The Research and Practice of a Long Pulse Synchronous Data Measurement Method

Xiaodan Zhang¹, Yi Zhang¹, Wandong Xue¹, Shaorong Wei¹, Yong Xie¹*

¹Qinghai University, Xining 810016, CHINA

*Corresponding author e-mail: 75044183@qq.com

Abstract. The research and implementation of a long pulse synchronous data measurement method is mainly presented in this paper from the aspects of requirement analysis, hardware platform support, software design and testing result. The NI multi-function data acquisition board card is adopted as the hardware platform. The software program platform is based on the LabVIEW virtual instrument platform. The long-pulse data acquisition technology, LabVIEW multithread data processing technology, computer transmission control technology and data compression processing technology as the key technologies are applied in this paper. The main functions of the system include (1) accurate sampling for the long pulse measured signal at the specified sampling frequency and sampling time; (2) a variety of acquisition control modes are provided to meet the different application requirements; (3) the data collected is easily stored and retrieved after a specified algorithm; (4) the real-time display and historical playback functions for measuring signals; (5) the data transmission and storage functions; (6) simple and friendly interface which is easy to operate. By software testing, the software can meet the functional requirements above and it can meet the data sampling at 1000s or even longer with 50KHz sampling rate. Experiments show that it can work stably and reliably, and it has a very important practical application value. This software has universality and can provide valuable reference for the applications of long pulse data measurement based on other hardware systems.

1. Introduction

In the scientific engineering experiment research and the actual production application, it will produce a massive of original data during the process of a system development, the test, the movement. How to obtain the original data accurately, which has the vital significance to the test result analysis. On the other hand, a large number of experiments and applications of engineering science are intermittent pulse type in reality [1]. That's to say, the data only generated during the operation of a system is effective and needs to be measured. The pulse applications mode are divided into short pulse mode and long pulse mode according to data measurement time. For the short pulse mode applications, the data can be accessed and analyzed in one time fleetly after the system runs. While for long pulse mode applications, with the increase of pulse, the amount of data is also increasing. Meanwhile, it's necessary to wait until the end of the system operation, and then process, analyze or display the...
measurement data, which will cause serious waste of time. So, it's really very necessary to explore and practice a long pulse synchronous data measurement method to solve the problems above. In this paper, the specific measurement method and software implementation will be presented as follows.

2. The data measurement method research and functional analysis
When the long pulse synchronous data measurement method is applied, it's mainly used to acquire the original voltage or current signal of the measured system in real time. Considering the diversity of measured system, the dispersion on physical location and the complexity of the field environment in practical application, a distributed data measurement system architecture based on network technology will be adopted [2, 3]. There are two logical subnet layers. One is field measurement subnet for data acquisition devices and measured system objects. The other is server control subnet for offering necessary control services and data services. All the relevant devices are connected by Internet for realizing information exchange and data transmission among multiple devices.

![Function modules diagram of a long pulse synchronous data measurement system](image)

**Figure 1.** The function modules diagram of a long pulse synchronous data measurement system

The main functions realized includes the accurate sampling for the long pulse measured signal, a variety of acquisition control modes (the local mode and remote mode), an effective data storage, transmission and playback mode, as well as a simple and friendly interface. So, the overall system structure and function modules diagram of a long pulse synchronous data measurement system can be described as Fig.1 above.

3. The hardware platform support
In this research, a data acquisition device, a data server and a control server are needed as the hardware platform. The data server and control server can be replaced by two PC devices just for running corresponding server software to realize related control and data services.

NI multi-functional data acquisition board card PXI6133 is selected as the testing data acquisition development tools, together with the matching PXI chassis and controller as hardware platform. PXI6133 is a type of multi-functional data acquisition card with 14 bit sampling accuracy and 8 channel synchronous sampling analog input [4]. In high-speed mode, the sampling rate of each channel can reach 2.5 MS/s. For analog acquisition input, the voltage selection range and channel gain can be
programmed by software. Based on PXI6133, the designed software is used for testing long pulse data acquisition at 1000 s or more longer.

What needs to be explained is, although PXI6133 card is chosen to verify and test the feasibility of our long pulse data synchronous sampling method in this paper, this method and software programming can be easily extended and applied to acquisition system based on the other hardware platform.

