International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 5 Issue 5 ǁ May. 2017 ǁ PP. 36-41

Research on Power Quality Real-Time Monitoring System For High Voltage Switch Gear

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ABSTRACT: As an important equipment of high voltage switch cabinet distribution plays a key role in the power system of power generation, transmission and distribution of electricity, and monitoring the operation of electrical parameters, based on virtual instrument technology, make full use of the data processing, data analysis, data expression and network function and other advantages, build a set based on the LabVIEW real-time power quality monitoring system innovatively applied in high-voltage switch cabinet. Through building a power quality monitoring platform based on high voltage switchgear in the laboratory, the accuracy of the system measurement is verified. The experimental results show that the design of power quality real-time monitoring system has good performance, high accuracy, friendly interface, and has a good market prospect.
Keywords: high voltage switchgear, power quality, LabVIEW, real-time monitoring

I. INTRODUCTION

High voltage switchgear is an important device for distribution of electric energy in the power supply system in power system, power generation, transmission and distribution, electric power lines in the process of commitment on and off system, fault protection, power parameter data monitoring function of [1], widely used in power supply and distribution system. High voltage switch cabinet as connected to the power supply terminal and a center hub terminal, power quality real-time monitoring of the power quality index, obtaining key parameters, one can evaluate the operation level of power grid level, on the other hand can cause the entire power grid problems and solutions provide the basis, and can be real-time master the running status of electrical equipment, so as to find the hidden danger of the equipment timely, make preventive measures to reduce losses.
1 software development platform based on LabVIEW

In the control system, to obtain the original signal through the data acquisition hardware, and then use the PC software to complete data processing, analysis and results show that the construction of measurement instrument based on PC mode is called virtual instrument. The core of virtual instrument, which is a new concept measuring instrument, has great advantages in its application software, and the use of software platform to complete data processing and build visual interface. In the virtual instrument, we can change the software system without changing the hardware system, and then we can change the software programming content according to the user's request, and then we can get the measuring instrument with different functions. Therefore, the key of the virtual instrument is software, and the measurement and control function of the instrument is mainly realized by software.
the virtual instrument can complete various test applications. Virtual instruments have the following advantages:
(1).Development cost is low, cycle is short;
(2).User defined measurement and control function, flexible configuration, to meet the changing functional requirements;
(3).Upgrade the measurement and control capability and level of the system conveniently;
(4).Easy to interconnect with other devices.

The virtual instrument platform of this system is using national instruments NI LabVIEW graphical programming language and development environment, the use of LabVIEW to create icons instead of a text line application, programming style is simple and direct, continuous improvement, update and improvement, has unique advantages in data processing and analysis, data expression and network function etc. Full use of virtual instrument technology, anti-interference ability, flexibility and scalability, low cost, cost-effective, user-friendly interface, etc., to build a PC based power quality monitoring system. Especially when the system requirements have changed, or when the system will be used in different environments, just need to make some necessary software modifications and additions can meet the functional requirements of the system.

II. SOFTWARE ARCHITECTURE

The data acquisition module, data processing and analysis module and real-time display module three parts including power quality parameters monitoring system, data acquisition is completed by the traditional hardware, different data analysis and display module is implemented by computer software. For the study on the power quality parameters monitoring system, the software is the core part of the hardware, as long as the monitoring points of voltage and current signal transmission through the sensor, signal conditioning and embedded data acquisition conversion digital signal transmission to the computer software on the platform, you can use the virtual instrument LabVIEW to complete the processing and analysis of electric energy the quality parameters, data storage and display results.

The design of virtual instrument of power quality parameters monitoring and analysis system based on the power quality parameters monitoring functions include: voltammetric measurements, frequency measurement, power measurement, three-phase unbalance measurement, harmonic measurement, flicker measurement and capture transient events, and complete data storage, query, print statements, remote history access and other functions.The architecture of the system software is shown in figure 3-1.

