Research on the Fiber-optic On-line Monitoring System for Electrical Equipments Based on LabVIEW

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Abstract: Dielectric loss is a key parameter in capacitive power equipment insulation on-line monitoring. The implementation of dielectric loss on-line monitoring for high-voltage capacitive equipments is of great significance to its safe operation. Based on LabVIEW virtual instrument technology, a set of optical power, optical synchronous and optical fiber transmission dielectric loss on-line monitoring software system is developed in this paper. The SCADA software interface is designed, which is clean, simple and easy to operate. It designs the functional modules such as data acquisition and processing, information query and the remote monitoring module. The acquisition module communicates with the USB interface of the computer through the virtual instrument software architecture; Information query module implements the connection with SQL Server database by LabSQL, facilitating data storage and user query; The remote monitoring module through Microsoft's ASP.NET web development model and combined LabVIEW remote publishing technology, realizes the remote monitoring capabilities based on B/S structure.

1 INTRODUCTION

With the widespread use of virtual instrument, software is playing an important part in the system of insulation testing. Most systems on insulation testing have developed into system of hardware combining with computer software from system of pure hardware. Bringing in the virtual instrument reduces cost, and it makes the whole system be complicated and powerful [1-6].

Based on LabVIEW virtual instrument technology, a set of fiber-optic on-line insulation monitoring software system of capacitance equipment is developed in this paper. This system designs the SCADA software interface which is clean, simple and easy to operate. Using the module and layer, it fulfills four functions which include data acquisition, data processing, information query and the remote monitoring.

2 THE WHOLE STRUCTURE OF SYSTEM

The basic idea of Fiber-optic on-line insulation monitoring system is that we can achieve the voltage and current's reliable measurement of the capacitance equipment through OPDL (Optically Powered Data Link). The voltage and current signal will be transferred by fiber. At the same time, the system can attain the purpose of long-term on-line monitoring with the technology of light synchronous, signal processing and virtual instrument. The hardware framework of the system is shown as Fig 1.

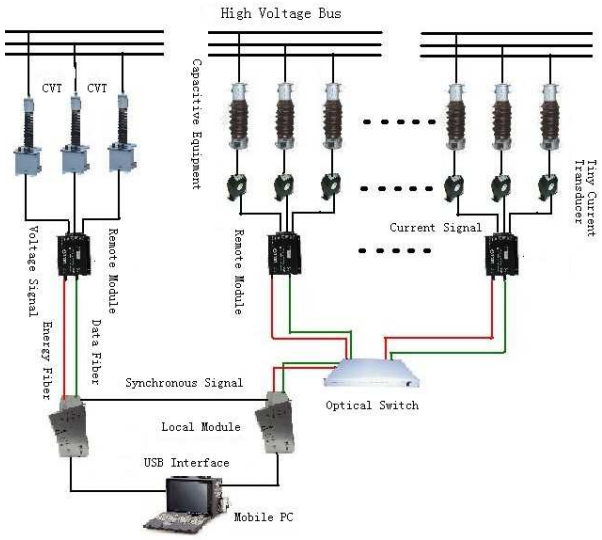

Fig 1: Hardware framework of on-line insulation monitoring system

The software system adopts module and layer's idea, which improves efficiency on software maintaining and upgrading, conducts to be compatible to other systems. The main job of software is instrument controlling, Data Acquisition (DAQ), information query and remote announcing. It is divided into graphic system, monitoring system and information query system. The software framework is shown as Fig 2.

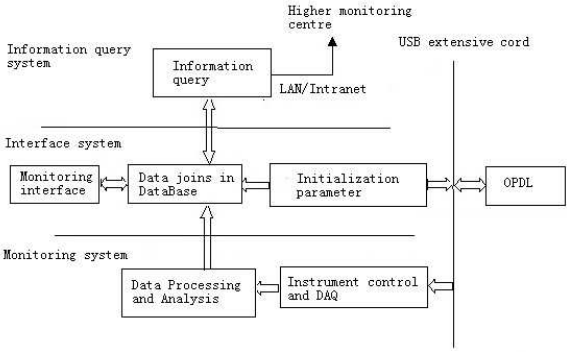

Fig 2: Software framework of on-line insulation monitoring system

The graphical user's interface of monitoring system is designed through the graphic system. According to equipment information monitoring, system makes data collection, analysis and calculation and returns the results to the equipment information database. At the same time, the state of corresponding equipment will be showed on the Monitoring picture; Information query system mainly completes to query native information and releases network data and then sends the data to the Higher Monitoring Centre through LAN or internet.

