

High Speed Data Acquisition System for Power Quality Monitoring

Yuhong Zhou, Yunfang Xie, Limin Shao*

*College of Mechanical and Electrical Engineering,
Agricultural University of Hebei, Baoding 071001, Hebei,
China*

** Corresponding author(E-mail: shaolm@126.com)*

Abstract

Aiming at the localization of data acquisition method of the complex testing system, an excellent performance of power quality data acquisition system of high precision based on LabVIEW is designed and implemented. The network protocol and the design principles of its hardware and software are also illuminated. In the construction of hardware and software for power quality monitoring system various coordination and optimization methods are synthetically explored, and taking the establishment of a real-time power network harmonic analysis system for example the application research is conducted. The high speed, high quality and the high reliability of the acquisition circuit are certified by simulating, analyzing and applying it, and the results showed that the data acquisition system can satisfy the demand of power quality analysis system.

Key words: POWER QUALITY, HIGH SPEED DATA ACQUISITION, SIGNAL ANALYSIS

1. Introduction

In the field of power quality monitoring, the key technology is to collect the real time data. How to run a variety of complex analysis algorithms without affecting the accuracy and continuity of the sampling in the case of high speed continuous sampling is the direction of the research in the field. A power virtual instrument with excellent performance and stable operation must be based on the data acquisition module with multi channels and high quality. The data acquisition module should have good anti-interference ability. The traditional integration testing method is more and more unable to meet the needs of complex test tasks. Therefore, the appearance of network instrument becomes inevitable. Virtual instrument is using the latest computer technology to achieve and expand the function of traditional instruments, which can use the internet to transmit data to achieve remote measurement and calculation analysis [1].

In the past monitoring circuit, the data acquisition module/technology which used single chip circuit has many shortcomings, such as it is difficult to make

full use of the software resource and data acquisition speed is greatly limited by the data transmission bottleneck, especially when the frequency of the acquisition rate is higher. At this time the circuit has lost its use. Therefore, the circuit based PC or DSP (Digital Signal Processor) will replace the original single chip microcomputer system. PCI (Peripheral Component Interconnect) local bus speed, bandwidth and support DMA (Direct Memory Access), so the PCI local bus based virtual instrument has been widely developed [2].

Starting from designing cost and technical requirements, a high performance multi data acquisition system of power virtual instrument which can meet the requirements is designed. Compared to various optimization schemes, a soft real time system is designed based on the virtual instrument technology which is optimized for a specific power system.

2 NI-LabVIEW development platform

LabVIEW is a virtual instrument software development tool which is based on G language (graphical programming language). It mainly used in the devel-

opment of data detection, data acquisition system, industrial automation control system and data analysis system. LabVIEW is similar with C, Basic, Pascal and other traditional programming languages, but their biggest difference is that the traditional programming language with the text language programming, and LabVIEW using the graphical programming language, the program is the form of block diagram with the interface very intuitive image [3].

The program of LabVIEW is called VI (Virtual Instruments), each VI has three main parts: the front panel, block diagram program, icon/connection port. The front panel is used to simulate the front face of the real instrument. The program language is used to control the control object on the front panel. The icon/connection port is used to define the LabVIEW program as a subroutine, which can be implemented in a modular programming. The LabVIEW features are attributed to the following aspects:

- a) Graphical programming approach, the use of intuitive image of the data flow pattern of language writing program source code;
- b) Provides a wealth of data acquisition, analysis and storage of the library functions;
- c) Provides program debugging functions, such as setting a breakpoint or probe, single step execution, syntax checking, etc;
- d) 32bit compiler to generate a 32 bit compiler, to ensure that the user data collection, testing and meas-

urement program of the high-speed implementation;

e) Provides the mechanism of a large number of external code or software to connect, such as DLLs (Dynamic Link Libraries), DDE (shared libraries), ActiveX, CIN, etc;

f) Including all kinds of instrument communication bus standard of all functions, such as DAQ, GPIB, PXI, VXI, RS-232/485, so that the designer can drive different bus standard interface devices and instruments;

g) Powerful internet function, support the development of common network protocol, remote measurement and control instrument.

2.1 System hardware

The hardware structure of the virtual instrument is shown in Figure 1.

