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An Intelligent Monitoring System of Sensor Laboratory Bench Based on LabVIEW

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Abstract: Based on the existing sensor laboratory bench, an intelligent monitoring system was designed and implemented using a multi-channel data acquisition board and programmable analogue switches. All the signals of major nodes in the test bench were acquired and displayed through Lab VIEW; Using the graphical display function of virtual instrument, the dynamic acquisition and display of experiment data were implemented and the experiment range of test bench was expanded; After real-time monitoring the key points of the test bench, faults can be located quickly and the maintenance cost of laboratory equipment is reduced significantly.

Keywords: Virtual instrument; Multi-channel data acquisition board; Analogue switch; sensor laboratory bench

1. Introduction

The 21st century is the information age, and as the key access to information, sensor is an important one of the pillars of modern information technology [1]. ‘Sensors & Testing technology’ has already become a specialized foundation course in majors of automation electrical engineering instrument science and technology in universities, meanwhile, the experimental teaching of this course is an vital part in all teaching progress; In experimental lessons, students can underst and the working principle, see the structure and composition of sensors, deepen theoretical knowledge of the measuring circuits and know typical applications. Experimental teaching is an important way to develop the practical abilities and innovation abilities of undergraduates [2-5].

CSY series of sensor test benches can complete all kinds of experiments which contain electric resistance sensors, inductive sensors capacitance sensors, eddy-current sensors, Hall sensors optoelectronic sensors, temperature sensors, and etc., The test benches are typical teaching equipments of sensors and widely used in the experimental teaching in many colleges and universities [6];except all kinds of sensors themselves, they can also complete conversion, amplification and filtering of the sensors’ conventional output electrical signals, however, the benches don’t have the dynamic test capabilities and the test results of the output signals can only be displayed in voltage or frequency in meters. Hence, when the students take experiments on these benches, one oscilloscope must be configured to each bench accordingly. If there are many experiment groups, oscilloscopes will be needed a lot, the teacher will check each group’s test results on purpose, which will cause low efficiency, besides, the inappropriate operations in experiments will lead to damage of the interior power supply or electric circuits and some specialized persons will be needed to maintain the experimental equipments, which will increase cost.

In response to these problems above, the virtual instrument technology can be used to achieve comprehensive monitoring of CSY series of sensor test benches. Automatic measurement, recording and data processing would be realized by this technology, which integrates measurement, computers, signal processing, electronics and other high-tech applications. With this technology, it is easy to implement the virtualization and automation of the laboratory experimental test platform, the experiment resources like oscilloscopes and universal meters also can be shared in a wider range, it is powerful and has high cost performance [7,8].

An intelligent monitoring system of the sensor laboratory bench was constructed in this paper by means of National Instrument (NI) Company’s virtual instrument software LabVIEW. This software has great visual programming capabilities, counting on this, the system has realized a real-time signal acquisition and dynamic display the internal main nodes of test bench, expanded the dynamic performance in experiments, and realized the real-time monitoring the state of test bench to reduce maintenance costs.

2. The Whole Structure of The Monitoring System

2.1. Monitoring requirement analysis

The voltage of main power supply in the CSY sensor laboratory bench is ± 15V, then the voltage regulator modules generate ± 2V, ±4V, ± 6V, ± 8V and ± 10V from it to supply the internal circuits, during the experiment, some misuses may damage parts of the power modules, thus, it is necessary for real-time monitoring of the voltage of each power supply. In order to save the channel resources of the data acquisition board, programmable switches are considered to use to inspect the DC power supply voltages periodically to locate the faults in time, which will reduce the maintenance cost of the system.

ACSY sensor laboratory bench integrates a variety of sensors, and the translation circuits of all kinds of sensors vary, electric bridge circuits, capacitor switching circuits, charge amplification circuits, photoelectric conversion circuits, eddy-current transformation circuits, temperature conversion circuits and other circuits are configured; Indifferent test modes, the outputs of all kinds of switching circuits are subject to signal processing to meet the needs, like voltage amplification, differential amplification, phase sensitive detection, phase-shifting transformation or low-pass filtering. The order or combination of these signal processing parts depends on the sensor's type and test mode; under static conditions or extremely low frequency test requirements, the test results can be showed through the 3 voltage meter equipped in the bench, but for the dynamic test case, obviously it cannot meet the requirements only reading the output of a single channel of the meter, thus, we can take advantage of virtual instrument technology to real-time sample and display the waveforms of all the processed signals.

