The Design and Application of Data Acquisition System based on NI-DAQ

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Abstract—With the development of the computer science and information technology in the field of automatic control, data acquisition system and the combination of analysis and processing system has been in a wide range of applications. This paper discusses the NI-DAQ-based data acquisition integration of the hardware and the software to establish a complete set of virtual instruments and equipment, and conduct error analysis in order to achieve an integrated system with high speed, high precision, and multi-channel accesses. The developed system provides an effective solution for the data collection system in real practice.

Keywords: data acquisition system; LabView; driver software; error analysis

I. INTRODUCTION

The development of computer and micro-electronics technologies prompts the improvement of speed, accuracy, I/O and perturbation resistance capabilities of the Data Acquisition Systems (DAS). These new developments are mainly in the following fields:

1) Arise of new data transition with faster speed and higher resolution: 16 and 18 even 24 bits of the A/D and D/A device, the single chip, A new hybrid circuit device introduced, makes the data acquisition module, and greatly improve the performance of card products, especially with supporting data collection of microprocessors, has large parts produced and widely applied to the personal computer facilities for data acquisition card, then form the plugin to the personal computer based on virtual instrument.

2) Combination of data acquisition and signal processing leads to the high-speed special signal processor which can process the signals in real time;

3) Sensors and microprocessors are integrated to achieve more accurate and optimal test and functional self-diagnosis, which make the so-called intelligent sensors.

4) The appear of PC-based data acquisition NI-DAQ (National Instrument driver software for DAQ hardware) bring a new way to conduct scientific test. The version 7.2 of NI-DAQ indicates the 3rd generation of the DAQ driver software. It can test and collect data easier and faster. DAQ software also provides one-spot I/O running at 50 kHz which can be timed either by software or hardware. Comparing with the first two generations the I/O speed increased twenty times and two times, respectively. Many test and control areas from temperature and position measurements to process control and managements are all benefiting from the increased running speed of the DAQ[1][2].

II. DATA ACQUISITION SYSTEM PROPERTIES

The performance index of the objectives and systems to be tested are the basis of design of data acquisition systems. In another words the following factors should be taken into consideration in the design of data acquisition system.

A. Input Signal Properties

Input signal properties include the quantity and characters of signals. In the design one need to consider if the signal is an analog signal or a digital signal, if the signal source is connected to the earth, and if the signal is periodic or instantaneous. One need also consider the power and dynamic range of the signal, and the input characteristics like the single-terminal input or differential input, single polarity or double polarity, the frequency range of the signal, the common mode voltage, signal noise and the resistor of the signal source.

B. Requirements to the Data Acquisition System

1) The Passing Speed

It is also known as the system speed, transmission speed, sampling speed, and swallow speed. It is defined as the number of sampling to the analog signal in unit time interval. The reciprocal of the passing speed is the passing time, also called the system response time or system sampling period which indicates the time period to sample and process a data. It is an important property for data acquisition systems, especially for a high-speed data acquisition system.

2) The System Resolution

It is the minimum variation that the data acquisition system can identify. Usually it is denoted by LSB (Least Significant Bit), percentage of full graduation, or the real voltage value that the system can distinguish.

3) The System Precision

It is the difference between the observation and the real value when the data acquisition system is working at the nominal passing speed. It indicates the system overall error. It is worth noting that the precision and resolution are different concepts [2][3].
C. Interface Properties

Interface properties include the output format of the sampled data like the parallel output or the serial output, encoding format of the data, and store/load format of the data. The connecting transmission bus, I/O interfaces are also considered for the interface properties.

In the design of the data acquisition system, we choose the system architecture first depending on the properties of the tested data and the system performance index. The main concerns are the number of channels and variation speed of the tested data, measure precision, resolution, and the passing speed. In this design the data acquisition system contains 16 analog channels. The flow chart of the data acquisition is shown in figure 1.