Following are voltage sampling conditioning and current sampling and conditioning circuit, the realization of the operational amplifier which is OP07 series op amps, the power supply is +12V, at the end of each conditioning channel parallel a transient voltage suppressor TVS tube, to protect the subsequent circuit card. R1, R4 and R8 are equipped with adjustable resistance in specific implementation circuit, and then the value of the measured signal can be adjusted by changing the value of these resistors. The potential signal conditioning circuit is shown in Figure 2. The current signal conditioning circuit [4] is shown in Figure 3.

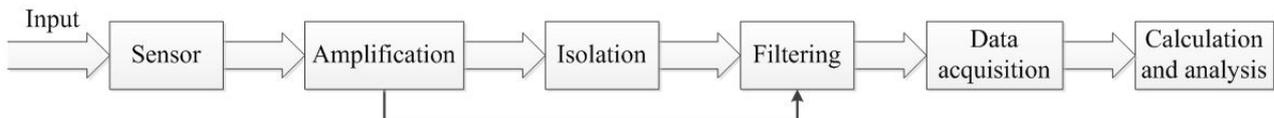


Figure 1. Flow diagram of the hardware

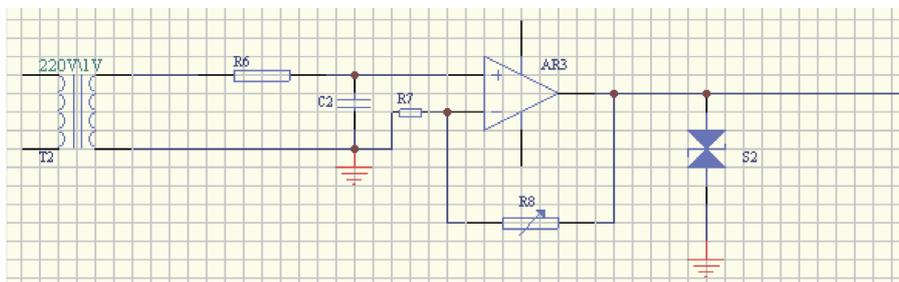


Figure 2. Potential signal conditioning circuit

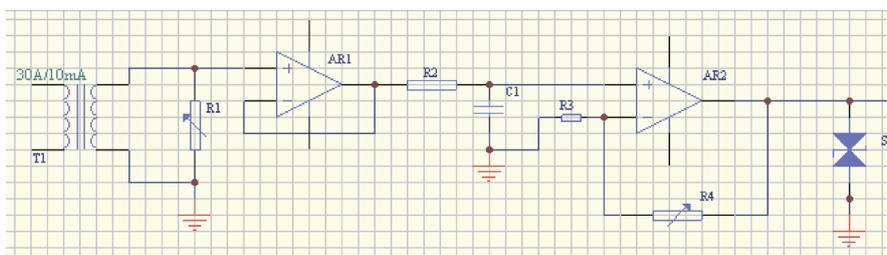


Figure 3. Current signal conditioning circuit

The system of data acquisition card using the DAQ-2010 multi function data acquisition card. It is a card based on PCI bus of plug-in data acquisition, with the same size of computer card, directly into the computer PCI slot can constitute a test system. DAQ-2010 has high performance and reliable data acquisition function, it can meet the requirements of data acquisition in a wide range [5]. It has 14 bit resolution of four bit resolution synchronous analog input

channel, the highest real-time sampling rate can reach 2MS/s, with analog and digital trigger function; two analog output channels of 12 bit, two 40MHz counter/timer of 24 bit and 24 digital I/O channel. The principle diagram is shown in Figure 4.

3. Software platform of the system

3.1 Program design

The block diagram of the multi - channel data acquisition program is shown in figure 5.