2.2. Architecture design of monitoring system

Based on the above analysis, the intelligent monitoring system of sensor laboratory bench is designed and the architecture is shown in Fig.1, the monitoring object is divided into four categories: the power section, the excitation, the outputs of the signal conversion circuits and the signal processing circuits.

The power section includes all DC power supplies except ± 15V, the monitoring object can be selected or patrolled via the front panel. The selected signal enters into the data acquisition unit in turn after the cooperation of the program-controlled switches and the strobe control signal and directly display via a visual interface; the excitation part includes the oscillation excitation signals used by the sensor, such as the output signal of the audio oscillator and low frequency oscillator output signal. The converting module monitors the sensors and signal conversion circuits in the bench, such signals are usually too small to detect directly, so the amplified ones are monitored. The signal processing module mainly monitors the final demodulated signals, the signal states are corresponding to the sensitive ones of sensors intuitively. Students can understand the characteristics of the sensors and application circuits easily through the comparison of the signal waveforms in all aspects of transmission.

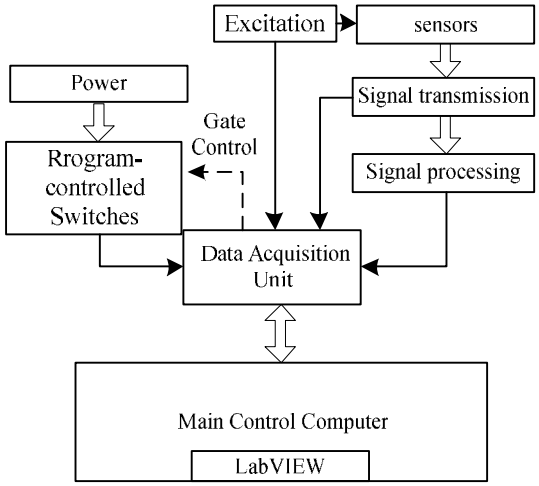

Figure 1. Thearchitecture oftheintelligent monitoring system of sensor laboratory bench based on LabView

3. Hardware Design

The monitoring system adopts AD7506 as the program-controlled switch to meet the needs forgating and monitoring of multi-channel analog signals. AD7506 is a monolithic 16-channel analog multiplexer. It switches a common output to one of 16 inputs, depending on the state of four address lines, with low power consumption, small on-resistance, fast switching speed, each channel can pass analog signals between -15V and +15V, so the 10-channel DC voltage signals in CSY sensor test bench can be applied.

The data acquisition unit of the system takes the universal PCI multifunction cardPCI-1710 from Advantech, Advantech also provides Lab VIEW programming driver interface. The card has 16 analog input channels, the gain of each channel can be programmed individually, the conversion accuracy is 12-bit, the sampling rate is up to 100ksps, it also integrates 16-bit DIO, and the DO channel can be used for the AD7506's channel selection.

The hardware circuits of the intelligent experiment monitoring system based on LabVIEW is shown in Fig.2,The channel switching unit implemented by AD7506 is placed inside the sensor laboratory bench, powered by the internal main power; the signal channel selection is implemented by DO0 ~ DO3 control in PCI-1710, the gain of each channel is assigned by the LabVIEW monitoring program, the benches and the master computers are interconnected by 25-pin shielded cables.

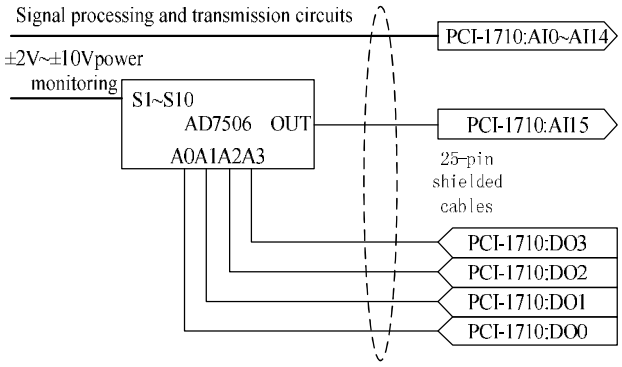

Figure 2. Hardware circuits of the intelligent experiment monitoring system

4. Software Design

The monitoring system software interface has been developed by LabVIEW LabVIEW has a large number of widgets and supports the third-party application VI (Virtual Instrument) library. Thus, Advantech's Lab VIEW Driver can be used to drive and control PCI-1710 multifunction card hardware. The main functions of the system software include channel and signal sampling, the programming of channel switching is reflected in the digital signal output, the signal sampling programming is reflected as an analog signal input, have been implemented through the Advantech VI library. The programming process is divided into two parts: the front panel and the program block diagram.

