

Design of Temperature Measurement and Data Acquisition System Based on Virtual Instrument LabVIEW

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Abstract

The LabVIEW virtual instrument consists of three parts: data acquisition, data test and analysis, output display. System control part is realized on the LabVIEW platform, data collection, data processing, and data recording, alarm and historical data readback function. The system uses DS18B20 to measure temperature. The paper present design of temperature measurement and data acquisition system based on virtual instrument LabVIEW. Finally, this paper realizes the temperature acquisition and detection system, which is a new type of intelligent. System hardware circuit design is using digital temperature sensor DS18B20, and experiments show that the proposed method has a good effect.

Keywords: temperature measurement, virtual instrument, data acquisition, LabVIEW

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1. Introduction

Virtual instrument is the core of computer hardware platform, its function by the user design and definition, which has a virtual panel, a computer instrument system the test function is realized by the test software. The essence of virtual instrument is to simulate the control panel of traditional instruments using the display function of computer monitors, expression and output results in many forms; arithmetic, signal analysis and processing the data using the powerful software function in the computer; completed the acquisition and conditioning signals using the I/O interface equipment, to complete a computer instrument system test function. Use the mouse or the keyboard virtual panel users, like using a special measuring instrument.

LabVIEW is a virtual instrument development platform software, can support and expression analysis function equipment source level with its intuitive and simple programming style, many drivers, diverse, created the basis of conditions for users to quickly build their own instrument system needed in practical engineering [1]. The LabVIEW function is very powerful. Like C and C++ and other advanced computer language, LabVIEW is a general-purpose programming language, has the functions of powerful variety, various, including data acquisition, GPIB, serial instrument control, data analysis, data display and data storage, and even network function. LabVIEW also has a perfect simulation, debugging tools, such as setting breakpoints, single step execution. LabVIEW dynamic continuous tracking mode, continuous, dynamic observation of the data flow and the changes of the program, and it are other than the language development environment more convenient, more effective.

Virtual instrument measurement system is a thermometer used virtual instrument technology transformation of traditional; enable it to have the more powerful features. The sensing element instrument system temperature sensing device through the front end of the measured object, the temperature into a voltage or current signal simulation, power amplification, filtering and other processing by signal conditioning circuit, transform into standard voltage signal can be data acquisition card. In the data acquisition card converts the analog signal to digital signal, and the data acquisition command sent to the computer bus, for a variety of data acquisition processing required by using virtual instrument software has been installed at the PC machine.

The temperature often subjected to various disturbances that affect the detection accuracy, thus the need for filtering processing of measurement. The traditional temperature

measuring instrument is generally realized by hardware circuit, but this way are complex circuit, high cost, unstable performance and other issues, at the same time, the development of instrument function is limited, and the virtual test technology based on virtual instrument can solve these problems well. This paper based on Labview technology as the core, the design method for temperature detection system hardware platform with computer, data acquisition card and other devices.

LabVIEW is a set of specially designed for data acquisition and instrument control, data analysis and data presentation and the design of graphical programming software, the data acquisition of general and instruments are combined, can the design of virtual instrument. General computer temperature tester is signal acquisition and processing system for an intelligent, in the main structure completed by computer internal temperature signal acquisition, amplification and front end hardware part of preprocessing and data acquisition. The paper present design of temperature measurement and data acquisition system based on virtual instrument LabVIEW.

2. Development of Temperature Acquisition System Based on LabVIEW

Temperature acquisition is the first step to measure all the testing, testing physical signal generated by the sensor signals into voltage or current class and then through the data acquisition card data acquisition transmission machine, with the help of software control data acquisition card for data analysis, processing. Pressure for its simple programming, different data acquisition card support, powerful data processing, friendly man-machine interface which becomes the best software control and it is development of data acquisition card.

LabVIEW integrates all the functions of the hardware and data acquisition and meet the GPIB, VXI, RS- 232 and RS- 485 protocol card communication. It also features a built-in library functions for TCP/ IP, ACTiveX and other software standards [2]. LabVIEW is an end-user tool, it provides a convenient way to instrument programming and data acquisition system for the user, principle of using it for research, design, test and implement instrumentation systems, can greatly improve work efficiency.