III. DESIGN AND IMPLEMENTATION OF THE DATA ACQUISITION SYSTEM

A. Driver software and system integration

The computer receives raw data by measuring equipment. Signal processing using sensors and switches part to handle, make physical measurement equipment more easily receive data. These primitive data acquisition software, can understand that they form, In data processing, data can be graphics, form or document form statements. Software is also of the measuring system control, notice when measuring equipment shall be collected and from which channel or generate data. NI measuring equipment and software application is driven with NI-DAQ software integration programming NI together all measuring equipment configuration, functions, such as collection, from NI measuring equipment to send data to generate data and measuring equipment and not personally NI write these procedures. Application software, such as Labview, sending commands to the driver, such as acquisition and returns a thermocouple readings, and then display data collection and analysis[9]. It can support any ANSI C Labview or interface DLL (DLLs) call programming environment using NI-DAQ driver. Measurement system are shown in figure 2.

B. Install DAQCard-6024E driver program

Our data acquisition system is a portable one, i.e., the data acquisition interface card and all wire connections are housed in a single data acquisition box. The system can take differential input or single-terminal input. The former requires 8 input terminals and has two internal terminals at BNC interface, which can connect two input lines. The latter requires 16 input terminals and has one internal terminal at BNC interface to induce the input signal or can be connected to the outer data acquisition box.

The computer takes in original signal via measuring equipments. The original physical signals are processed by transducer and transistor so that they can be conveniently accepted by measuring equipments. The system software collects these original data, displays them in an understandable format and processes them to generate data reports in the form of graphics, tables or files. The software also controls the measuring system and notifies measuring equipments when and from which acquisition channel data should be collected. Functions of NI measuring equipments such as system configuration, data acquisition, are implemented by integrating system software with NI-DAQ driver without need of programming for each specific function. Software such as LabView can send commands to driver program to perform a specific task. For example, collecting a thermal transistor reading and sending it back to the system for display and analysis. Thus the NI-DAQ driver can be used in LabView or any programming environment that supports Dynamic Link Library (DLL) calls via ANSI C interface.

The next step is to install the DAQCard-6024E driver program. DAQCard-6024E is a 68-pin high-speed data acquisition card with 16 analog input channels, two analog output channels, eight digital I/O lines, operating at sampling frequency 200KS/S. Using the DAQCard-6024E card, we have designed a portable data acquisition system in the
LabView environment, which fully embodies advantages of a virtual lab[3][12]. The details are as follows:

1) Install software program such as National Instrument LabVIEW or Measurement Studio which sets up the running environment for data acquisition card[6].

2) Run NI-DAQ software program package from the software CD and install NI-DAQ driver. After installation completes the program will prompt to restart the computer. Choose No and turn off the computer.

3) Insert the DAQCard-6024E card into one PCI slot. Make sure the card is inserted securely and restart the computer.

4) Install the driver program: Starting menu → programs → National Instrument DAQ → NI-DAQ setup → click next in the dialog box → choose DAQ Card6024E in the Select DAQ Devices dialog box. Finish the installation of DAQ Card6024E data acquisition card and restart the computer.

C. I/O configuration of DAQ Card6024E data acquisition card

After installing the driver program we can configure the I/O of DAQ Card6024E data acquisition card. Double-click the Devices and interface icon on the Measurement & Explorer platform. This test panel can be used to test analog input, two analog outputs, two timers and basic digital I/O operation[4][5][11].

D. Acquisition channel configuration of DAQC Card-6024E data acquisition card

The device channel must be correctly configured when using the analog inputs or digital I/O functions of the DAQ device. The procedure to configure analog inputs is as follows:

1) Right-click the Data Neighborhood icon, select Insert New in the pop-up menu.

2) In the pop-up Create New Channel window, set channel type to Analog Input, then click Next.

3) In the Enter Channel Name and Description dialog box, set channel name and enter description, then click next.

4) In the Channel Wizard dialog box, set Unit to Volts. Specify input range and set scaling factor to No Scaling, click next and Finish.

