Design of Full Digital Telemetry Recording System Based on Disk Array

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Abstract: Aiming at the design flaws of the previous generation DRS, a new remote sensing digital recording system RDRS based on RAID technology and 64-bit PCI bus was redesigned and implemented. The architecture design and system software and hardware design were comprehensively and deeply explained. The entire design process.

1. Introduction

China's telemetry recording equipment has experienced two generations of double-density tape drive and rotary head tape drive, which are still in use.[1-3] They are all analog recording devices in terms of recording principle. In the long-term use, many defects have been exposed: (a). Tape consumables Dependent on imports, expensive, with small recording capacity, low reuse rate, and short data retention time. (b). The magnetic head and the mechanical belt transport mechanism are precision processing devices, the adjustment process is quite complicated, the long-term use is severely worn, the recording performance is significantly deteriorated, and the maintenance of the equipment is greatly inconvenient. With the rapid development of computer hard disk manufacturing technology and the advent and continuous application of digital storage technology, DRS (Digital Record System), which uses large-capacity high-speed hard disk to record analog telemetry signals, has emerged and has become a replacement product for telemetry recording equipment. However, there are insufficient design: (a). The degree of digitization is not high - the recording signal center frequency is only 2.1MHz, and the left-right circularly polarized 70MHz pre-detection signal cannot be directly recorded. It depends on the additional analog down-converter for conversion processing, and it is not suitable for the new digital integrated baseband remotely. Recording requirements for the equipment. (b). Poor scalability - due to the use of dedicated data transmission channels, limited bandwidth (16bit) and fixed, once you want to increase the number of recording signals, you can only increase the number of hardware channels to increase the bandwidth, correspondingly increase the board to control the drive record The number of cards and the relationship between the input and output interfaces has changed. (c). The reliability of the single hard disk working mode is difficult to guarantee. Once the hard disk is damaged, the entire system is faulty and the recorded data cannot be recovered. (d). Failure to use internationally accepted technical specifications and standards is not conducive to product upgrading, and it is difficult to form new industry standards in the long run. The above shortcomings indicate that DRS has fundamental flaws in the initial architecture design. If you want to completely overcome it, you must re-improve the architecture design and try to adopt the advanced and popular technology in digital storage at home and abroad. The remaining disk array technology provides us with new design ideas and concepts. After in-depth research and demonstration and a large number of preliminary experiments, the RDRS of the all-digital telemetry recording system with RAID array as the core was finally designed and implemented.

2. Design of the System

2.1. Machine architecture design.

The RAID standard provides a comprehensive solution for digital storage. RAID5 uses a physical strip of disks with distributed parity to distribute data and redundant parity information across a single disk. This ensures data security. Get high data throughput and disk utilization, especially for high-speed continuous large block data transmission. Considering the extremely high security,

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real-time, large storage space and more recording channels of the telemetry record, the array module uses 5 SATA hard disks with 100GB capacity to form the RAID5 standard, and uses the high-performance ARECA-1120 SATA RAID. The control card is used for driving, and the RAID card adopts OEM products, which can reduce the hardware development workload. The reason why the higher performance SCSI hard disk is not used as the module is because the SCSI hard disk data interface is too large (50 core), and the SATA hard disk is the next generation high performance hard disk of the increasingly popular serial ATA interface on the market. The data transmission rate has reached 300MB/s, which is close to SCSI hard disk (320 MB/s), but its interface cable is only 8 cores. The wiring is very convenient and flexible. It is very suitable for forming array modules, which can save space and facilitate quick replacement. The overall architecture is shown in Figure 1.

