THE DESIGN OF RURAL POWER NETWORK POWER QUALITY MONITORING AND ANALYSIS PLATFORM ON LABVIEW

Chunling Chen*, Xiaofeng Wang, Tongyu Xu, Yong Yang

College of Information and Electrical Engineering, Shenyang Agricultural University, Liaoning province, P.R.China 110161

* *Corresponding author, Address: College of Information and Electrical Engineering, Shenyang Agricultural University, shenyang 110161,Liaoning province, P.R.China , Tel: +86-024-88760090, Fax: +86-024-88487122, Email:snccl@163.com*

Abstract: A design of power quality monitoring and analysis platform based on the virtual instrument technology is proposed which aims at the key issues affecting quality rural power grids. This article discusses the typical algorithm of harmonic analysis, voltage deviation calculation and unbalance in three-phase calculation. Completing software design of power quality monitoring and analysis platform based on LabVIEW, which including visual design algorithm of the monitoring and analysis, graphical display of the calculation and analysis of the results, and the results of the export data. Simulation results show that the platform test results are accurate, friendly interface, stable performance and practical.

Keywords: Power quality; LabVIEW; Harmonic analysis; Voltage deviation; Unbalance in three-phase

In recent years, with the development of rural economy and the country's industrial structure adjustment, township enterprises have continuously increased and a large number of industrial and mining enterprises transferred from the city to the rural areas(Chen et al., 2007). The non-linear, non-symmetry and volatility in the rural power network has become increasingly serious and caused many incidents such as electrical burning, electric energy measurement error, overheated transformers, capacitors can not work in normal operation, relay protection and automatic device malfunction tripping, and causing serious harm to the rural power network, users' electrical equipments and all kinds of appliances. In order to ensure the rural power supply system and the majority of users of electrical equipment and all kinds of appliances are running safely and economically, it is necessary to monitor and analysis each index of the power quality, therefore it can provide accurate historical data and basic data to project construction and accident analysis.

1. DESIGN OF HARMONIC MONITORING PLATFORM

Power quality monitoring system of rural power network is designed achievement by using virtual instrument technology, with the least hardware supporting, and uses software programming instead of hardware circuit to complete the functions of data processing, calculation, analysis and results display, so it changes the idea from the hardware to the software(Ding et al., 2004). The framework chart of this system include software and hardware system structure. The software part has power quality analysis and display functions. The hardware part mainly includes transducer, signal adjustment and data acquisition card, the system architecture in Fig.1.

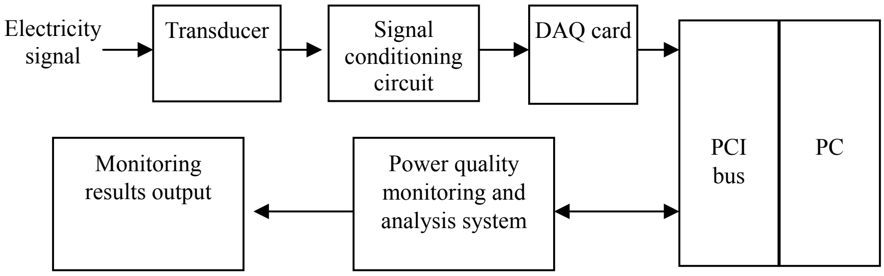

Fig. 1. The power quality monitoring platform topology of rural power network

1.1 Hardware circuit

The detailed processes of PC-based data Acquisition system and interpolating board as follows: External signal input → Signal connect terminals → Signal sensors → Signal conditioning (Signal amplification → Isolation) → Acquisition.