The same procedure can be used to configure other analog input channel, analog output channel, digital channel, even global DAQ channel. In the Project menu of LabVIEW window, select DAQ Wizard → DAQ Channel Viewer to see the channel configuration of the DAQ device.

In addition, the data acquisition card can be tested to check its performance. NI-DAQ provides a “Test Panel” function for this purpose, which can be found in the Measurement & Explorer platform. This test panel can be used to test analog input, two analog outputs, two timers and basic digital I/O operation.

IV. System Error Analysis

Data acquisition system is intelligent instrument and various computer control system, the computer simulation and the communication channels, from the Angle of measurement errors, because the computer can have high precision operation, thus data acquisition system error is intelligent instrument and various computer control system of the main error sources.

Data acquisition system components, from the data acquisition, processing, frequency-field, signal output, through many aspects, including both analog and digital circuit, and various error sources is very complex. According to the specific system error analysis, circuit and components. The reasonable design of data acquisition system, should understand the parts of the system and its main error sources include sampling error, error and analog conversion errors.

A. Sampling error

1) Frequency errors due to restore the original signal, and sampling frequency should be bigger than the highest frequency signal effectively. In order to avoid the input signal in frequency components of stray, sampling, before using pretreatment cut-off frequency( f c ) low-pass filter, namely the antioxidant aliasing filters filter. In addition to improving the methods through sampling frequency aliasing to eliminate the error. In the intelligent instrument or automation systems, such as possible, often choose above the highest frequency 10 times even a few times sampling frequency.

2) System through the rate and the error caused by sampling frequency components and devices: choose the speed indicator must meet the system throughput rate (through) the requirements, analog switch and sampling/keep and A/D converter dynamic parameters must meet the total time every time equals throughput. If the experiment data acquisition chip, special attention should be paid to the chip sampling frequency this index has integrated the data acquisition system of dynamic
parameters of each part of the circuit[7][8][10].

B. Analog circuit of error

1) Analog switch conduction resistance($R_{on}$) of error: Analog switch conduction of resistance, signal after analog switches will produce the pressure drop. Analog switch is generally sample loading or amplifier. Obviously, the more resistance, the greater the pressure drop greater error. So the conduction resistance changes will make amplifier or sampling/keep the input signal wave, causing error.

2) Multi-channel analog switch leakage currents($I_{leak}$): Analog switch the leakage current ($I_{leak}$)in general, when a way through the rostrum are disconnected, leakage current, they all through the conduction of switch and the way of the signal. If the signal source resistance, and signal output signal of the low level, we must consider the effects of leakage current analog switches.

3) can be sampled attenuation and amplifier error: One is the main error amplifier system, including the source of nonlinear error, gain amplifier zero error, error, etc.

C. A/D converter error

A/D converter is an important component of the data acquisition system, and its performance index of the whole system plays an important role, but it is also an important source of system error. Choose A/D converter, must consider from the precision and speed, such as considering the digits, speed and output interface, etc. A/D converter static error mainly include: the A/D converter limited resolution of digital output and input analog equivalent deviation between the quantization error (i.e., disorders error, A/D converter actual transmission curve and ideal transmission characteristic curve of slope (i.e. gain error) and A/D converter actual transmission characteristic curve and average transmission characteristic curve of maximum deviation between the nonlinear error) (i.e., A/D converter error is the main component of A combination of error [3].

Therefore, the error analysis, combined with the application of data acquisition software to further improve the accuracy is necessary.

V. CONCLUSION

In modern measuring systems, data acquisition system plays a key role in information access and signal analysis. It is also a preceding component for signal measurement. Utilizing the PCMCIA-bus based DAQ-Card6024E data acquisition card, we have designed a data acquisition system which can be used for on-site data collecting. It has a complete set of functions and can be easily configured in Labview environment, which facilitates real-time data acquisition. With the rapid growth of micro-electronics technologies, measuring and control system technologies, the NI-DAQ data acquisition system, which integrates data collection and data analysis, will play more and more important role.

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