3 THE FUNCTION AND THE REALIZATION OF THE SYSTEM SOFTWARE

3.1 The design of interface system

The user can control the program of this system through the menu which can make the function be hierarchical. It gives user great convenience to understand and use this system. Meanwhile, it uses Automation of Electric Network Management SCADA interface (the wiring diagram of primary device) as main body's graphic designing interface, so the site scene can reflect visually on the monitoring screen of monitor station. This system highlights the monitored device, and includes dynamic front view which displays real-time state of device. This system has alarming function which is completed by the Boolean type indicator associated with monitored device when it is at fault. Meanwhile, it has friendly interface and operating conveniently. Main system interface is shown as Fig 3.

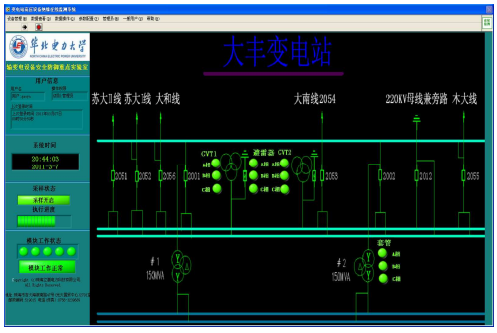

Fig 3: Main interface of monitoring system

In order to better grasp equipment's running status, the program designs a powerful real-time waveform displaying function. Users can view real-time waveform of single-phase equipment or the same type's real-time waveform of three-phase equipment on time by clicking the corresponding equipment number on main interface. The real-time waveforms of three-phase equipment are shown as Fig 4.

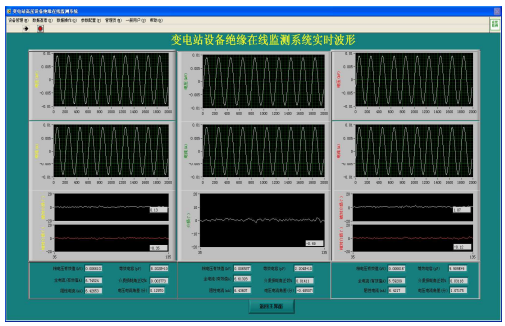

Fig 4: Real-time voltage and current waveforms

3.2 The design of data acquisition module

The system of data acquisition is mainly in charge of controlling the communication between OPDL local module and computer. Connected with USB extensive cord, the OPDL local module and computer communicate with each other based on VISA (Virtual Instruments Software Architecture) of LabVIEW virtual instrument.

3.2.1 The fulfillment of USB virtual serial port

In view of easy extension, data transmission speed and high reliability, this paper adopts the USB virtual serial port communication instead of physical serial port communication in communicating OPDL local module with computer. The internal local module adopts chip which turns USB interface into serial port. In these chips which accomplish the conversion between serial port and USB protocol, there is a serial port on one side and a USB interface on the other side. In operating system, the chip shows a serial port device after connecting to computer through USB interface. In this case, the application software on PC side still aims at RS-232 serial port programming and the appearance is also based on RS-232 as Data communication channels. The physical connection between PC and peripheral equipment is on the USB trunk, data communication is also the USB data format. USB trunk's high transmission rate and the character of PnP get high efficiency [7-9].

3.2.2 The USB interface applications' design based on the VISA

This paper develops the USB driver applications through NI-VISA based on the LabVIEW environment, so it completely avoids the complexity that develops the USB driver before and shorten the development cycle. VISA, short for Virtual Instrument Software Architecture system, is a program library to control VXI, GPIB, PXI, PCI, USB, serial, and other types of equipments based on the LabVIEW development platform. It is also a high-levelled Application Programming Interface (API) which can package various bus drivers jointly.

It is Using the built-in serial port function modules of VISA to complete the underlying data-driven development of the OPDL. The specific realization of Visa's communication program is shown as Fig 5.

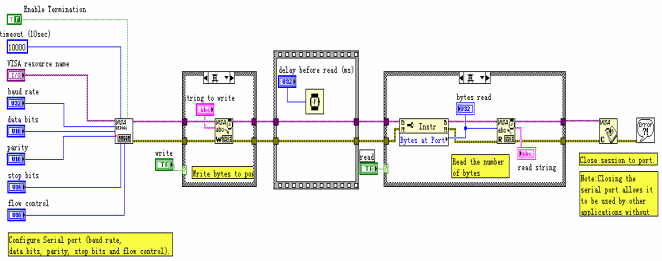

Fig 5: Serial communication programs based on VISA

Firstly, call the VISA Configure Serial Port to complete the serial port, baud rate, data bits, stop bits, parity bit and flow control settings such as serial port parameters. When complete the Initialization, you can use the VISA Write, VISA Read function to send and receive data. Before receiving the data, it needs to use VISA Bytes at Serial Port attribute nodes to query the current data of the receiving buffer bytes. If the VISA Read needs to read more data in the buffer than the data of bytes, the VISA Read operation will have to wait until the data of Timeout or the bytes in the buffer reaches the required number. In some particular cases, we need to use the VISA Set I/O Buffer Size function setting the serial port to receive or send buffer size and the VISA Flush I/O Buffer to clear reception and transmission buffer function. After the using of the Serial Port, we should use the VISA Close function to end the conversation of serial port referred by the VISA resource name [10].