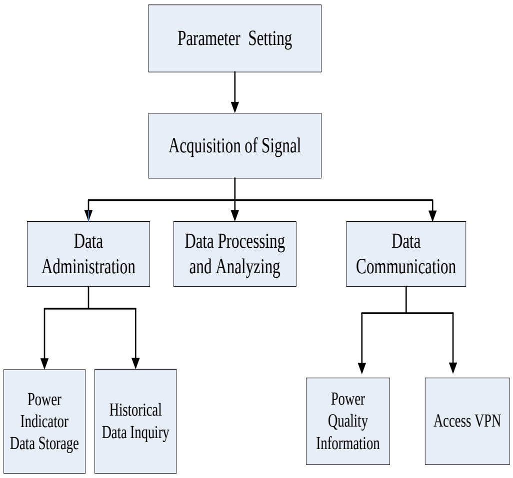

Fig.3-1 The system software architecture

System software implementation part includes three parts:

(1). Data processing and analysis mainly include real-time waveform display, basic parameter measurement calculation, three-phase unbalanced calculation, harmonic calculation and analysis, voltage fluctuation and flicker measurement, transient disturbance capture, and so on;

(2). Data management mainly completes waveform data recording, power index data storage, historical data inquiry, report form printing and so on;

(3).data communication, mainly to complete the power quality information release and user remote access function, through the network to achieve server-side data and client data services and sharing.

III. IMPLEMENTATION OF THE SOFTWARE PART

3.1 Design of serial communication module

The serial communication module is used to transmit the raw data of the signal source of the monitoring system, which is very important to the software of the monitoring system. This system uses LabVIEW serial communication VI to complete the data transmission, as shown in figure 3-1.

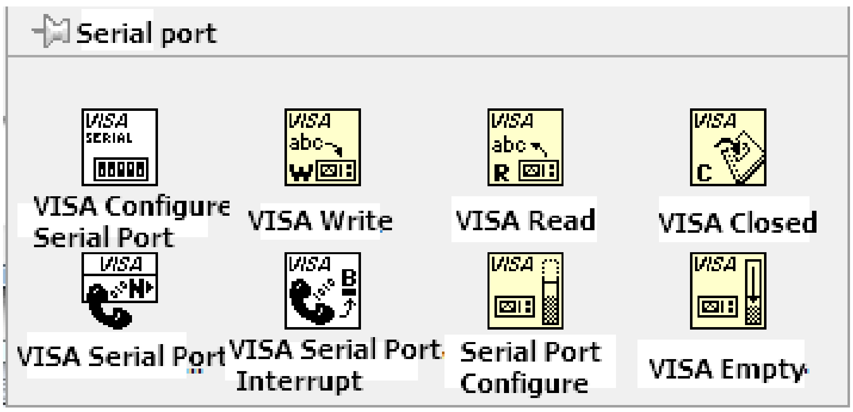

Fig.3-1 The serial port communication VI of LabVIEW

Complete the serial communication program for data transmission, as shown in Figure 3-2, and encapsulate it as a subroutine.

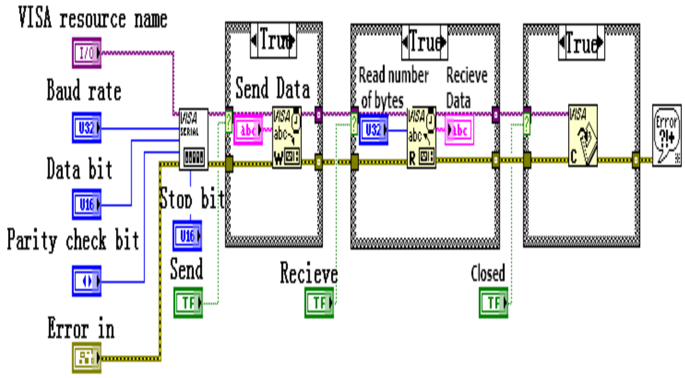

Fig.3-2 Data serial communication subroutine

(1) Call the "VISA configuration serial port" function module to complete the serial initialization configuration, that is to complete the establishment of related parameters, including the serial port resource name, baud rate, data bits, stop bits, parity bits, etc.;
(2) After completion of initialization, use this serial port to receive data. Through the "VISA write" function module to send data, through the "VISA read" function module to read data. Among them, the VISA read operation will wait until the data bytes in the buffer reach the data bytes required in the current serial receive buffer to begin receiving data.
(3) After the use of the serial port, use the "VISA shutdown" function to end the communication with the current serial port, releasing all the resources occupied during the execution of the task.

