

Development of the Intelligent Voltage Monitor System for the 220KV Transformer Station

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The monitoring of voltages in electrical power stations is essential for the evaluation of the quality at different levels of the electric network. It is the vital foundation upon which the relevant authorities are able to create the voltage chart, plan the electric network layout and arrange the proper operation protocols. Currently the voltage monitoring undertaken by domestic manufactures can monitor only one spot. The data acquired in real-time is stored in the EPROM. Because of its small capacity, the information used for analysis is very limited. The intelligent voltage monitoring instrument development by the author of this paper is specifically designed for the Shumuling Transformer Station of the Hunan Changsha Electric Power Bureau. It can monitor multiple loop circuits simultaneously and record statistics on the maximum and minimum values of voltage and the rate of qualified voltage. It also allows the user the capability to query and monitor the daily voltage curves and print daily and monthly reports.

I. The basic features of the intelligent voltage monitor

1) This intelligent voltage monitor was installed in the Shumuling Transformer Station of the Hunan Changsha Electric Power Bureau. It can monitor the two channels of 200KV PT voltage, two channels of 110KV PT voltage, four channels of 10KV PT voltage, two channels of 220V DC voltage and two channels of 380V DC voltage in real time. The monitor acquires the voltage sample by effective values. The sampling rate is one sample per second, with pre-processing storage. It takes one minute as a statistical unit, and takes the average pre-processed voltage value within one minute as the actual operational voltage of the system being monitored.

(2) The ability to query by time

(3) The ability to display in graphics mode

(4) The ability to make daily and monthly statistics. It can display or print the voltage evaluation time, the rate of qualified voltage and the accumulated time, the rate of the voltage exceeding the upper limit and corresponding accumulated time, the rate of the

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voltage exceeding the lower limit and the corresponding accumulated time. It can also save data up to 3 months.

(5) The ability to print the whole hour and the ability to take maximum/minimum values and print a readout for the corresponding time.

(6) The ability to make data backup, data read and data delete etc.

Within the range of $\pm 20\%$ of rated voltage U_n , the composite measurement error of the monitor $r \leq \pm 0.5\%$

II. The hardware architecture of the system

The system architecture is show in Figure 1. The system consists of two [I-7017](#) data acquisition modules, 1 RS232/485 conversion module ([I-7520](#)) and 12 voltage transmitters.

[I-7017](#) data acquisition module is an 8-channel analog input module manufactured by ICPDAS. It has 8 differential input channels, 16-bit resolution and up to 115.2K bps communication speed. It's mainly used in industrial fields or other distributed data acquisition systems. It uses RS232/485/422 communications networks and transfers the distributed signals to the master PC or control remote sites from via PC. It has a unique feature of dual watchdog design, i.e., the software watchdog and hardware watchdog. Each [I-7017](#) module has an internal hardware watch dog. This means If the module is down, it can reboot in nearly no time. The master PC and each [I-7017](#) module have a software watchdog interlock. In case the master PC is down, all the output modules will enter the pre-set safe mode, which is in compliance with the industrial safety requirement. If the RS-485 communication network is disconnected or some other malfunction occurs, the host PC and the individual modules can not interlock or communicate with each other, which can also activate the software watchdog. The design of the software watchdog is very clever and easy to use, and significantly improves the system reliability and safety.

[I-7520](#) is an RS-232 /RS485 conversion module, which can be directly plugged into the extension slot of the PC without any independent power supply. [I-7520](#) has an internal self-adapting functionality. It can check the data communication baud rate and data format automatically and thus accurately control the RS-485 network while also decreasing the system cost and increasing the system reliability.

We use the WB400 series electric signal isolated sensor manufactured by Southwest Automation

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Institute as the voltage transmitter. This type of sensor adopts specifically designed isolating modules. When measuring AC voltages in real time in power networks and circuits, it has the advantages of high precision, high isolation, wide frequency response, low drift, proof of impact, and high performance/cost ratio. The V411D1 module can convert the secondary 100V voltage of the PT to 5V DC voltage; the V332A module can convert the 220V or 380v DC voltage to 5V DC voltage. Its level precision is 0.2 and its linear range is 0~120% of the rated input.