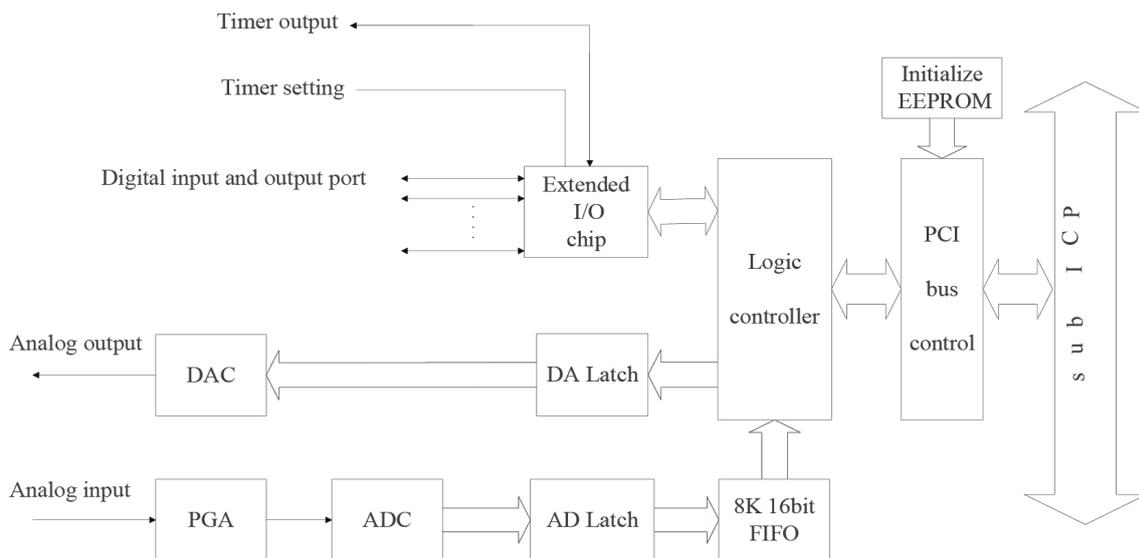


Figure 4. Schematic diagram of DAQ-2010 multi function data acquisition card

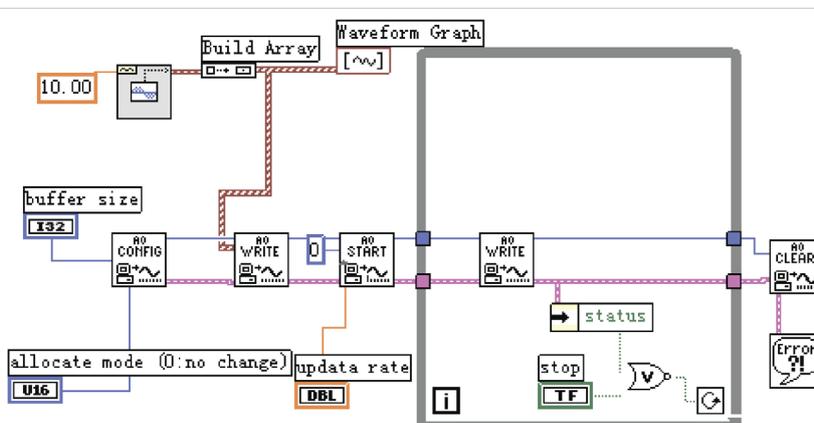


Figure 5. Waveform and diagram after acquisition procedures

3.2 Signal analysis

The real-time acquisition of voltage distortion waveforms is shown in Figure 6 and the change curve of voltage THD is shown in Figure 7.

The result to measure and analyze the voltage of one phase is shown in Figure 8. The basic parameters set includes sampling frequency, sampling point setting, FFT analysis is based on the selection of the Hanning window, which can choose to measure the voltage or current, take A phase voltage measurement for example [6]. The frequency, effective value, and deviation of the measured voltage (current) are shown

in figures and data. The display is the real-time waveform of voltage U2, due to the presence of harmonics, the signal has obvious distortion, FFT transform of the voltage, the corresponding FFT spectrum display which contains three times, five times, 7 times and 9 times harmonic, and The total harmonic distortion THD reached 15.3%. The bus general statistical is shown in table 1.