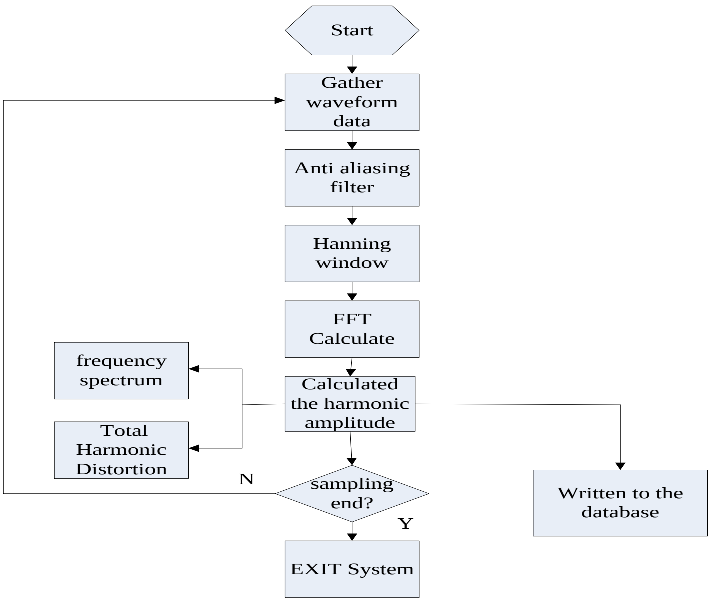

Fig.3-3 The flow chart of harmonic analysis

The module of harmonic calculation and analysis: first, the acquired waveform data are filtered by anti-aliasing filtering, and then FFT is added to the window to obtain the amplitude of fundamental wave and the amplitude of each harmonic, and the total harmonic distortion THD is calculated. Finally, the basic wave amplitude and the rate of each harmonic are written into the database for users to query data.

3.2 Design of flicker measurement module

At present, flicker measurement is the most widely used method, or flicker detection method recommended by IEC. First, extract the fluctuation signal through the square demodulation method, the input signal is square after 0.05 ~ 35Hz band frequency pass filter to filter the DC component and higher than 35Hz, the amplitude modulation and demodulation from power frequency voltage signal. Then, the instantaneous sense signal p (T) is obtained after the weighted filtering, square and smoothing weighted filtering of the center frequency of 8.8Hz. Finally, the horizontal hierarchical state time method, that is, the cumulative probability function (CPF) curve, is used to do the progressive hierarchical processing of the signal. According to the flicker calculation method, the CPF curve obtained by short flicker Pst, long flicker value Plt (2H detection time) can be obtained by n Pst and then the cube root. The program flow chart of the IEC flicker measuring instrument is shown in figure 4-4.

① The transfer function of the first order high pass filter at cutoff frequency 0.05Hz is:

$$\mathrm{H}(s)=\frac{s/\omega}{1+s/\omega} \qquad (4\text{-}1)$$

In which， ω =2π×0.05。

②The cutoff frequency 35Hz low-pass filter selects the 6 order Butterworth filter, whose transfer function is:

$$\mathrm{H}(s)=[1+\sum_{\mathrm{i}=1}^{6}b_i(s/\omega)^i]^{-1} \qquad (4\text{-}2)$$

In which， ω =2π×35， b_1 =3.864， b_2 =7.464， b_3 =9.141， b_4 =7.464， b_5 =3.864， b_6 =1.0。

③A sensitivity weighted filter of central frequency 8.8Hz is constructed based on the sensitivity coefficient frequency characteristic, and the transfer function is as follows:

$$\mathrm{K}(s)=\frac{k\omega_1 s}{s^2+2\lambda s+\omega_1^{\ 2}}\times\frac{1+s/\omega_2}{(1+s/\omega_3)(1+s/\omega_4)} \qquad (4\text{-}3)$$

In which， K =1.74082， λ =2π×4.05981， ω_1 =2π×9.15494， ω_2 =2π×2.27979， ω_3 =2π×1.22535， ω_4 =2π×21.90。