In order to obtain good results and effective measurement accuracy, transducer and transmitter output signals must be adjusted before it access to the data acquisition card. Signal conditioning typically include signal amplification, filtering, electrical isolation and multi-channel technology. Passband filter is used to prevent the noise and interference from the aliasing, overcome the spectrum-aliasing which may lead to the distortion. Data acquisition card (DAQ) is the key to hardware devices, and the accuracy and speed of the conversion have a major impact on system real-time and accuracy. The system chooses LingHua DAQ2010 interpolating data acquisition card, which based on PCI, bus structure, with the advantages of speed, technical characteristics: 14-bit A/D resolution, 4 channels simultaneous analog input, the maximum sampling frequency is up to 2MHz. According to the sampling theorem, the sampling rate should be at least equal to or greater than twice of the highest frequency, the data acquisition card is sufficient to meet the requirements of 50th harmonic analysis.

1.2 Design of system software

This system uses LabVIEW, a graphics-based programming language development environment from National Instrument. LabVIEW uses flow chart programming, the style of programming is simple and effective, and very direct-viewing, LabVIEW have abundant powerful functions of numerical analysis, function and signal processing.

Using virtual instrument technology as the core, and PC-BASED mode to construct power quality monitoring platform, it can take full advantage of the PC resources. Especially when system requirements change, or when the monitoring system used in different environments, we only need to carry out some necessary structural adjustments, amendments and supplements, without change hardware, thus it can save development time and the costs(Hu et al., 1997; Hu et al., 2007).

Power quality monitoring and analysis software application modules are shown in Fig.2. The software modules include: parameters setting module, real-time data acquisition and display, software analysis module. Software parameters setting module includes sensor variable ratio, data acquisition card sampling frequency, data storage path and power quality monitoring relevant parameters, etc. Software analysis module is the core of this software, including harmonic analysis, voltage deviation calculation, unbalance in three-phase and exporting the harmonic analysis data.

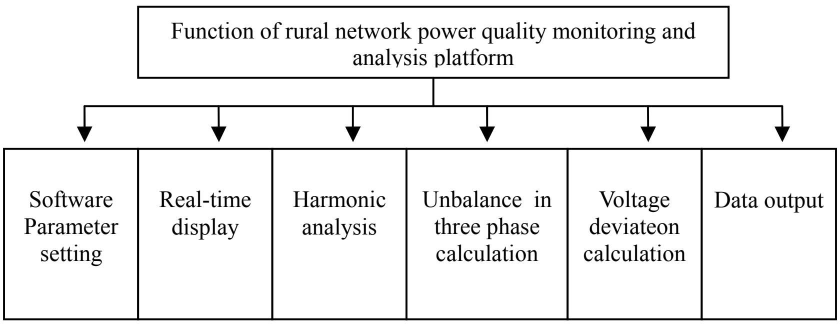

Fig. 2. Function diagram of software

2. THE MAIN ALGORITHMS OF POWER QUALITY MONITORING PLATFORM IN LABVIEW

2.1 Voltage deviation(Luo et al., 2006; Pang et al., 2003)

Sampling according to the sample rate and calculating voltage deviation ΔU per minute.

$$\left\{\Delta U\right\}_{(\%)} = \frac{V - V_N}{V_N} \times 100 \quad (1)$$

The system will cumulate monitoring voltage time, calculate the percent of pass everyday, and obtain the maximum positive and negative from statistics.

2.2 Harmonic analysis(Luo et al., 2006; Pang et al., 2003)

After the signal being pretreatment and A/D convert acquisition, it uses Discrete Fourier Transform (DFT) to Fast Fourier Transform (FFT) basic theory to calculate the voltage and current harmonics. The continuous-time signals *f(t)*, divide a sampling period *T* into *N* equal points, and sampling period is $T_s=T/N$, it will obtain the discrete time signal, the discrete time point is $t = k\,T_s$, (k=0,1,2,⋯,N-1), and the sampling value is f_k, so

$$\dot{F}_h = \frac{1}{N}\sum_{k=0}^{N-1} f_k W^{kh}, h = 0,1,2,\cdots, \mathrm{N-1} \quad (2)$$

