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The Multi-parameter Detection System of Industrial Controller

Abstract: The detection system of industrial controllers' temperature and angle using virtual instrument and LabVIEW as hardware and development software are introduced. This system adopts NI PXIe-8840 controller through two slots No.3 and No.4 on NI PXIe-1087 respectively using platinum thermistor acquisition card NI PXIe-4357 and universal card of data acquisition NI PXIe-6341 to make detections. One channel is to use platinum thermistor PR-18-2-100-1/4-6-E of temperature sensor through acquisition card of platinum thermistor to collect temperature signals which can be transmitted to NI PXIe-8840 controller. The other channel is to use Omron E6HZ-CWZ6C rotary encoder to collate signals which are transmitted to NI PXIe-8840 controller by NI PXIe-6341 data acquisition card. Then, these signals are showed in the LabVIEW interface background and generated real-time data detection chart according to the data by temperature sensor and the writing data by manual. As a result, this detection system has not only plenty of features such as friendly man-machine interface, perceptual intuition, high precision, safety and reliability but also strong data visualization analysis, strong control ability of controlling instrument and the advantages of simple operation that is easy to complete daily sheet of watch keeper.

Keywords: LabVIEW, platinum thermistor acquisition card NI PXIe-4357, platinum thermistor PR-18-2-100-1/4-6-E, NI PXIe-8840 controller, universal card of data acquisition NI PXIe-6341, E6HZ-CWZ6C rotary encoder
1 Introduction

The detection of industrial controllers’ parameter is an important work in the field of industrial control, and having been always an important research topic on the properties of the detection of industrial controller [1]. With the development of the modern technology of industrial control, the detection technology of industrial controller is constantly also increasing at domestic and foreign, and having a wide range of applications. In particular, the detection of the original form of the sensor is more extensive [2].

The majority of the industrial controller detection systems are controlled by single-chip MCU, with a complex programming, complicated hardware circuit and inaccurate detection. This detection system of industrial controller is based on LabVIEW, PC, rotary encoder and temperature sensor. The system can detect temperature, angle, angular position and angular acceleration in real time, and a higher precision.

2 The Hardware Devices of Industrial Controller Detection System

Detection system consists of temperature sensors, rotary encoders, and PC and LabVIEW components. System block diagram is shown as Figure 1.

This system adopts the Virtual Instrument (Virtual Instrument, referred to as VI) hardware system, which is based on computer with Lab VIEW software, based on the test items and matched with the corresponding hardware module with function test as signal I/O interface, and accomplish the signal collection, measurement and conditioning [3]. According to the needs of users, designers can design and develop a virtual operator panel with good human-computer interaction ability that is the front panel of LabVIEW program. All the test functions are realized by LabVIEW and virtual instrument hardware, which is also a new type system of computer instrument.
Compared with traditional instrument, virtual instrument is enriched and enhanced the function of traditional instrument. Analyse, display, storage, printing and other management the collected signals, and focused on the computer for processing [4]. Virtual instrument hardware and software have developed an open industry standard, raise the repeatable utilization of resources, the function is easy to extend, standardized management, production, maintenance, and can save equipment purchase and maintenance costs [5]. Can be formed through the computer network of a complex and distributed test system for remote testing, monitoring, and diagnosis [6].

2.1 Temperature

Platinum thermal resistance PR–18–2–100–1/4–6–E is produced by the omega RTD thermal resistance sensors, RTD is one of the most accurate temperature sensors, it has high precision, long life, high resistivity and low heat capacity, and the corresponding advantages of fast speed, etc., and the resistance value has good linear relationship with temperature changes, but also provides the advantages of good stability and repeatability, RTD can also relatively avoid electrical noise, therefore, it is particularly suitable for temperature detection in complex industrial environ-
ments, especially around motors, engines and other high-voltage equipment, and is especially suitable for standard measuring device and high precision measurement. Platinum thermal resistance PR-18–2–100–1/4–6-E is characterized by aluminium head, 3 wires, using the PT100, 1/4 inch diameters, 6 inches long, and the temperature range -200°C to 600°C. Because the platinum thermal resistance PR-18-2-100-1/4-6-E is a standard three-wire configuration, the red wire Corresponding to the NI PXIe–4357 analogy signal EX+, the rest two black lines 1 and 2 of by respectively NI PXIe–4357 analogy signal AI+ and AI- (no corresponding requirements, 1, 2 black line can also be respective by NI PXIe-4357 analogy signal AI+ and AI-).

2.2 Rotary Encoder

This test system uses the Omron E6HZ-CWZ6C rotary encoder. There are five terminals, in which the brown wire is connected to the positive power supply, the blue wire is connected to the negative power supply, the black wire, the white wire and the orange wire is respectively the output signal of A, B, Z.

Because this is a type of NPN incremental encoder, and is an open collector output, when it is wired with NI PXIe–6341, needed to pick-up resistor on the output of the signal, and its resistance is in the range of $1\Omega$ to $5\Omega$. The schematic is shown as Figure 2.