④The smoothing filter selects the first order low-pass filter, the cutoff frequency is 0.53Hz, and the transfer function is:

$$\mathrm{H}(s)=\frac{1}{1+0.3\mathrm{s}} \qquad (4\text{-}4)$$

IV. EXPERIMENTAL VERIFICATION AND RESULT ANALYSIS

4.1 Experimental verification scheme

In order to verify the accuracy of measurement results of the system, we choose the Fluck Corporation Fluke 437 power quality analyzer as compared with the measured value of instruments, as the actual reference value, the high performance of the instrument, its technical parameters are as follows: the effective value of voltage measurement accuracy is 0.1%; the current effective value measurement accuracy + 0.5% the frequency measurement accuracy of 0.01Hz;; power factor measurement accuracy + 0.1%; unbalanced voltage measurement accuracy of + 0.1%, unbalanced current measurement accuracy of 1%; 1 to 50 harmonic measurement, harmonic voltage and current measurement accuracy of + 0.1%; flicker measurement accuracy + 5%. Therefore, it can be considered that the data measured by Fluke 437 is accurate and effective, and the accuracy and reliability of the system are verified by comparing with its measurement results. Therefore, set up the experimental system as shown in Figure 4-1, compare the measurement results of this system and Fluke 437.

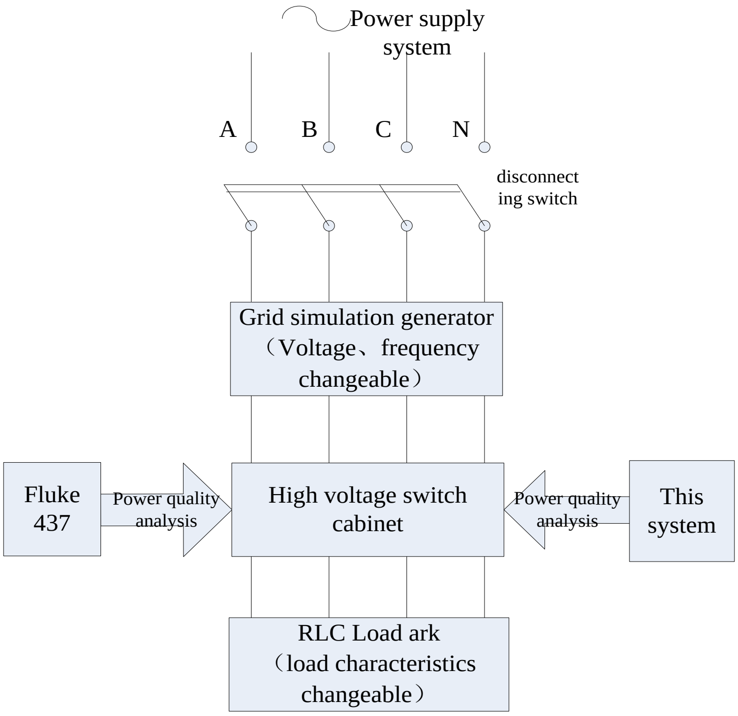

Fig.4-1The diagram of experimental system

During the experiment, the power grid voltage generator simulation simulation, the high voltage switch cabinet RLC load applied to the cabinet, then change the voltage amplitude, frequency of the power system simulator, and adjust the load cabinet in the resistive, inductive and capacitive properties of three kinds of load, constant modification for electrical properties and load properties by repeated experiments. High voltage switch cabinet as the experimental platform as monitoring points, the use of Fluke 437 and the simultaneous monitoring of its power quality, obtain comparative data, analysis of experimental results and conclusions。

(a) Fluke 437 power quality **analyzer** **(b)** Grid simulation generator

Fig.4-2 Experimental instruments

(a) Load cabinet **(b)** High voltage switch cabinet

Fig.4-3 Experimental cabinets

Among them, the 437 type power quality analyzer physical map and the grid simulation generator as shown in Figure 4-2, RLC load cabinet and high voltage switch cabinet as shown in Figure 4-3.

4.2 Experimental verification scheme

In the design of the system interface, taking into account the monitoring system of power quality parameters more content, so in order to make the measurement more beautiful and friendly interface, user-friendly, using LabVIEW user controls Tab classification of power quality parameter data and charts, the power quality information visually displayed to the user. The results show that the system has high measurement accuracy, can achieve the national standard "General requirements" of power quality monitoring equipment for the performance requirements, the system can be applied to the actual power quality monitoring.

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