In the formula (2), F_h is the complex value of each harmonics, fundamental waves and DC components. So we can deduce the occupancy of the *h*^th-harmonic of voltage and current:

$$HRU_h = \frac{V_h}{V_1} \times 100, (\%)$$
$$HRI_h = \frac{I_h}{I_1} \times 100, (\%) \quad (3)$$

THD of voltage and current:

$$THD_u = \frac{\sqrt{\sum_{k=2}^{N/2} V_h^2}}{V_1} \times 100, (\%)$$
$$THD_i = \frac{\sqrt{\sum_{k=2}^{N/2} I_h^2}}{I_1} \times 100, (\%) \qquad (4)$$

Because FFT algorithm have barrier effect and spectrum leak in the harmonic analysis module, this problem affects the harmonic measurement accuracy. So it should compensate the original signal with adding window function, it can reduce the leak effect. LabVIEW provides us 12 window functions such as Hanning and Hamming window.

2.3 Unbalance in three-phase

This device use component of symmetry to calculate unbalance in three-phase, and divide the unbalance voltage into positive-sequence, negative-sequence and zero-sequence, because the calculation of the harmonic sequence component is very complicated, so here only considering the fundamental-wave signal sequence component. Using FFT to obtain three-phase fundamental-wave voltage, the following formulas are to calculate each voltages and unbalance in three-phase.

$$\begin{vmatrix} V_0 \\ V_1 \\ V_2 \end{vmatrix} = \frac{1}{3} \begin{vmatrix} 1 & 1 & 1 \\ 1 & e^{-j120^0} & e^{-j240^0} \\ 1 & e^{-j240^0} & e^{-j120^0} \end{vmatrix} \begin{vmatrix} V_a \\ V_b \\ V_c \end{vmatrix} \qquad (6)$$

$$\varepsilon = \frac{|V_2|}{|V_1|} \times 100\% \qquad (7)$$

3. CONSTRUCTION OF THE POWER QUALITY MONITORING PLATFORM

In LabVIEW platform, using virtual instrument to construct the power quality monitoring platform, Fig.3 shows a part of Block-Diagram of the monitoring platform—Harmonic analysis module

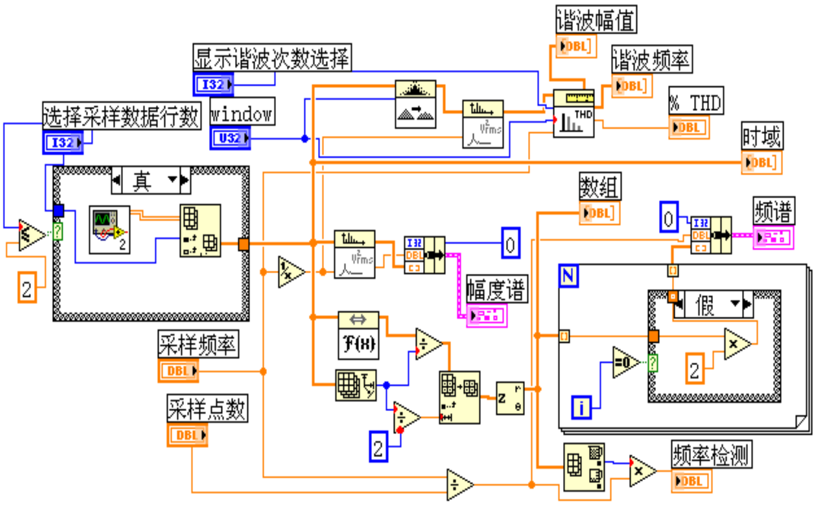

Fig. 3. Diagram of rural power network power quality analysis

4. SIMULATION RESULT ANALYSIS

Real-time waveform of the three-phase voltage and current, is shown in Fig.4.