The channel switching is relatively simple, the main technical connotation of the software is timer trigger DioWritePortByte.vi outputs different binary values.

The sampling program chart is shown in Figure 3, the loop body has been used to complete high-speed circular sampling and display the signal automatically, and the set enable button or time-out error capture function can terminate the cycle.

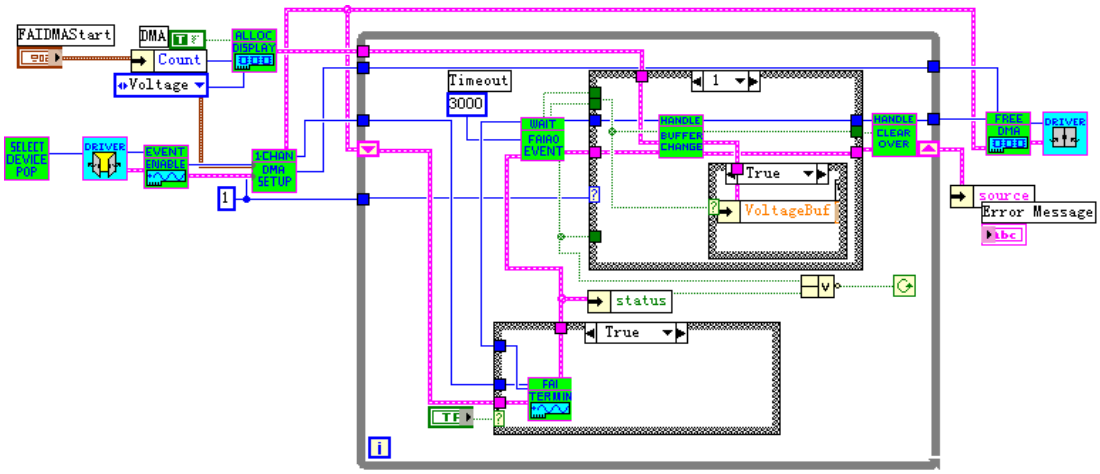

Figure 3. The sampling programchart

The functions of each VI in Fig.3 are briefly described as follows: SelectDevicePop is used for selecting a hardware card device, DeviceOpen is used for opening and initializing a boars card device, EventEnable is used for setting a DMA trigger event, Single ChannelDMASetup is used for configuring the number of analog input channel and the cycle mode parameters of a card, AllocDSPBuf for setting data cache area, WaitFastAIOEvent for waiting for the arrival of DMA events, BufferChangeHandler for data transfer, FAITerminate for the termination of high-speed sampling cycle, FreeDMABufis used to release data cache area, DeviceClose is used to close the board device.

The intelligent monitoring system of the sensor laboratory bench based on LabVIEW has been successfully realized through the design and debugging of the system hardware and software. The actual software user interface of the system is shown in Fig.4. The left side of the interface is the power monitoring area, controlled by the enable button in the bottom left corner. Three groups of waveform display box are in the middle of the interface for dynamic signal display and monitoring, the right side is for gain control and channel selection; enable buttons are all set to control the three groups of waveform display.

5. Experiments

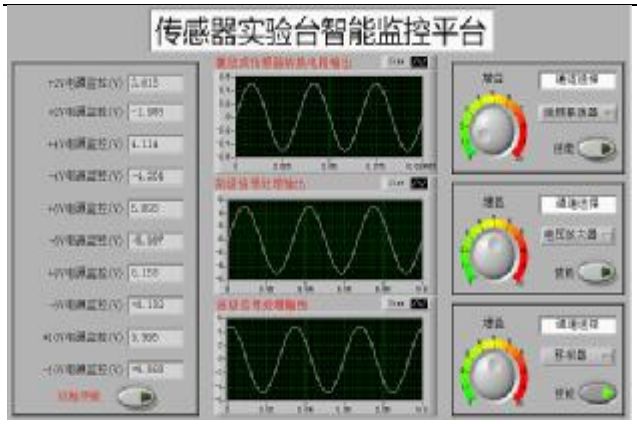

Figure 4. Software interfaceof the intelligent experiment monitoring system

6. Conclusions

The realization of the intelligent monitoring system of the sensor laboratory bench has solved the problems such as the unfriendly interface of the traditional experimental device and the lack of experimental results display; at the same time, the internal state monitoring of the experimental platform has been realized. However, because of a certain degree of time lag in the multi-channel signal acquisition, the accuracy of signal phase monitoring isn't very high, a sample-and-hold circuit can be equipped in the sensor test bench to improve it.

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