Remote sensing data acquisition system based on FPGA sampling time variable

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Abstract. The microwave imager is based on remote sensing data acquisition system to conduct remote sensing observation of the earth. The sampling mode and sampling time affect the Microwave Imager. After analyzing the traditional remote sensing data acquisition system, when collecting multi-channel data, the sampling interval time and sampling start time can’t be controlled, and multi-channel data acquisition can’t be carried out in parallel. The new remote sensing data acquisition system uses fully parallel mode and FPGA to control sampling time and sampling interval. Simulation results and test results show that the remote sensing data acquisition system is multi-channel and controllable.

1. Introduction
With the development of the data acquisition system, there are many methods for multi-channel data acquisition.
For example, Mingqing Dai selected channels through the analog switch and used FPGA to choose analog switch addresses [1]. Different addresses correspond to different channels. For example, Jiahong Li designed the multi-channel parallel acquisition system based on TIADC (Time-interleaved ADC). In this process, multiple AD channels take turns sampling one input signal and then recombining the sequence [2]. This method is suitable for sampling systems with high sampling rate. This acquisition system often uses as a test and measurement equipment. There is another method, such as Weiqing Wang used ADS278 chip with eight channel input to collect multi-channel signals [3]. But the method of paper [1] causes a delay in the acquisition of all channels because the channels selected in turn. Jiahong Li’s method in [2] couldn’t collect multiple channel signals. In Weiqing Wang’s method of [3] couldn’t use multi-channel AD chips to control the sampling start time and sampling interval time of each channel.
Remote sensing data acquisition system used completely parallel to control multi-channel parallel acquisition.

2. The influence of acquisition mode on Microwave Imager

2.1. Forward line acquisition principle
After the signal of multiple channels comes in, it passes through the signal conditioning circuit, then through the analog switch of level 16 and 1. According to the analog switch address of the output of the FPGA, it chooses to output one signal. After the second analog switch, a signal is selected by the
same control mode, and finally output to the ADC for acquisition. After picking up a channel signal, the analog address switches and the next channel signal collects along the way.

![Figure 1. Schematic diagram of the anterograde acquisition](image1)

This method used an ADC to collect multi-channel signals. It saves cost and reduces weight. The disadvantage of this method is that it can't collect multi-channel in parallel.

2.2. Limitations of anterograde acquisition

When the satellite observes the earth, the parabolic antenna, the feed and the receiver of the Microwave Imager move around the vertical surface at a uniform speed.

![Figure 2. Schematic diagram of earth scanning observation](image2)

Because the feeds of different frequencies share one reflector antenna, the incident angles of each channel are different, and the corresponding ground observation positions are different [4]. To make each channel start at the same pixel location, it is necessary to set the appropriate start time for each channel.

2.3. The influence of sampling interval on spatial resolution

The sampling interval affects the spatial resolution of the Microwave Imager and affects the imaging quality [5]. According to [1], the undistorted sampling interval in Microwave Imager should be 0.4-0.6 times the ground dwell time of antenna half power beam.

\[ T_d = \frac{d}{u} \]  \hspace{1cm} (1)

Where \( T_d \) is the dwell time of antenna footprint, that is, the time it takes for an antenna beam to scan a beam width. And \( d \) is the beam width, that is, the spatial resolution. And \( u \) is the scanning speed.

3. Parallel multi-channel programmable remote sensing data acquisition system

In this paper, a multi-channel parallel programmable remote sensing data acquisition system was designed. In this system, the starting time and sampling time of channel acquisition are controllable. This system is the first acquisition method for microwave imaging detector in China.

3.1. Hardware Design

Next show the schematic diagram of the hardware design of the remote sensing data acquisition system.
The remote sensing data acquisition system mainly realized the functions of data acquisition, storage, framing, packaging, synchronous serial transmission, asynchronous data reception, position pulse reception and so on.

3.1.1. Selection of major components. In remote sensing data acquisition system, the most important thing is to select ADC, FPGA chips. Requirements for ADC: resolution is higher than 14 bits, the acquisition rate is higher than 70 KHz, and working environment temperature range is wide. After many comparisons, this system selects a 16-bit AD converter with a single input channel. Analogy Device Company produces AD976[6].

This system used the EPF10K70 of ALTERA company. Its performance index [7] is 70,000 typical gates (logic and RAM), 118,000 maximum system gates, 3744 logic units, 468 logic array units, nine embedded array arrays and 358 maximum I/O pins. Its working voltage is 5V. It is easy to debug the FPGA through JTAG port.