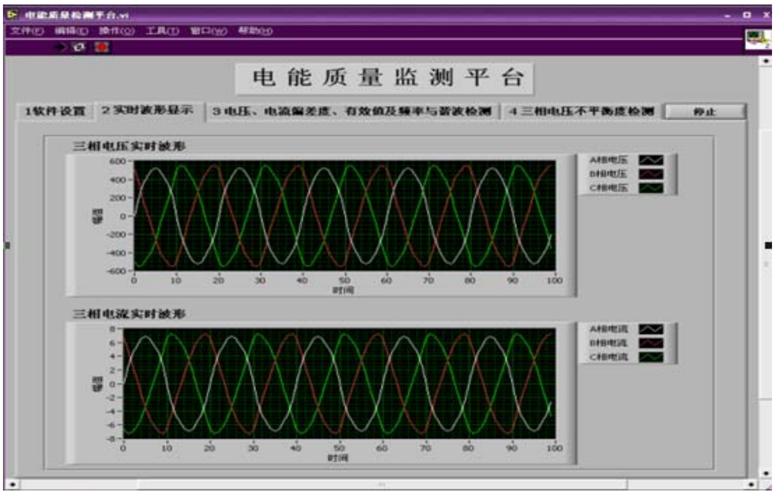

Fig. 4. Interface of real-time waveform

Here it measuring and analyzing 1-phase voltage, as the result in Fig.5. The voltage U1 has obvious distortion, and its corresponding FFT spectrum display the 3rd, 5th, 7th and 9th-harmonic, the THD reaches 13%. It is also can choose any times harmonic frequency or amplitude, and with the graphics and data showing the voltage frequency, effective value and degree of voltage deviation. With the powerful LabVIEW, we can export spectrum of harmonic analysis with data file, display harmonic amplitude. The specific data is shown in Table1.

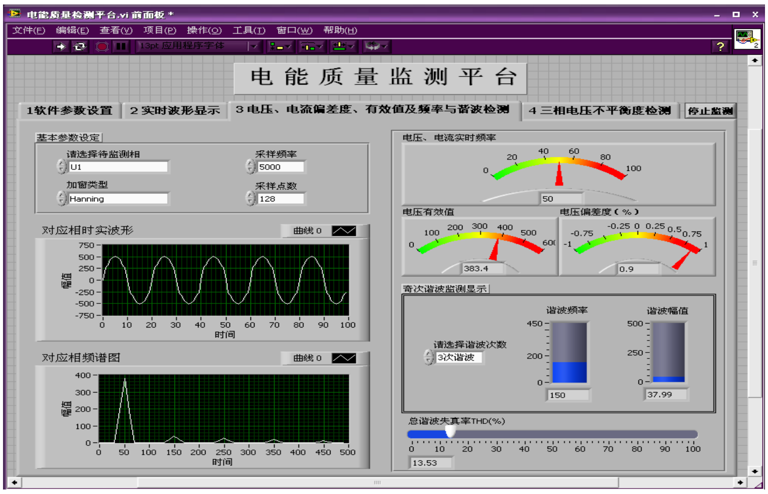

Fig. 5. Interface of harmonics analysis

Table 1. Harmonic amplitude

Harmonic times	Harmonic frequency（Hz）	Harmonic amplitude（V）
1	50	383.40
3	150	37.99
5	250	26.60
7	350	18.99
9	450	11.39

Running the platform with disconnecting one of the load, and measuring voltage unbalance in three-phase, the result shown in Fig.6. The three-phase voltage effective value, vector graph and THD show the voltages are complete balance; while there is no current B, so the THD reaches up to 53%.