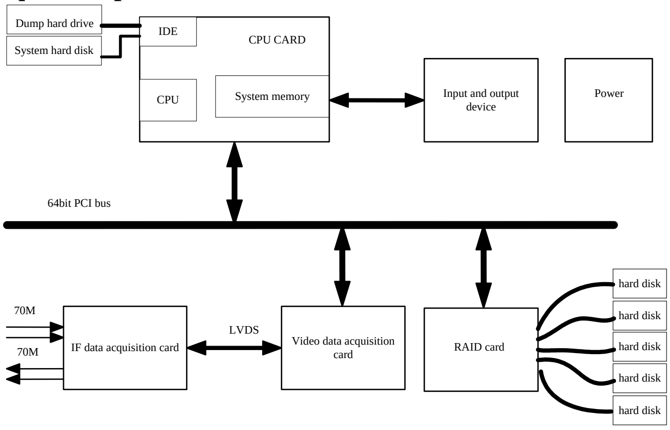

Figure 1. RDRS complete machine architecture frame

It uses a 64-bit extended PCI bus as a hardware development platform to provide high data transmission bandwidth of 528 Mb/s, while the CPU still uses a high-performance 32-bit P4 (2.4G) processor to directly map bus buffer through the host bridge. To the 64-bit bus address space. The hardware part independently developed a versatile and highly scalable PCI-based IF and video capture card. The software environment is based on the RT-Linux 3.1 real-time operating system kernel, developed under the RedHat 8.0 (kernel version Linux 2.4.18) system platform, and the underlying driver and user application are compiled using the standard C language. In the Kylix development environment, the user interface program under X-Windows is written in C++. Due to the system's specified recording and playback speed of up to 500Mbps, the PCI video capture card has a very high requirement for system interrupt response time. For this purpose, the Linux-based real-time operating system RT-Linux platform is specially selected. RT-Linux can be used in the Linux kernel source code. Based on the modification of part of the system program code to improve the real-time of Linux, the modified Linux (ie RT-Linux) can quickly respond to hardware interrupts (interrupt response time is less than 15 microseconds), meeting the real-time requirements of the system, for high speed Collecting without losing data guarantees. At the same time, a set of standard interface functions is provided to realize data transmission and sharing between RT-Linux processes and ordinary Linux processes. Because the data files recorded by the system are sometimes up to tens of GB or even hundreds of GB of capacity, the ordinary file system can not meet the capacity requirements under RT-Linux. For this purpose, the XFS file system is transplanted to manage the collected files. XFS is Silicon. A new high-performance 64-bit file system developed by Graphics that extends the partition and file capacity limits (up to 9000TB) and increases file storage processing speed.

2.2. System hardware design.

The hardware structure design is shown in Figure 2. The main design components are IF and video capture cards, which are divided into two parts: recording circuit and playback circuit. When data is recorded, the 70M IF signal is first filtered by the surface acoustic wave filter, and then the signal is fixed by the fixed gain and AGC circuit. The intensity is controlled within the ideal level range of

A/D sampling. The high-speed ADC (40MSPS) is used to directly sample the 70M signal and then send it to the FPGA of the IF acquisition card. The frequency spectrum of the mid-band pass signal is moved down to the baseband by digital down-conversion. The two baseband signals of I and Q are formed, and the CIC filter is used for sampling rate conversion to obtain a multi-channel video digital group signal, which is sent to the FPGA of the video capture card through the LVDS high-speed interface to complete data packing, buffering and timing. Control, when the data fills a data block size, the video capture card sends an interrupt to the system, requests data transmission, and after the system responds, it sends the data to the system memory through the 64-bit PCI bus in DMA mode, and the data in the memory accumulates to a certain amount of data. The PCI bus writes the data blocks to the RAID card and distributes them to the disk array. The playback process is the reverse process of recording. The main difference on the circuit is that the video digital group signal should recover the I and Q two orthogonal signals through the digital phase shift network and the digital group delay network respectively and control the frequency divided by the common DDS clock. The local oscillator NCO performs digital up-conversion to complete the baseband spectrum shifting upward, and then obtains 70M intermediate frequency analog signal through the high-speed DAC to complete the playback process.