The [I-7017](#) data acquisition module is installed in the field and acquires the output voltage signal of the transmitter in real time. It then converts the sample into RS-485 standard signal and transfer to RS-485 network. The [I-7000](#) series products implement voltage isolation of the field signals, and the EIA RS-485 is a dual-direction compensating communication protocol that is widely used in the industrial fields. Only one pair of twisted wire is needed to send and receive data at long distances at a high speed. The individual nodes are connected in parallel. Because modules are independent both from one another and from the network as a whole, system reliability is improved significantly.

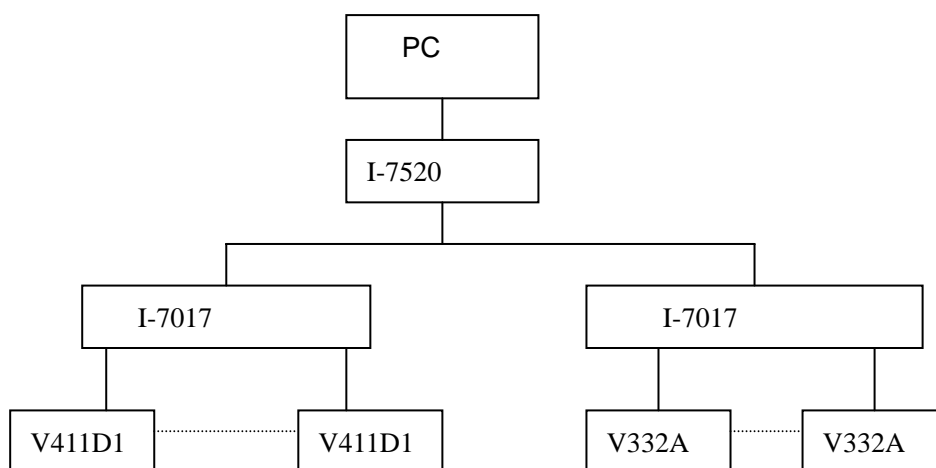


Fig. 1 System Hardware Diagram

III. The Software Architecture of the System

The system is developed using Powerbuilder 6.5. The system software is shown as following:

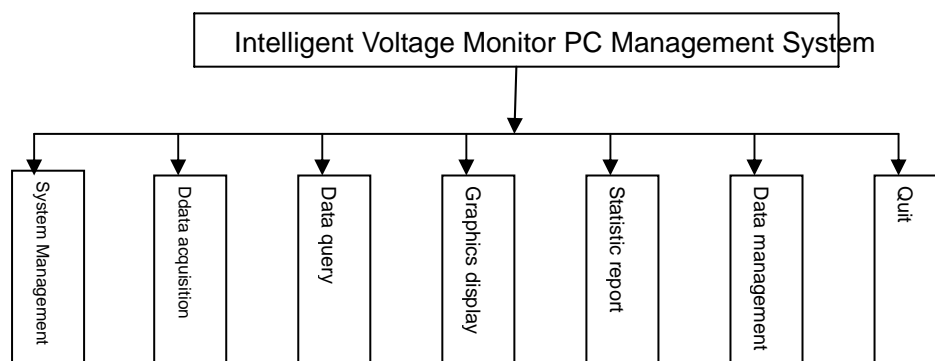


Fig. 2 System software diagram

1. System management

The system management module consists of user entry and print setting submodules. Access to this system software is governed as follows: In the system user entry module, you can enter the system user's name, password and permission information.

The system usage access protocol can be divided into two categories: general operator and system administrator. As a general system operator, you can only access the data acquisition module, the data query module and the graphics display module etc. As a system administrator, you can use all modules available.

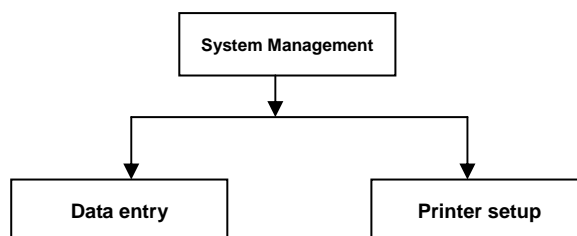


Fig. 3 System Management Module Diagram

2. Data acquisition

In the data acquisition module, you can get the real time data for the 12 different channels at a rate of one per second. An average of 60 samples is stored as the value for each one minute interval. With the data acquisition module, the user can also use the automatic daily statistic report, i.e.,

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every day at the time 23:59:59 the system will automatically generate a statistics report on the maximum voltage value, minimum voltage value, evaluation time, and the time when the maximum/minimum voltage values appear.