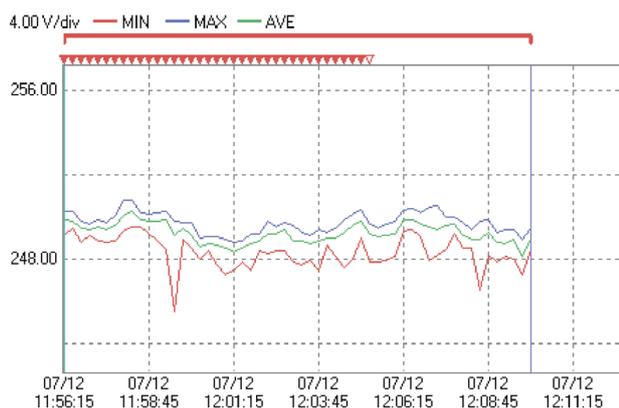


Figure 6. Chart of voltage RMS variation trend

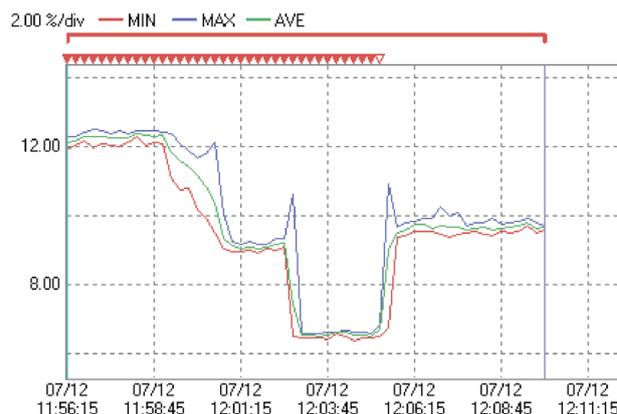


Figure 7. Change curve of voltage THD

Table 1. Bus general statistical table

A phase voltage statistics result							
Name	Unit	Maximum value	Minimum value	Mean value	95% probability value	Limit value	Limit number
THD	%	12.53	11.98	12.29	12.34	4	0
B phase voltage statistics result							
Name	Unit	Maximum value	Minimum value	Mean value	95% probability value	Limit value	Limit number
THD	%	11.83	11.22	11.57	11.66	4	0
C phase voltage statistics result							
Name	Unit	Maximum value	Minimum value	Mean value	95% probability value	Limit value	Limit number
THD	%	12.32	11.77	12.09	12.17	4	0

From the results of statistical report, the line A voltage 95% probability value is 12.34%, the line B voltage 95% probability value is 11.66%, and the line C voltage 95% probability value is 12.17%, which has greatly exceeded the national standard limit value of 4%.

From the view of the voltage and harmonics, the 5, 7, 11, 13, 17 and 19 times of the channel line voltage exceed the standard value, the 95% probability value has exceeded the national standard by the minimum short-circuit capacity calculated from the limit value. Specific values is shown in table 2.

Table 2. Specific values of voltage harmonics

channel	Harmonic number					
	5	7	11	13	17	19
CH1	13.260	8.660	9.730	8.390	8.210	6.310
CH2	11.990	8.550	8.710	8.830	6.930	7.370
CH3	12.620	8.550	9.310	8.600	7.640	6.930

The lower part can also display frequency and amplitude of a harmonic [7]. Using the powerful function of LabVIEW, the spectrum of the harmonic analysis is derived from the data file, and the amplitude of the harmonics is displayed.

3.3 Signal storage and reproduction

Save function is to get the time domain or frequency domain data, according to the need to convert into unique waveform file or excel file, text file format in

LabVIEW express to store in the computer's disk. Reproduction function is that at the end of the real-time data collection and analysis of data, the users can also reobservation and in-depth data acquisition and processing. The function of repetition of the signal acquisition is that once the data stored in the located file is selected the whole process can be continuous played back [8].