3.1.2. Design of data transceiver circuit. Considering that data acquisition system requires high accuracy of data, the differential signal is chosen to transmit data. Its advantages are strong anti-interference ability, effective suppression of EMI and timing accuracy and high reliability.

3.2. Software design
FPGA realized the acquisition of remote sensing and calibration data.
Power on initialization
CPU configures the initial sampling time and sampling interval of each module.

FPGA reads timetable content every 25us
Configuration completes, start timing work
Start synchronous serial transmission to channel gateway module
FPGA determines whether the sampling period ends
FPGA collect and store the corresponding channels according to the contents of the schedule

YES
NO
YES
NO
YES
NO
YES
NO
YES
NO

Figure 5. Channel collection flow-process diagram

FPGA mainly realized the controllable start time and controllable sampling interval.

Figure 6. Block diagram of remote sensing acquisition FPGA module

The whole function divided into two parts. One part controls the acquisition time of the channel. It mainly realizes the time sequence control of heat source, cold source, and calibration data acquisition under different working modes. The other part implemented data storage and transmission.

3.2.1. Sampling time control function. By receiving the instruction number, each channel determines the starting time of the acquisition. After the start module which controls the acquisition of ADC receives the start pulse signal and the start time, it judges this. When the counter reaches the start time, it sends the start signal to ADC to control its acquisition.

Note number instruction includes not only the start time of each channel acquisition but also the sampling interval of each channel. The time module especially writes to confirm different sampling points according to different work modes. Sampling points send to the module that controls the acquisition of ADC, and the sampling cycle of this cycle is ended by judging the acquisition times.

3.2.2. RAM cache function. The process of writing RAM is as follows. Firstly, it receives the READY signal and data, as well as the initial pulse signal after the acquisition of the AD chip. After judging that the initial pulse is a low pulse signal. The system starts collecting. Store the collected data in a fixed spatial address. The data of each channel storages in a fixed continuous area.
The process of reading RAM is as follows. Firstly, it determines that all channel data collects and a start signal gives to the sending module. The sending module sends out synchronously according to the specified data transmission rate.

4. Simulation and test results and analysis

Next picture is normally working simulation waveform.

![Simulation Waveform](image)

**Figure 7.** System simulation waveform

After reaching the acquisition time, AD976 starts to collect signals. The control signals are O_RC1, O_CS1, and O_BYTE1. When writing data to RAM, the o_ram_rd_n signal is always high level. When the o_ram_cs_n and o_ram_wr_n signals are low levels, the RAM writes. O_ram_cs_n and o_ram_rd_n are both low while performing read operations on RAM.

![RAM Write Operation](image)

**Figure 8.** RAM write operation

During RAM operation, multiple ports access simultaneously. These ports are read data module and write data module of each channel. Each channel has a different storage address. If channel one starts at 0X0004H address and two starts at 0X0304H, other channels will not be listed one by one.

![Multichannel Parallel Acquisition](image)

**Figure 9.** Multichannel parallel acquisition of remote sensing mean value data

In the above remote sensing image, it shows that each channel has different input voltage values. Each point represents the average of each packet. In the process of calculating the average value, removing the points without sampling in the special working mode. The abscissa is the packet count, and the ordinate is the voltage value. The unit is V.

In the above figure, the line of each color represents the mean value of the remote sensing data of a channel. In the first 550 packets of data, different voltage values are collected for each channel respectively. In the middle, the sampling interval is changed by the number of injections, without changing the voltage values of external analog input, and the mean values of remote sensing sampled are relatively stable. From 551 to 620 packets of data, the voltage of each channel changes by the number of injections in the geodetic system. At this time, the magnitude of the change voltage value is different. In this process, the sampling value is relatively stable. The data of the other packages do not change the sampling interval and the analog input voltage of each external channel, and the external voltage of each channel does not change at the same time.
5. Conclusion
Simulation results show that FPGA supports multiple channels and writes RAM simultaneously. Data for each channel storage in a fixed address space. When all channel sampling completely, the data is packaged and sent out.

Experiments show that when the external voltage of each channel is maintained, the data collect by each channel remains unchanged after the injection times change the initial sampling time. The remote sensing data acquisition system is injected by the test system when different voltage values collect in each channel, and the external analog voltage is constant. By changing the sampling interval time, the mean value of each channel before and after the operation is stable. From the above results, it can see that the remote sensing data acquisition system has the functions of multi-channel parallel acquisition, adjustable sampling start time and controllable sampling interval.

Acknowledgments
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