Because PowerBuilder supports MS OCX, I use the MSCOMM32.OCX of VB4 to implement the communication with the COM port. The implementation is as follows. First, add an OLE control in the window and choose MSCOMM32. The program for the comm port is as follows:

```
ole_comm1.Object.CommPort = 1 // ole_comm1 is the name for the OLE control. CommPort is the port.
ole_comm1.Object.Settings = "9600,N,8,1" //set communication protocol
ole_comm1.Object.InputLen = 0 //Initialize Input
ole_comm1.Object.PortOpen = True //Open COM port
ole_comm1.Object.Output = "#"+ "010"+ CHAR ( 13 ) //Send character to COM port
Do
    Yield() //wait until there is data in InBuffer
LOOP Until ole_comm1.Object.InBufferCount >= 1
ls_Output = ole_comm1.Object.Input //Get data
```

where, ole_comm1.Object.Output = "#"+ "010"+ CHAR(13) In order to send a command to the port, it's necessary to read the analog data from channel 0 of the I-7017 data acquisition module.

The interface for data acquisition is shown below:



Fig. 4 Interface for data acquisition

3. Data query

In the data acquisition module, the related records and data will be listed and can also be printed out according to the query time entered.

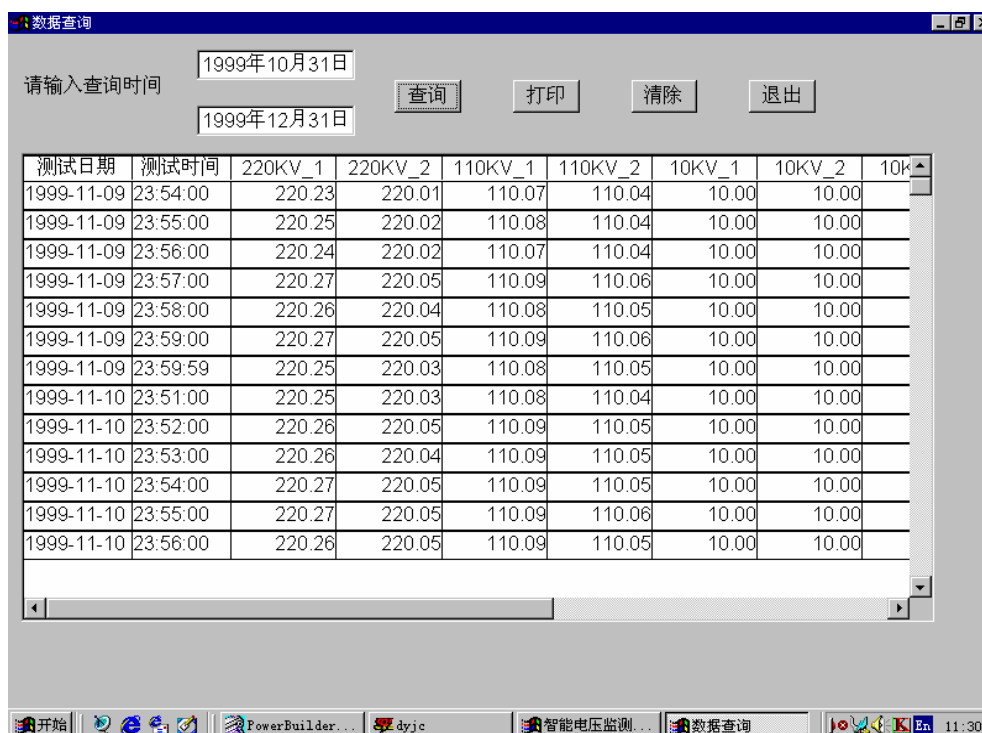


Fig. 5 Interface for Data Query

The interface for query is show in Fig. 5.

4. Graphics display

To engage click the graphics module, enter the time to query for, and choose the name of the line. The user can retrieve the voltage sample value for this line on the entered date, and a curve of the change will also be displayed. To print out the voltage curve choose the print function.