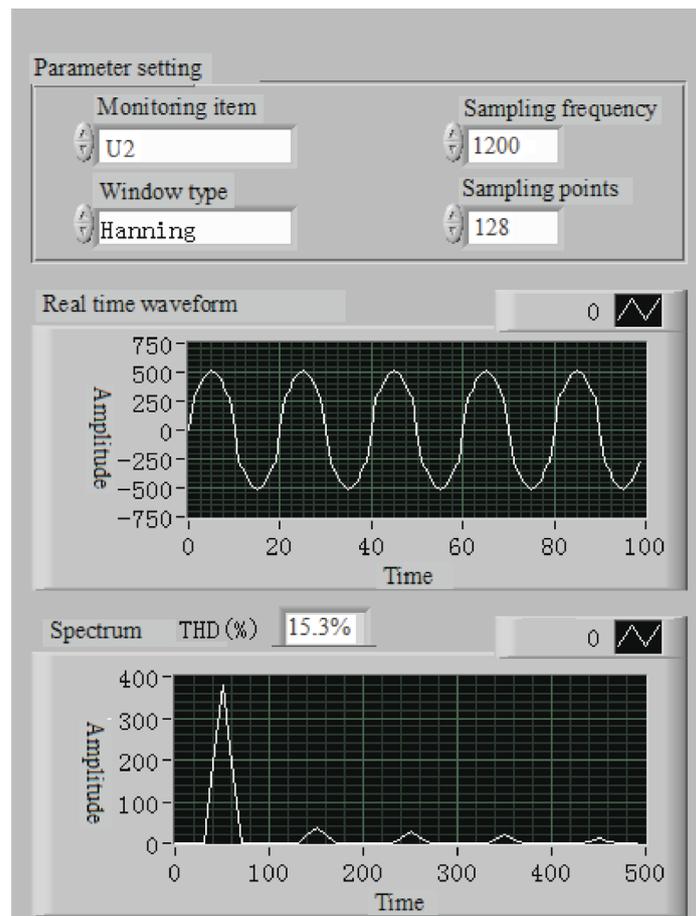


Figure 8. Interface of harmonics analysis

4. Conclusions

The general data acquisition system based on LabVIEW has the functions of data acquisition, display, FFT analysis, time domain, frequency domain performance calculation, data storage, etc. Compared with the traditional data acquisition system, it has obvious technical advantages in the aspects of intelligence, data processing, data analysis, operability and so on. This paper has designed a data acquisition circuit, which is based on the basic requirements of high voltage electric quantity collection and harmonic analysis. The effect of input output isolation, approximate linear filtering, multiplexing, high-speed data acquisition, reliable and fast data transmission has been achieved. The scheme is based on the principle of minimizing hardware cost, which has good popularization value. Data acquisition system based on general computer and data acquisition system has the characteristics of a computer, user defined function and convenient maintenance, which represents the development direction of the instrument in the future.

Acknowledgements

This work was supported by Baoding Science and Technology Research and Development Project (14ZG004, 11ZG029) and Polytechnic Foundation of

Agricultural University of Hebei (LG20140203).

References

1. Sudipta Nath, Arindam Dey and Abhijit Chakrabarti (2009) Detection of power quality disturbances using wavelet transform. *Proceedings of world academy of science. Engineering and technology*, No.37, p.p. 869-873.
2. M. I. Gasik. (2010) development and implementation of electric steelmaking technologies for manufacture of railway transport parts and main steel routes. *Metallurgical and Mining Industry*, 2(2), p.p. 109-115.
3. V. V. Parusov, O. V. Parusov, I. N. Chuyko, A. B. Sychkov (2010) Scientific and technological aspects of high-grade rolled wire production. *Metallurgical and Mining Industry*, 2(2), p.p. 137-142.
4. W.C.Chan, C.W.Chan, K.C.Cheung (2001) On the modeling of nonlinear dynamic systems using support vector neural networks. *Engineering Applications of Artificial Intelligence*, 14, p.p. 105-113.
5. Yuan Liao, Jong-Beom Lee (2004) A fuzzy-expert system for classifying power quality disturbance. *Electrical Power and Energy System*,

- 10(26), p.p. 199-205.
6. Francis E.H.Tay, Lijuan Cao (2001) Application of support vector machines in financial time series forecasting, *Omega*, 9(4), p.p. 309-317.
 7. Hong-Tzer Yang, Chiung-Chou Liao, Pai-Chuan Yang, et al. (2001) A wavelet based power quality monitoring system-considering noise effects. *IEEE Transactions on Power Delivery*, 16(3), p.p. 353-360.
 8. Julio Barros, Ramon I.Diego (2006) A new method for measurement of harmonic groups in power systems using wavelet analysis in the IEC standard framework. *Electric Power Systems Research*, 76, p.p. 200-208.



Signal Monitoring System for Power Supply with High Current

Xinxin Wang

*School of Mechanical, North China University of
Water Resources and Electric Power, Zhengzhou
450011, Henan, China*

Jianlin Zhao

*Department of Electronic and Information
Engineering, Henan University of Animal
Husbandry and Economy, Zhengzhou 450044,
Henan, China*

Jinhui Guo

*School of Mechanical, North China University of
Water Resources and Electric Power, Zhengzhou
450011, Henan, China*