4. The specific implementation of software programming

The control server software and data server software is developed by C/C++ language. The data acquisition software programming is based on LabVIEW virtual program platform with Windows OS. LabVIEW is a programming language with graphical development environment. It has a huge and rich library of functions for any editing task, the functional module of data acquisition, data analysis, data storage and data display are included [5]. Because of LabVIEW’s special graphic programming interface, powerful programming function library and convenient way of program construction, it can shorten the system development cycle and improve the test efficiency. So it is favored by system developers and software programmers. That is the reason why it is chosen as the software programming development environment in this research.

In functions, the system mainly realizes data accurate sampling, procession, transmission, storage and display in a variety of acquisition control modes for the long pulse measured signal. In functional modules, there are initialization module, information listening module, data acquisition information receiving and configuring module, data acquisition and channel separation processing module, data transmission and storage module, experiment number service module and data display module. Next, the specific implementation of each functional module will be introduced.

4.1. The initialization module

The main work in this part is initialization before the software runs. Such as variable initialization and network initialization. The network initialization is needed or not will according to user's settings. If the remote data acquisition is set, the network register to control server is necessary. And if success, the data acquisition software will get configure information or remote "START" command from control server. Otherwise, the configure information comes from a local defaults files or manual settings through user interface.

4.2. The information listening module

This part depends on whether the data acquisition software is running at a remote mode. With the help of multi-thread LabVIEW data processing technology, an independent listening thread is created [6]. The mainly information listened from control server includes data acquisition configurations (acquisition channels, name, gain, time, rate and so on) and remote “START” command. Once the configurations are received, they are saved to local file. And they are used at the next software starts or data acquisition. Once "START" command is received, the data acquisition thread will be started immediately for sampling. The information listening module based on LabVIEW TCP communication control is shown as Fig.2.

![Figure 2. The information listening module](image)
4.3 The data acquisition configuration module
The research provides a variety of data acquisition modes. According to the trigger source and type, there are four data acquisition modes. The local internal or external trigger acquisition, the remote internal or external trigger acquisition for example. The data acquisition configuration module mainly configures the sampling physical channels, ranges, rate, time and trigger source (analog or digital), trigger edge (rising or falling), clock source (internal or external) of data acquisition card. All the configurations can be set on the user's interface directly and part of configurations can from control server when it runs at remote mode, as it's mentioned above.

4.4 The data acquisition and processing module
This module is a key part in our research. After configuration, the data acquisition thread will wait for local "START" command or remote "START" command from control server. If "START" command is caught, data acquisition card will start to read data from designed physical channels immediately (internal trigger source) or waiting for trigger signal from external trigger signal source. For meeting the requirements of the long-pulse data sampling, the data acquisition mode which based on 'producer-consumer' mode is adopted in our LabVIEW software programming [7]. Through creating an independent stack queue, the original data those read from the hardware cards are saved to a temporary data file on our local disk for realizing to read and write simultaneously. Because the original data are saved on disk temporarily through a stack queue, a long pulse time (1000 s or longer) sampling will be completed continuously. The corresponding module is shown as Fig.3.

Figure 3. The long-pulse data acquisition module
For saving storage space, a LZO lossless compression algorithm is applied to compress the original acquisition data. Because all original data is saved in one temporary file, the first thing to do is channels separation before dealing with LZO algorithm. The specific channel separation is presented as Fig.4. In Fig.4, the loop time is the sampled number of physical channels actually. And the other parameters are used for recording and identifying each channel data.

Figure 4. The channel separation program implementation
In the research, with the help of a dynamic link library for sharing executable code offered by LabVIEW, the LZO compress function is called and used conveniently. It's programmed with C/C++ programming language and is put into a dynamic link library file (DLL file). We just need to call the dynamic link library file through the LFI (Library Function Interface, LFI) module provided by the LabVIEW virtual platform. In the programming method, only when the program runs to the function node, the dynamic link library file can be loaded into memory and executed. This method not only simplifies LabVIEW programming and provides conveniences to programmers, but also saves the system runtime memory use. The implementation of LZO compress algorithm is shown as Fig.5.