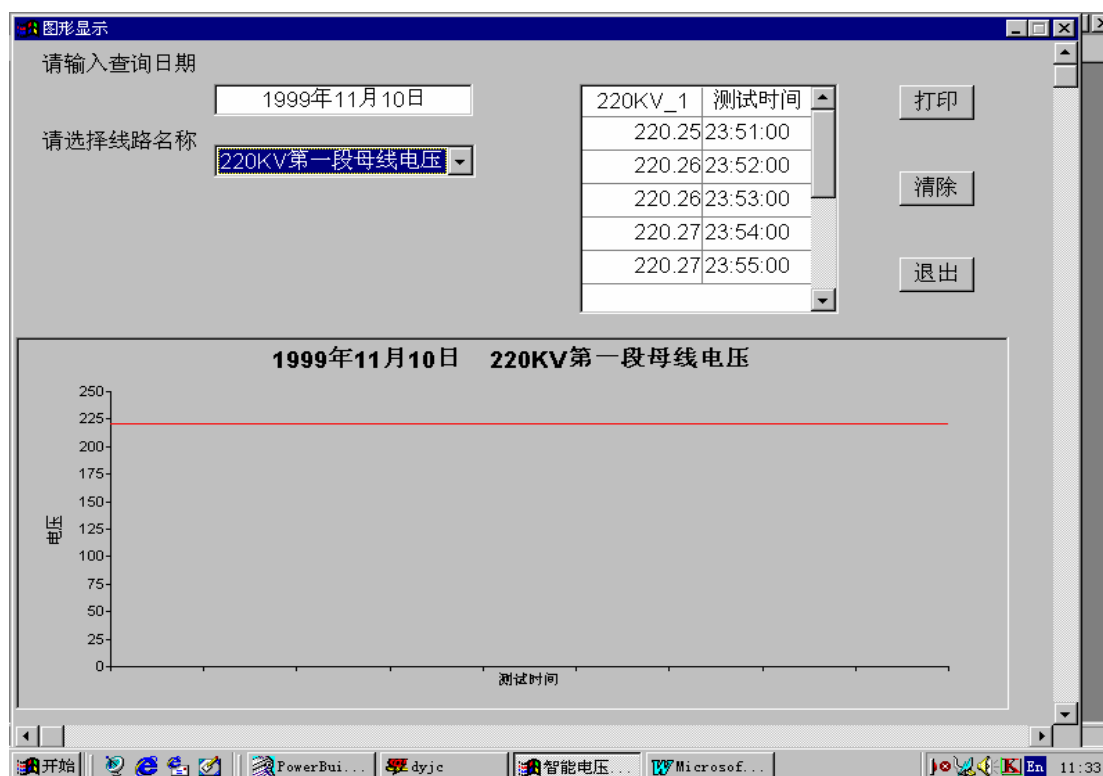


Fig. 6 Graphics interface

5. Statistics report

The statistics module consists of daily report and monthly report modules. In the daily statistic window, enter the time to query for. The statistical information for the 8 lines on the given date about the following: total evaluation time, out-of-upper-limit time, out-of-lower-limit time, qualifying ratio, maximum value, minimum value, time for max. value and time for min. value and the average value of the day will be made. The user presses Print to print out a report. For the monthly report, you can get the statistics for the month and the statistics for the year. Specifically this means after the user enters the query month, it will make a summary on the following: total evaluation time, out-of-upper-limit time, out-of-lower-limit time, qualifying ratio and annual accumulated out-of-upper-limit time, accumulated out-of-lower-limit time, accumulated power supply time and accumulated qualification rate. Pressing Print prints out the report, rather naturally.

The interface for the daily statistic report window is shown in Fig. 7.



Fig. 7 Daily Report

7. Data management

The data management module includes data backup, data removal, data entry and monthly statistic generation functionality. The user enters the time period for which he or she would like to back up the data in the data backup window and the module will proceed to load the selected data onto the hard disk. If the data in storage becomes outdated, the user can retrieve and then remove that data through the data removal window. It is possible to restore the backup data to the database through the data entry interface.

IV. Conclusion

This intelligent voltage monitoring system has passed electromagnetic compliance experiments and a precision evaluation by the Hunan Electric Power Experimental Research Institute. All the data fit the design specifications. The user-friendly interface and ease of use the software's shown has earned a wide welcome.