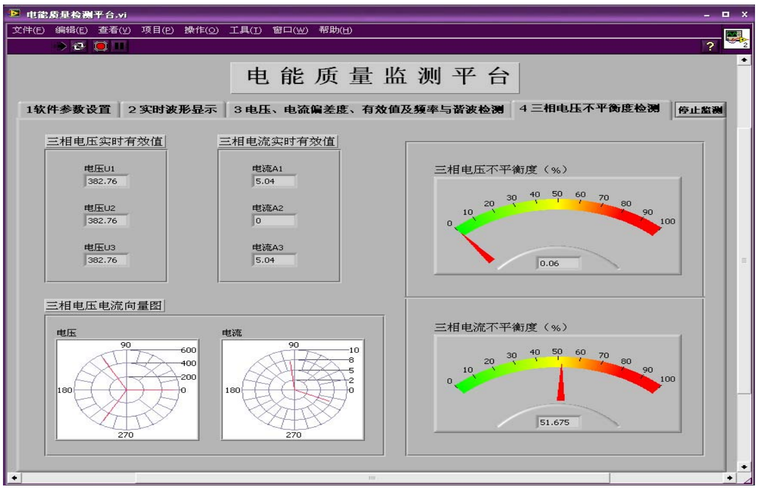

Fig. 6. Interface of unbalance in three-phase analysis

Simulation results show that this system can accurately analyze the unbalance in three-phase of voltage and current, and the actual situation of the rural power network. So it can provide reliable scientific basis for power quality management.

5. CONCLUSION

The system uses “Data acquisition card + PC + LabVIEW” to construct the power quality monitoring and analysis platform of rural power network, is flexible and open. In terms of hardware, it needs configure different accuracy and speed of the DAQ card according to the requirements; In the terms of software, it can take full advantage of LabVIEW’s powerful signal processing and analysis, variety of integrated measures of power quality measure and analysis; we also can construct a user-friendly, feature-rich power quality analysis and management platform base on PC resources. This platform has a broad prospect to against the rural power network which power quality increasingly complex.

REFERENCES

Chen Xihui, Zhang Yinhong. LabVIEW 8.20 Programming[M]. Beijing:Tsinghua University Press, 2007

Ding Yifeng, Cheng Haozhong, Zhan Yong, Sun Yibin, Yan Jiangyong. Present status and development in power quality monitoring. Electric Power, 2004, 37(7):16-19

HU Guangshu. Digital Signal Processing[M]. Beijing:Tsinghua University Press, 1997

HU Qian, TANG Zhen-zhou. Electric harmonic test system based on virtual instrument. Electronic Measurement Technology,2007,30(2):90-92

Lei Zhenshan. LabVIEW 7 Express Technique Tutorial[M]. Beijing: China Railway Department Press, 2004

Luo An. Control of power network and reactive compensate technical and equipment[M]. Beijing: Electric Power, 2006

Pan Wen, QIAN Yutao, ZHOU E. Power Harmonics Measurement Based on Windows and Interpolated FFT(Ⅰ) Transactions of China Electrotechnical Society,1994,9(1):50-54.

Pang Hao, LI Dong-xia,ZU Yun-xiao. An Improved Algorithm for Harmonic Analysis of Power System Using FFT Technique[J].Proceedings of the CSEE,2003,23(6):50-54.

PRC National Standard. GB/T14529-93, Power Quality-Public power network harmonic, Beijing, National Bureau of Technical Supervision, 1993

Wu Jingchang． Harmonic of Power System[M]. Beijing: China Electric Power Press，1998．

Xiao Xiangning, XU Yongmei. Problems and Comprehensive Control of Power System Harmonics[J].Electric Power,1998,31(4):59-61

Zhan Yong, Cheng Haozhong, Ding Yifeng. Design and development of power quality monitoring analysis system. HuaDong Power, 2004, 32(10): 10-14

Zhao Chengyong, GAO Benfeng, JIA Xiufang. Comprehensive power quality detecting system based on LabVIEW. Journal of North China Electric Power University, 2006, 33(2):63-67

Zhao Wenchun ,MA Wei-ming, HU An.FFT Algorithm with High Accuracy for Harmonic in the Electric Machine[J]. Proceedings of the CSEE, 2001,21(12):83-87

Zhou Zhiyu, LI Yuneng, GUO Songmei. Design and Implementation of On-line Harmonics Monitoring System Based on Technology of Virtual Instrument. Process Automation Instrumentation）, 2005, 26(12):34-36