![Figure 5. The implementation of LZO compress algorithm](image)

4.5 The data transmission and storage module
The data transmission and storage module realizes the functions of saving data to local disk and uploading data to data server. The stored data are LZO data files formed by each physical channel. The LabVIEW programming for local data storage is shown as Fig.6.

![Figure 6. The LabVIEW programming of local data storage](image)

Whether data is upload to data server to achieve distributed backup storage or not, it's determined by users. When "Upload" is selected, all the data in current experiment number will be transported to data server. And for parsing each network packet and storing each channel data correctly by data server, a data header structure is formulated and added to each data file before transmission. The data transmission structure is shown as Fig.7. The structure is composed by 32 Bytes. The channel number (int type, 4 Bytes), signal name(char type, 20 Bytes), current experiment number(int type, 4 Bytes), data length (int type, 4 Bytes) are included. After the data header, it's the real LZO data file.

![Figure 7. The data transmission structure](image)

4.6 The experiment number service module
The main function of this module is the management of experiment number. Because original data and
each compressed data will be stored in the folder path created with the current experiment number, this number is very important and can't be repeated, otherwise the historical data will be overwritten. In this paper, the experiment number can be got from two ways. The first way is that the number is required from data server when each experiment sampling task is over. The other way is that it's managed by data acquisition software itself. In order to ensure the continuity of data storage and avoid to overwrite data, the number will be added 1 after a each data acquisition stop.

4.7 The data display module
This module provides the real time display function of sampling data and playback function of historical data. Data display interface is realized by waveform control provided by LabVIEW. Users can not only view the sampled data in real-time, but also can call back historical data of a specified signal by experiment number and channel number. The data display module is presented as Fig.8.

5. The Practice and Results
The overall software implementation interface is shown as Fig.9. From the interface, the physical actual data sampling physical channels, data sampling rate, sampling time, sampling range, trigger source, clock source, trigger type and edge, experiment mode, server IP address and port information and so on, are easily set by users. The interface also offers some monitoring status to users, such as register server status, data acquisition stop status, data transportation status and so on. The software has friendly, clear and intuitive interface. User can operate it easily and it also can display real-time sampling data, as well as historical data intuitively. Through testing, the functions of the system are well satisfied. Under 50Hz sampling rate, the sampling time can reach 1000 s and more.
6. The Conclusion

The research of a long pulse synchronous data measurement method has been introduced in this paper. Based on NI PXI hardware platform and LabVIEW virtual programming environment, the method has been practiced. The testing results show that it is practicable and can meet the requirements of data measurement for long pulse application, data compression, data transmission, storage and display very well. The final developed system offers a friendly, clear and intuitive interface. The two layers network subsystem architecture and the mode of data acquisition processing provide valuable reference for the applications of long pulse data measurement. The system has universality and can be expanded to other data measurement systems based on other hardware systems. While the system has been testing at the settings with 1000 s/50KHz , for higher long pulse sampling time and sampling rate, that will be the next research and practice direction.

Acknowledgements

The authors gratefully acknowledge the supports of the National Natural Science Function of Qinghai Province (No.2017-ZJ-959Q, 2019-ZJ-7065) and the National Natural Science Foundation of China (61572370).

References

[1] Xiaodan ZHANG, Xiaoying WANG, Chundong HU, et al. The development of data acquisition and processing application system for RF ion source. Plasma Science and Technology, 2017, 19 (7):1-6
[2] Xiaodan ZHANG, Chundong HU, Peng SHENG, et al. The implementation of Computer Data Processing Software for EAST NBI. Plasma Science and Technology, 2014, 16 (10) : 984-987
[3] Patel V B, Patel P J, Singh N P, et al. 2010, Operational Experience of SST1 NBI control System with prototype Ion source. 23rd National Symposium on Plasma Science and Technology, Gujarat, India
[4] PXI6133: http://www.ni.com/pdf/manuals/371231d.pdf
[5] network resource: https://baike.baidu.com/item/LabVIEW/4165214?fr=aladdin
[6] network resource: http://zone.ni.com/reference/zhs-XX/help/371361H-0118/lvconcepts/labview_and_hyper_threading
[7] ZHANG Xiaodan. The design of data processing software for key parameters of NBI control system. PhD theris, Hefei, ASIPP, 2015