The hardware is mainly composed of computer and signal conditioning components, wherein the computer includes a microprocessor, memory and display, which is mainly used to provide real-time data processing performance. The signal conditioning components can be GPIB instrument module, VXI module, PXI module or instrument instrument data acquisition card, it is mainly used for data acquisition, signal transmission. Mostly used at present is the data acquisition card and the VXI instrument module, especially the data acquisition card special for the majority of scientific and technological personnel loved. In addition, the virtual instrument and a good hardware platform of VXI bus system, it is suitable for open in the world scope, high speed 32 bit modules supplier instrument bus, as is shown by Equation(1).

$$T = \frac{\sum_{k=1}^L \frac{T_k}{Q_k^2} + \frac{T_o}{Q_o^2}}{\sum_{k=1}^L \frac{1}{Q_k^2} + \frac{1}{Q_o^2}} \quad (1)$$

The function DAQ VI library contains all the NI into the collection and output data type and process of DAQ products. Application of inserting the high-speed and direct control is ideal. Because of the low price, it can greatly reduce the cost of each channel. Analysis of LabVIEW library functions, wide application range, and the analysis software of comparable. This analysis library includes statistics, introduction, regression, linear algebra, signal generation algorithm, the time domain and frequency domain algorithm and digital filter etc.

Temperature measurement system using optical fiber probe was used as the sensor, the temperature field of radiation absorption and transmission through optical fiber. The fiber end connected to a Y coupler, the optical signal transmission is divided into two parts, and each one has a narrow-band interference filter, so it can be obtained approximately two different wavelengths of light signals. Then the optical signal by photoelectric conversion, and some

$$\begin{aligned}\mu_{s|a} &= E\{s(\hat{k}) | a(\hat{k})\} \\ &= \mathbf{M}^{-1} \left\{ \beta(\hat{k})^T \Sigma_{\varepsilon(\hat{k})}^{-1} (a(\hat{k}) - \alpha(\hat{k})) + \frac{s_0(\hat{k})}{\sigma_{s(\hat{k})}^2} \right\}\end{aligned}\quad (2)$$

The system uses DSI8820 to measure temperature, and the basic requirements for all 1-Wire bus as the communication port: microprocessor must be bidirectional, whose output is an open drain, and the line with weak pull-up; microprocessor must be standard speed 1-Wire communication required to produce accurate 1US delay; communication process cannot be interrupted. The system for the measurement of temperature and humidity measurement and control system, the frequency is not high, so the system adopts AT90S8515 MCU receives the temperature, humidity data, and from the RS232 port to transfer data to a computer.

The various kinds of data acquisition system is diverse, the purposes and functions are also different, there are several common classification methods: according to the functional classification of data acquisition system: data collection and data distribution: according to the data acquisition system to adapt to the environment: classification of isolated and non isolated type, centralized and distributed, high, medium and low speed type; classification according to the control data acquisition system: intelligent data acquisition system, non intelligent data acquisition system; according to the nature of the analog signal: voltage signal and current signal, high signal and a low level signal, a single ended input (SE) and the differential input (DE), unipolar and bipolar; classification according to the structure of the signal channel: single channel, multi-channel mode.

Measurement data acquisition module to achieve the temperature and the collected data are stored into a data table, to prepare for the follow-up data processing, computing and printing. Data acquisition is the main function of the system software, data processing, drawing and other modules [5]. LabVIEW can display the waveform of the data acquisition module. When the data acquisition module to collect the measured signal, a discrete set of signal values, through the graphical display controls on a computer display point by point and line display, can display the measured signal, as is shown by Equation (3).

$$H_{1,L}(f) = 2 \sin^L(\pi f) \sum_{l=0}^{L/2-1} \binom{L/2-1+l}{l} \cos^{2l}(\pi f)\quad (3)$$

At the same time the highest temperature real-time measurement system is also constantly monitor and record the object appeared and the lowest temperature detection of objects, so you can better state, at the same time, the system also has alarm and alarm function. When the temperature of the object beyond the normal range, but in the allowed temperature range, the system will give a warning signal; when the temperature exceeds the allowable range, the system directly alarm. In accordance with the above procedure connection and set parameters, stand-alone operation, begin to collect, then single front panel pause button.

Three wire PT100 requirements leads to three wire section area and length were the same, circuit measurement of platinum resistance is generally not balanced bridge, platinum resistance as a bridge arm resistance bridge, will lead to the power supply end of a bridge, bridge arm are respectively connected with the two arm bridge is located adjacent to the platinum resistance and last, when the balance of the bridge, the wire resistance change has no impact on the measurement results, so as to eliminate the measurement error caused by wire line resistance.

The virtual instrument front panel like instrument operation and display panel, a variety of parameter settings and data display are completed by the front panel. On the front panel click of the mouse on the parameter setting can be achieved, as in a real instrument.