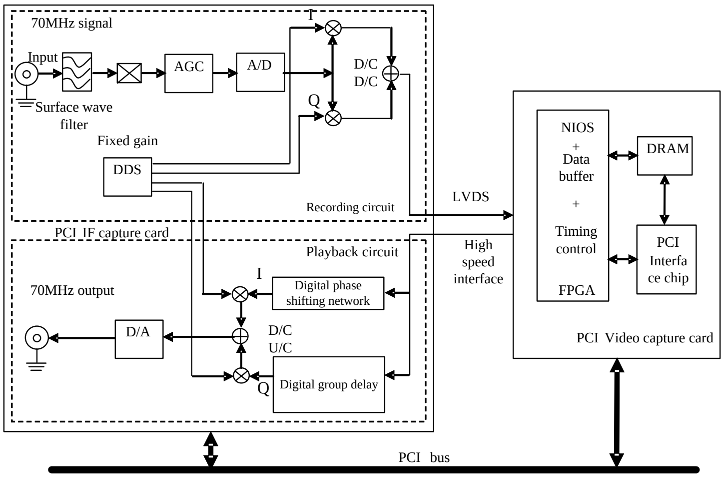

Figure 2. Hardware block diagram

2.3. Design of the system software.

The main function of the system software is to coordinate with the supporting hardware to complete the real-time recording and post-playback of the signal before the intermediate frequency detection. It is divided into a video capture card driver module, a master process, a recording/playback process, and a user interface. The video capture card driver module is inserted into the kernel space as a driver in the form of a module. Since the user space process cannot directly access the underlying hardware device, the driver module is a bridge between the upper application and the physical layer of the device, and the upper application does not have to care. The specific information of the hardware device can be used to control the video capture card through the RT-Linux instruction FIFO. The driver module is responsible for completing the setting, control and status acquisition of the video capture card, and periodically reading the B code value and the lock flag in the video capture card. The upper application can also set the B code value in the video capture card through the instruction FIFO. The video data acquisition card module and the upper application share the critical state and control data of the system through the shared memory of RT-Linux, and realize data sharing between the kernel mode and the user mode program. The main control process is a normal Linux process of user space, which is responsible for completing the initialization, maintenance, and instruction transfer of the system. Complete the instruction transfer between the user space program and the kernel space program. It is mostly in a wait state. When receiving an instruction from the user (X-WINDOW window interface or text debugging interface) (implemented by semaphore), it is sent to the kernel process through the FIFO to realize the instruction transmission. At the same time, when it sends the start acquisition/playback command, it will be responsible for creating an independent read/write disk process to realize hard disk recording and playback of data. The master process maintains an initial system configuration parameter file. After the system stops running, it saves the current state of the system. It is used to initialize the system parameters when the system starts again. At the same time, the master process will disk array each time it starts. The task file on the file is repaired to ensure that the task file that has not been completed can be repaired when the shutdown occurs due to an unexpected power failure such as a power outage. After the recording/playback process is created by the master process, data is continuously transferred between the hard disk and the acquisition buffer (MBUFF). As long as the acquisition buffer (MBUFF) has data, it writes the data to the disk array. In playback, it first fills up the captured data (MBUFF), and then reads the data in the hard disk array again after the data is transferred by DMA, filling up the empty acquisition buffer (MBUFF). When the recording/playback stops, the process ends automatically. The user interface is a user process based on X-WINDOW. It provides the user with a visual control platform in the form of a window, real-time display system status, task content information and disk space usage status, accepting the following instructions from the user: B code setting/display, start recording, task file on the disk array Administrative functions such as playback, renaming, dumping, deletion, and data correctness verification. When the user starts to collect records, the control command is sent to the main control process, and the main control process establishes a write process. At the same time, the acquisition command is sent to the underlying video capture card through the instruction FIFO, so that the video capture device starts collecting data. The video capture device continuously collects the input intermediate frequency pre-detection signal stream data into the ping-pong buffer in the video capture card. When the ping-pong cache buffer is full, he will switch to another ping-pong buffer to continue collecting data, and a data will be generated. Ready interrupt, triggering the system's interrupt service routine. The interrupt service program initiates a DMA transfer to sequentially transfer the data in the ping pong buffer to the acquisition buffer (MBUFF), and adjusts the next stored data acquisition buffer (MBUFF) pointer so that the collected data is temporarily stored here and is not overwritten. In the real-time detection and acquisition buffer (MBUFF) of the write disk process, there is newly collected data. If there is a hard disk array that will be written immediately, the 512M acquisition buffer (MBUFF) ensures that the collected data is not written before being overwritten. Into the disk array. Similarly, when playing back, the playback data on the disc is read into the buffer in advance, and then the playback command is sent, so that even if the temporary reading speed is lowered, it is ensured that enough playback data in the buffer is output to the video capture card. The continuity of playback is guaranteed.

3. Summary

In order to test the performance and reliability of the system, the prototype was tested for 1000 hours of environmental stress test (including test time) and 100 hours of accelerated life test. The performance was stable and reliable, and the recorded data met various indicators. At the same time, the disk array single-disk power-down data recovery test of the recording process was repeated, and the results were satisfactory, which fully verified the superiority of RAID technology for digital recording.

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