3.3 Based on the design of LabSQL Database Module

The data collected by system is all stored in the way of database, which is achieved to connect mutually with LabSQL's opening tool kit of LabVIEW. LabSQL is a free, multi-database, cross-platform LabVIEW database Toolkit. Using Microsoft ADO (ActiveX Data Object) and the SQL language to complete the database access, LabSQL will package the complex underlying ADO and SQL operation into a series of LabSQL VIs. The advantage of LabSQL is easy to understand, and simple to operate. It just needs programming simply and can be implemented database access in LabVIEW [11].

This system achieves the functions of abundant data query and data manipulation, of which data query module mainly achieves the functions of data query the very day, historical data query (including the dielectric loss of the absolute and relative query), and fault records query, and so on. Data manipulation module mainly achieves the selective update, delete functions for a variety of database tables. In order to facilitate timely statistic data and analysis, system also designs the reporting function that can implement the data graphical trend analysis and reporting analysis during any time period in the query module. As Figure 5 and Figure 6 show, they achieve the historical data query. Users can choose the trend map of historical changeable curve form to query and master the equipment operation intuitively. Also they can choose the data form to query and learn more concrete information about equipment operation.

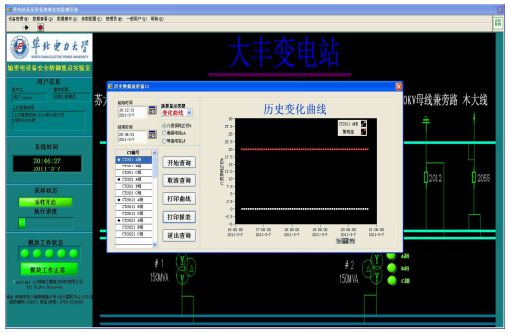

Fig 6: Historical data trend chart

Fig 7: Form inquires of the historical data

3.4 The design of the remote monitoring module

Based on the existing Internet architecture, we can explore the network remote monitoring system without costing a large investment in hardware. The shortness of development circle is a shortcut of the remote control system. This paper adopts

ASP.NET technology and LabVIEW remote panel release technology which can realize information retrieval system and remote control system basing on browser/server (B/S) model. Under the B/S structure, this system has advantages of high efficiency, short development cycle, platform independence and openness without developing client software.

3.4.1 The network structure of monitoring system

Network remote monitoring system model diagram realized by this system is shown as Fig 8.

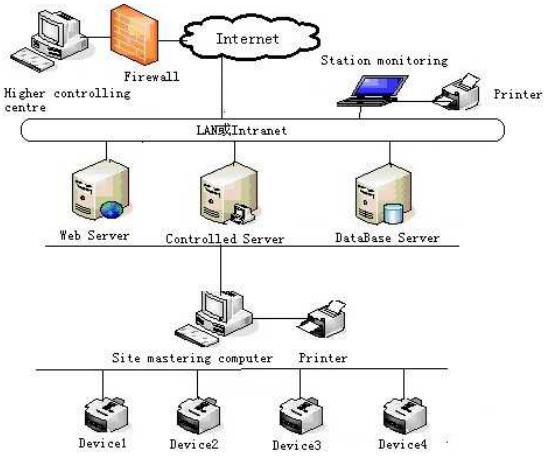

Fig 8: Remote monitoring system network structure

Remote monitoring system is such an open distributed system as the figure's show. It is mainly consisted of database server, Web server, Controlled server and other components. The main functions of every system as follows:

(1) Web Server: it is mainly providing Web inserting service, user certification management, opening communicated environment and the generation of dynamic website. Web Server stays for HTML Web pages and asp.net programs that is used for interacting with users and performing remote monitoring. After accepting user's information coming from the browser, web server produces dynamic page according to a corresponding user's request and then returns to the client browser for viewing.

(2) Controlled Server: it is mainly used to complete the equipment's data acquisition and program controlling. The result will be stored in the corresponding database.

(3) Database Server: it is used to cooperate with the user's account management, dynamic web generation and the storage and management of various monitoring data.

3.4.2 The achievement of the monitoring system function

Based on the VStudio.NET platform, the paper applies the C# language to develop the ASP.NET dynamic web page program and uses the ADO.NET to connect the data base. Fig 9 is showing the Remote Monitoring System. This Monitoring System has achieved the four functions: login management, data inquiry, real-time monitor and background management.