In precision instrument, weak signal detection, automatic control instruments, always want to offset voltage operational amplifier to be small and do not vary with temperature. Low drift operational amplifier is designed for this purpose [6]. The commonly used high precision, low drift operational amplifier with OP07, OP27, AD508 and composed by MOSFET chopper stabilized low drift device ICL7650. OP07 high precision operational amplifier with very low input offset voltage; low input offset voltage drift, noise voltage amplitude and long-term stability

LabVIEW block diagram of the program, without conventional programming syntax restriction. First of all, choose the function node need from the menu function, position is positioned on the panel will; and then use the line (Wires) connecting ports in the program graph of each function node, is used to transmit data between nodes in the function. These nodes include simple arithmetic a function are advanced data acquisition and analysis and is used to store and retrieve data file input and output functions and network function. Using graphical VI LabVIEW developed is hierarchical and modular [8]. We can be used for the top-level procedures, can also be used for other program or subroutine subprogram. Apparently LabVIEW attachment and development of the concept of modular program design. Graphical program programming is simple and intuitive, the development of high efficiency.

This paper presents the development of temperature measurement system based on LabVIEW2010, according to the design principle of local in general, through the analysis of the system function; the whole system is divided into several parts to achieve different functions, and each part of the design. In order to realize the function of the temperature detection system, the system is divided into two parts of upper machine and lower machine: upper machine is a PC machine with LabVIEW2010 software, the lower is a small system and single chip computer and peripheral circuit. The two parts are to communicate through the PC machine in the USB serial port. The output of which the slave part mainly completes the temperature signal acquisition and temperature data; upper part to complete the driver on the hardware, data processing and storage, display, generating over temperature alarm and man-machine interface.

DS18B20 supports the "bus line" interface, measurement of the temperature range $55^{\circ}\text{C} \sim +125^{\circ}\text{C}$, in the $-10 \sim +85$ range, accuracy is $\pm 0.5^{\circ}\text{C}$. In situ temperature directly to the "digital bus line" transmission and it is greatly improving the system's interference. The on-site temperature measurement, suitable for harsh environment such as: environmental control, equipment or process control, temperature class consumer electronics products.

The functions of the program are to specify a name for the VISA resource serial according to specific initialization settings. The polymorphic instance data connection to a VISA resource name input can be determined to be used. This procedure VISA configuration serial data set to 9600 baud rate, data bits, parity 8, 0.

Data conversion module sampling procedures in a cycle, pre acquisition data processing, is mainly to the voltage signal is converted into a temperature. Due to the small voltage signal generated by the thermocouple, the acquisition to the amplified voltage signal of the division operation, reducing the voltage of thermocouple value, the voltage signal of the actual array are arranged on the table, the procedure for claim, the voltage signal through practical conversion module lookup procedure comparison, when the voltage signal is collected by the above indexing table defined value, stop, move on to the next cycle of acquisition, when the voltage signal collected in the indexing table definition of value, the voltage signal is compared with a voltage dividing table, output temperature corresponding array, a successful conversion, as is shown by Equation (4).

$$\hat{q}_b(y_0) = C_1 \sum_{i=1}^n k \left(\left\| \frac{y_0 - X_i}{h_1} \right\|^2 \right) \delta[(I(X_i) - b_j)], \quad \text{if } 1 \leq j \leq m \quad (4)$$

This paper is the design of temperature measurement system based on virtual instrument technology, the system has the advantages of simple structure, easy maintenance, and has strong universality, the hardware of the system can be designed into a standard module, build new system which can directly use, software can be modified according to the user demand, the system can be used for temperature measurement in some harsh environment, with a certain value.

VISA is a general term for an I/O interface software library and standard. The presence of I/O interface software in the instrument and the instrument driver, complete the direct data storage operation of instrument internal registers, and provides the underlying software information transfer for instruments and instrument driver. Application of LabVIEW icon (i.e. instrument driver) set the serial port, serial data reading. Because all the Mo Ren serial port settings (9600bps 8 data bits, 1 stop, 1 bit start, no handshake signal), the lower position

machine gathering procedures comply with the agreement, the direct use of reading icon read serial data.

DS18B20 signal by single bus communication protocol strict and it is in order to ensure the integrity of the data. The protocol defines several types of signals: reset pulse, impulse response, write 0, write, read. In addition to impulse response, all of these signals are issued by the host synchronization signal. All data and command bus transmission is in bytes, low in the front.

Using DS18B20 chip temperature measurement temperature can reflect the trend of system on chip. Integrated parts of the functional circuit, so that the overall circuit more simple, build the circuit and the welding circuit faster. Moreover, using the integrated block, effectively avoid outside interference, improve the accuracy of measuring circuit. So the use of integrated chip will become a trend in the development of circuit. Here we use the temperature chip DS18B20. DS18B20 is a 1-wire digital temperature sensor, 3 pin TO92 small package. Temperature measurement resolution is 0.0625°C, 16 bit digital quantity is measured by temperature sign extended serial output. The working power supply can be introduced in the distal end, can also be produced by the parasite power. CPU needs only one port line can and many DS18B20 communication, occupy the microprocessor port is less, can save a lot of lead and logic circuit.

