer scans the status of the main and backup machines, data packet status and fault status in each cycle. According to the logical relationship between the three, the fault status and communication status of the main and backup machines can be judged. It can realize automatic switching between the main and standby machines. When working in real time, the two computers simultaneously receive data from the external network and the internal network, and perform corresponding real-time data processing at the same time. After the processing is completed, the data is sent to other computers on the internal network at the specified intranet transmission time nodes, but in Only one computer sends data to the external network in the same cycle. After the host is started, in the first 50ms cycle, only the "Enable Host" command is sent to the internal network, and the second cycle begins to send data to the internal network and the external network at the same time. At the same time, the network status is monitored at any time. Interruption, that is, send the "switch standby command" to the intranet in the same cycle, the next cycle will no longer send data to the external network, the backup machine monitors the network status at any time, after receiving the host intranet data is abnormal or not received in the host When the network and the external network data, replace the host to send data to the external network. The switching process is shown in Figure 1.
5.5. Result analysis

In order to verify the data loss during the two-machine switchover process, we analyzed the data received by the external network center machine. During the test, the network cable of the external network of the A machine was manually pulled out. The data received by the central machine is shown in Table 3 below. It can be seen from the table that due to the period of network interruption, machine A is used to send a command to switch the standby machine to stop sending data to the external network. Therefore, the central machine receives data as a reframe, and the next cycle starts to send data to the external network. The data received by the central unit is back to normal.

Table 3. The center receives data

| Time       | Azimuth | Pitch angle | distance | Azimuth error | Pitch error | AGC | Data Sources |
|------------|---------|-------------|----------|---------------|-------------|-----|--------------|
| 10:25:16.300 | 13.256° | 28.032°     | 963.032 Km | 0.02V         | 0.01V       | 19 dB | machine A    |
| 10:25:16.350 | 13.324° | 28.104°     | 962.859 Km | 0.01V         | -0.01V      | 19 dB | machine A    |
| 10:25:16.400 | 13.409° | 28.179°     | 962.648 Km | -0.02V        | 0.02V       | 21 dB | machine A    |
| 10:25:16.400 | 13.409° | 28.179°     | 962.648 Km | -0.02V        | 0.02V       | 21 dB | machine A    |
| 10:25:16.500 | 13.586° | 28.267°     | 962.107 Km | 0.03V         | 0.02V       | 21 dB | machine B    |
| 10:25:16.550 | 13.647° | 28.346°     | 961.892 Km | 0.01V         | 0.01V       | 22 dB | machine B    |

Figure 1. Flow chart of dual-machine switching
6. Conclusion
In view of the shortcomings of the current angle measurement computer dual-machine cannot be automatically switched, which is difficult to meet the real-time requirements of the system, the task of dual-machine switching and the fault monitoring content of the main and backup machines are introduced. The conditions for automatic switching are determined as system failure and communication interruption, and According to the current equipment status, using the characteristics of the dual-network communication of the angle measurement computer, the dual-machine automatic switching is realized. When the dual-machine switching operation is performed, only the 50ms period of the switching is used to process the switching command without data transmission, which is extremely Improve the reliability of the system. This method does not require the establishment of a dedicated heartbeat channel, no hardware changes, and only requires partial changes to the software and timing relationships.

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