2.3 Platinum RTD Acquisition Card NI PXI-4357

The NI PXIe-4357 has a typical accuracy of 0.09°C using 20 roads PT100 resistance temperature acquisition and supporting 2 wires, 3 wires and 4 wires RTD. There are 4 terminals in each analogy input channel, respectively, EX- said the excitation current return, EX+ said negative excitation current output, AI- said negative analogy input and AI+ said positive analogy input, and the three line of the thermal resistance we use three of them, respectively AI-, AI+ and EX+. 
2.4 General Acquisition Card NI PXIe-6341

NI PXIe-6341 data acquisition card which contains 16 AI ports, 2 AO ports, 4 timers and 4 counters, and we only use the counter 0 in this system.

2.5 Controller NI PXIe-8840

The NI PXIe-8840 is a modular PC with a PXI Express 3U form-factor, the highest configuration of 2.6GHz quad-core processor. The controller is small, powerful, and expensive, often used in industrial technology, making it ideal for processor-intensive modular instrumentation and data acquisition applications.

3 The Program Design of Industrial Controller Detection System

LabVIEW programming is distinct from other programming languages, mainly graphical programming language divided into front panel and program block diagram, while the program is mainly completed in the program block diagram. The main task of the front panel is interface and data display in the process of running, for example, temperature, pressure, position and speed, and so on.
3.1 LabVIEW Program

Figure 3 is the optional test interface front panel of industrial controller multi-parameter detection system. This interface is a selection interface, that is set by the program to return to the optional test interface, the user must be used in the system of industrial controller when a self-selected interface.

Figure 4 is the optional test interface program block diagram of industrial controller multi-parameter detection system. While loop used in the program, the purpose of the test program interface can be managed so that in turn continues to jump to a temperature online detection and angular position and speed online testing program interface, but also allows detection of two interfaces in turn constantly return to the choice test interface. And then placed an event structure, respectively, angle position and speed online detection, temperature detection and return to the test interface for the three events added to the event structure, in which set up flat sequence structure with two frames in the event structure. In the first frame of the sequential structure, the purpose is to open to the vi of jump events, and then close the operation of the current interface in the second frame. Note that the sequence structure under every event in the event structure, create a name of the path function or relative path of the input name and the incident must be the event source corresponding to this test panel in the open when the corresponding test project, and will not be chaotic procedures.

![Industrial Controller Temperature and Angle Detection](image)

Fig. 3: The optional test interface front panel of industrial controller multi-parameter detection system
3.2 Design of Temperature Online Detection Program

Figure 5 is the front panel of real-time temperature detection system, which can display the current temperature value and its real-time curve, and finally saved in the form of a document on it. In the front panel, it has the basic information of the tester, the current environmental situation as well as the comparison of the test results with the device temperature.

Operation, firstly, the tester should be filled your personal information, equipment temperature 1, error requirement of temperature 1, equipment temperature 2 and error requirement of temperature 2 on the front panel. Then the program is running, clicking to start the measurement, it will detect the current real-time temperature, while producing the actual temperature 1 error value and actual temperature 2 error value. The temperature 1 and the temperature 2 will appear the real-time temperature by the temperature sensor detected. On the right side of Figure 5 showing the current real-time temperature value of the two forms of temperature value of the two forms of performance by the thermometer and the temperature curve, which form does tester like, can choose on the label above.
Figure 6 is the temperature online detection system program block diagram. Event 1 is the start of the measurement process, the data collected by sensor were being exported and split from the DAQ's port till temperature and curve being displayed, use the split temperature 1 and temperature 2 minus the equipment temperature 1 and equipment temperature 2 separately, then compare each result with corresponding precision standards of system that it was failed if greater than the temper-
ature deviation standards of system, or it is qualified. And then through the creation of form, collected data to the form function from the creation of the form, so that real-time data will be displayed in the front panel of the table, and then create the table form's port directly connected to the side of the MS Office Report function's data, lastly, displayed in own set of word templates. The MS Office Report function is used for report display, while the corresponding system word template is located in the D: LabVIEW/software/installation path/LabVIEW 2016/templates/Report directory, and Excel and Word system templates in it. However, the report shows that the system is used from the word templates; you can copy the template from the system, modifying, and then saving to your own set directory below. Collected two ways' data by the two sensors minus the equipment temperature compared with the precision of the system requirements, which the results linked to MS Office Report function temperature 1 and 2, displayed in the final report. In the word document in which needed to write data and text inserted bookmarks respectively, the bookmark's names have date, time, testers, ambient temperature, humidity, pressure, data, temperature 1 and temperature 2 in the template of the system report. Note that when adding bookmarks to the data, add a bookmark to the area where the real-time temperature is displayed, and temperature 1 and temperature 2 are the result of comparing the test data with the system data, not temperature, and finally save as a document template (*.dot) format and added to the MS Office Report function inside.