The system of computer and powerful graphical programming software LabVIEW together, set up measurement and control application program based on computer with flexibility; finally construct a system that meets your needs. The system consists of the following parts: a LabVIEW computer, MPC89E52 microcontroller, a level conversion chip MAX232, temperature sensor DS18B20.

In this paper, using the virtual instrument technology to construct the temperature measurement system breaks through the traditional instruments in the data processing, display, transmission and storage of such constraints, reduce the hardware cost and duplication of development, which makes the system hardware maintenance, expansion and upgrading software is very convenient. Especially for as long as the original program for minor changes, the user can according to their own needs, the instrument to design a variety of personalized display and operating panel. At present, with LabVIEW as the software platform of the virtual instrument technology is becoming the developing direction of the modern temperature measurement and the whole test field.

4. Design of Temperature Measurement and Data Acquisition System Based on Virtual Instrument LabVIEW

This paper on the development of software development environment of LabVIEW software are introduced, and then introduced the system user login, self-test, temperature and humidity monitoring, data processing, display and alarm, record data and historical data read back function design.

In the system of multi point temperature measurement, temperature measurement method is the traditional analog signal remote sampling for AD conversion, and in order to obtain higher measurement accuracy, we must adopt the measures to solve the problem of long distance transmission, error compensation for multi points measuring switching and amplifying circuit zero drift caused by. With digital temperature chip DS18B20 temperature measurement, digital output signal. Easy to handle and control MCU, many peripheral circuits of the traditional measuring method of eliminating. The physical and chemical properties and the chip is very stable, it can be used for industrial temperature measurement element, the element linear better. In the 0 - 100 degrees Celsius, the maximum linear error is less than 1 degree celsius.

The temperature signal by the DS18B20 digital temperature sensor, small system composed of a single chip computer to collect the temperature signal, and then the data will be transmitted to the computer through PC serial data RS-232, running on the computer LabVIEW program analysis to the input processing, the results will be displayed by the computer, and the computer LabVIEW to compare the set temperature value, realize alarm function.

The DS18B20 digital thermometer provides 9 bit (binary) temperature readings; indicate the temperature of the device [9]. The information after the single interface into the DS18B20 or from the DS18B20 sent from the host CPU to the DS18B20, so only a line (and ground). Because each DS18B20 in the factory has been given a unique serial number, and it is so any number of

DS18B20 may be stored in the same single bus which allows the temperature sensitive device in many different places. The measurement range of DS18B20 from -55 to +125, the incremental value is 0.5.

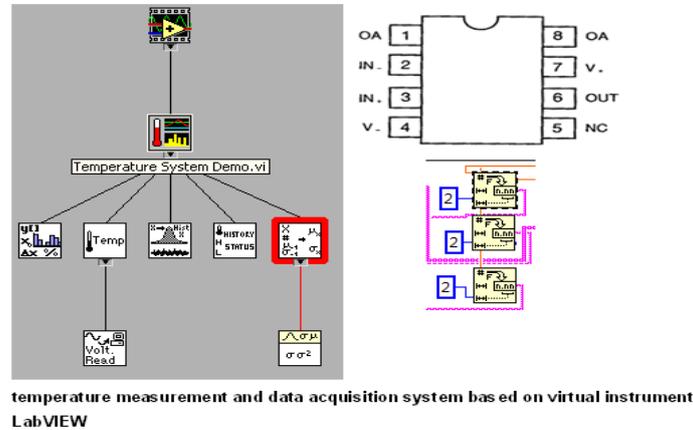


Figure 3. Design of Temperature Measurement and Data Acquisition System Based on Virtual Instrument LabVIEW Diagram

One of the biggest characteristics of DS18B20 uses the data transmission of single bus, temperature measuring device is composed of digital thermometer DS18B20 and micro controller AT89C51, digital signal which is directly output temperature, can be directly connected to the computer. In this way, structure temperature measurement system is relatively simple, the volume is small, and the AT89C51 can take more than one DS18B20, so it can be very easy to realize multi-point measurement.

This paper focuses on the monitoring interface using LabVIEW development environment design of the host computer, host computer RS232 serial port and 89E52 communication through USB, temperature measurement data is read from the temperature sensor DS18B20, so as to realize the real-time detection of the temperature parameter.

5. Conclusion

The paper presents design of temperature measurement and data acquisition system based on virtual instrument LabVIEW. This paper describes the design of a temperature detection system based on LabVIEW. The temperature detection system is mainly to achieve the following functions: the realization of serial communication between PC and single chip microcomputer, can timely send the temperature data sent to the PC machine, and in the PC interface stroke curve, showing temperature intuitive; detection parameters showed: such as the test time, the set temperature, the current temperature, when the temperature exceeds a certain a range of alarm; real-time monitoring of temperature curve display, but also has a digital display and waveform display.

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