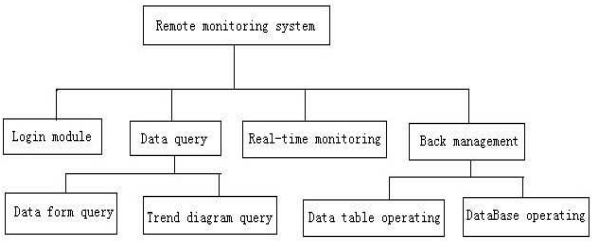

Fig 9: Remote monitoring system function diagram

Login module has achieved the member login management function which includes the aspects as follows:

1) Register: finish the information registration about the name of the new users and the password.

2) Login: new users can enter the system after the information including the name of the users and passwords are checked through the login module.

3) Edit password: users can edit the password; the system support the password question and password retrieval.

4) Mange roles: this function divides the users into three roles including administrators who can use and maintain all the function of the system, login users who can only use the data inquiry and real-time monitor function and guests who can only browse the help information of the system and cannot use any function.

Data query function realized the data inquiry of real-time and historical it realizes query by two ways: Data form query and trend diagram query. In data query pages, the user can select "device type" and "device Numbers" to determine the present equipment that they will query. He can choose inquired time through the "start time" and "end time". Data query function module also supports the data's remote transmission. users can transport the queried data to the local computer through Network remote and import it to Excel or Word document automatically, in order that relevant personnel analyzes the data further more. Data form's inquiring function is shown as Fig 10.

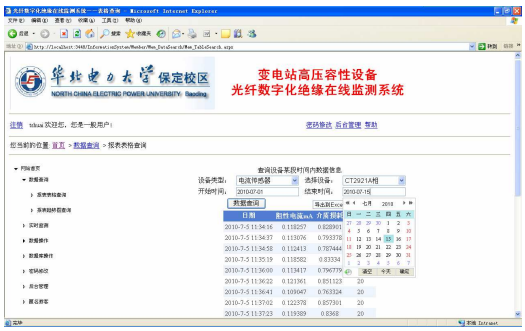

Fig 10: Data query function

The trend map query is able to dynamicly display of trend line at any time according to the date and time. It is intuitive then the user can clearly see the operation parameters of the equipments. Its function realization is shown as Fig11.

Fig 11: Trend diagram inquiry

Real-time monitoring page realises the remote control and monitor on site collecting module. The realization of the real-time monitor uses the remote panels' punishing technology of LabVIEW and the html page embedded function of ASP.NET. LabVIEW remote panels publishing is a communication based on TCP protocol. It adopts the browser mode to remote control the equipment. The user only sets the net communication parameter intuitively and conveniently remote monitor and it is without the user's programming [12-14]. After embedding the html in the ASP.Net, it realizes the function of remote monitor to the equipment. It is shown as Fig 12.

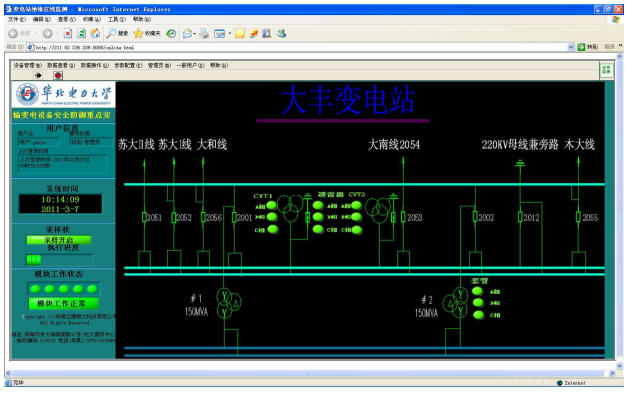

Fig 12: Remote control of the substation insulation monitoring

4 CONCLUSION

The paper designs a set of on-line insulation monitoring software system based on the virtual instrument technology. Its main characteristics are shown as following:

(1) It designs the software interface based on the SCADA, which is a graphical interface with the primary wiring diagram as its main body. The dynamic state demonstrates the condition of the equipment and the real-time waveform. It is used friendly and conveniently.

(2) The data acquisition module realizes the communication between the acquisition module and USB interface on computer by virtual instrument software architecture (visa)

(3) Information query module use the LABSQL toolkit of LabVIEW to realize the resource access between the software and SQL server database. It is easy for the information to be stored; meanwhile it can be used for multi-user query function.

(4) The remote monitoring module adopts the ASP.NET and lab view publishing technology and the B/S architecture to fulfil the software's web publishing. It realizes the remote controlling of the acquisition equipment and querying for acquisition information at different sites. It is beneficial to the integration with GIS and MIS, and then it improves the automation level.

5 ACKNOWLEDGMENTS

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