Event 2 is a program that returns the selected test interface event, which sets a flat sequence structure with two frames. The main purpose of the program is running from the current program interface can jump back to the optional test interface in the first frame, that is, the temperature and speed test vi front panel, which is set in the second frame off the current test program in the program.

3.3 Design of Angle Position And Speed Online Detection Program

Figure 7 shows the front panel of angle position and speed online detection. The options for manual setting are channel settings, trigger settings, precision settings and cycle time settings. Which channel settings in the counter option, because our rotary encoder connected to the virtual instrument in the third slot of the counter 0. So here we choose PXI1Slot3/ctr0, rotary encoder A, B and Z three terminals are selected for PXI1Slot3/PFI8, PXI1Slot3/PFI10 and PFI9. Pulse per revolution and cycle times were set to 3600P/R and 100ms. The rest of the collected data is obtained by the position of the rotary encoder, the right angle waveform curve, tachometer curve and acceleration curve.
Figure 8 is the program block diagram of angle position and speed online detection. First of all, set a function of while loop, which allows the cycle of events inside each other. Next, put the events of start the measurement (angle position and speed online detection program) and return to the test screen added to the inside of the while loop structure.

At the beginning of the measurement procedure in the event 1, applied to an integrated function in LabVIEW, that is a DAQ assistant. It contains the data acquisi-
tion tasks in the sampling frequency, the number of sampling settings and other functions in this function, while the physical data channel this function can also be completed. In the program design, it can complete the result of the data acquisition, displaying and preserving and other functions. Consequently, we start creating a function of virtual channel by placing a DAQmx, added the corresponding task and the corresponding I/O type, the rest of the input parameters can be set in the front panel. We set up a DAQmx channel attribute property node function, in which three elements are added, namely, the input information of the three terminals A, B and Z of the rotary encoder and the corresponding input is set, and then the parameters are set on the front panel. Then set down a function of the DAQmx trigger property node and creates three inputs, namely, trigger type, trigger source and digital edge. Later beginning the task placed a DAQmx start task function, which makes the program in the running state that the measurement program is started from here. Let the real measure of the program carried out in the while loop, which is placed the function of DAQmx read, it is the data output of the rotary encoder angular position. Note that the angle position of rotary encoder regard as the next starting point measurement at the end of each measurement. So DAQmx read function of the data collected is real-time location of rotary encoder. Setting down a shift register, in which the initial value assigned to 0, so that every object begins, removed the results of last operating. However, the output of the shift register returns the result of the previous loop back to the input of the shift register. The consequences of one cycle minus initial value and divided by the time for taking to run. Here also used the shift register for recording time, the purpose of the same, clear the last cycle of running time, using the final time minus the start time as the running time. Therefore, the angular position difference is divided by the difference of next time what is every millisecond rotation angle, and because the encoder pulse per revolution to 3600P/R, and then the above obtained every millisecond turn angle to 3600 is the number of revolutions per millisecond, the last multiplied by 60000, into the standard unit, that is, turn the number of turns per minute, so the data collected here is the speed we require, and finally its demand to derive the acceleration.

Event 2 is to return to the settings of the self-selected test interface program. here we are the same a two-frame flat sequence structure as in the above event 2 measured temperature, which opened the main program of measuring temperature and speed in the first frame, then closed off the current operating procedures in the second frame.
4 Experiment

4.1 Experimental Introduction

The detection system of the industrial controller is mainly online detection for temperature, angle position, and angle velocity and angle acceleration. Temperature online detection, it can test simultaneously 8 channels, and can be extended to 16 channels reserved for more. The system uses two of them to detect, and one route is to test the controller under test, the other is placed in the air for indoor temperature detection. In the process of testing, both the device temperature 1 and the device temperature 2 of the front panel are filled with the self-temperature value and the same temperature error requirement value of the detected device. Finally, perform numerical and curve displays and generate reports. In the angular position and speed on-line detection, it is detected when the rotation of the rotating device on the controller under test is stopped just after one rotation. Finally, on the front panel, display the running status of the rotating device and the detection in real-time as well as generate detection reports.

4.2 Experiment Results

When the temperature of the industrial controller under test is detected on-line, the operator should fill in error requirements of temperature and temperature of the equipment on the front panel, then the program is running and test is started. When the difference between the real-time temperature and the temperature written manually is detected less than the accuracy of the system, the program will automatically make a judgment in the Word report which will generate a judgment result that is when the difference is greater than the error required, display as unqualified, otherwise qualified. The angular position and speed of on-line testing are just the same as the temperature online testing process. The following is a real-time report of multi-parameter detection for industrial controller, as shown in Figure 9.
Fig. 9: Industry controller multi-parameters online detection report

5 Conclusion

Through the industrial controller detection system can be seen that based on LabVIEW development test and measurement application development[7], programming is simple, but the use of different hardware equipment wiring will be different, such as the design of the encoder must be pulled up by a resistor. The system of virtual instrument detection is built by the sensors, PC and LabVIEW, and having great potential for later development.

References


