

Design and Implementation of Motor Test System based on Virtual Instrument

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Abstract

Because of using Windows Multimedia Clock, most of existing test system based on General Computer has problems of inaccurate timing and poor real-time capacity. A motor test system is developed for improving above problems and testing more motors simultaneously by serial communication with high baud rate. The test system software uses LabVIEW development platform and is developed with the idea of software engineering, which is used to make each module functionally independent and to improve reliability of the system. Simultaneously the test system uses the characteristic of LabVIEW to complete relatively accurate timing tasks and has excellent portability. In communications, it is used that professional serial port board supporting high baud rate and bus connections. After using the system, it shows that the system is not only reliable, easy to operate, high availability and reduces test costs, but also it is able to meet the needs of the actual test.

Key words: Virtual Instrument; Motor Test System; Timing Tasks; High baud rate; Bus connections

1. Introduction

Virtual instrument, which integrates computer hardware resources with instrument hardware resources by software, is a computer-based automated test equipment system. Compared with traditional instruments, Virtual Instrument stresses that software is the core of instruments.

In the development of software, this system needs to collect and transfer data, storage and do other work. Software design is not only the most important and complex part of the entire test system, but the core of the test system. Therefore, choosing the right software development tools can play a multiplier effect. Because of easy to use and convenient, LabVIEW is more fit to this system¹.

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is an innovative software product of

National Instruments (referred to as NI). LabVIEW is a graphical programming language, known as the "G" language. G refers Graphical Programming Language. Compared with traditional software development language, graphical programming approach can save more than 85 percent of program development time and the speed of developed program is not affected. This doesn't only reflect a high level of efficiency, but also brings convenience from the LabVIEW controls. Coupled with LabVIEW's outstanding performance at data acquisition, analysis, chart displays and other aspects, LabVIEW program language has become a first alternative to this system².

In the aspect of communication, because of higher baud rates in the system, common serial port devices do not meet the requirement and devices' reliability is not well, so professional MOXA serial port board is selected. The bus is selected as the connection of communication link. Through broadcasts the command is sent to the next

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crew. At the same time there is only one answer audience-bit machine, so data interference on the link can be reduced greatly.

2. The Structure of Motor Test System

In Fig.1, it shows that the entire test system is made of a PC and four next crews, each of which is made of controller, Drive and sensor. Based on internal communication protocol, the PC communicates with each controller via RS-422 at bus link. Through graphic user interface, PC encapsulates the command that comes from the test staff into 9 bytes data frame with header, device code, command data, the checksum. Because PC connects with the next crew by bus connections, after PC sends the data, all the controller can receive this data. After receiving the data frame from PC, firstly, controller determines whether the device code field of data frame matches device equipment receiving this frame data. If not match, this frame data is discarded. Otherwise controller will calculate the checksum to verify the accuracy of the frame data. If controller confirms the correct frame, decapsulates the frame date to get command data, then send command data to the drive. After getting command from the controller, the drive makes motor work as testers' intention. Voltage, current, speed and other parameters of the motor running captured by the sensor and forming an analog signal sent to the A / D converter. A / D converter analog signal coming from the sensor is converted into a digital signal, and then sent to the controller. According to internal communication protocol, controller encapsulates data into 21-byte frames, sent to the host computer by serial devices through RS422 bus. After receiving the data frame, the same as controller, PC also verify the checksum to ensure the correct frame data, analyze the frame to get voltage, current, speed and other information from tested motor, and displayed in the interface³.

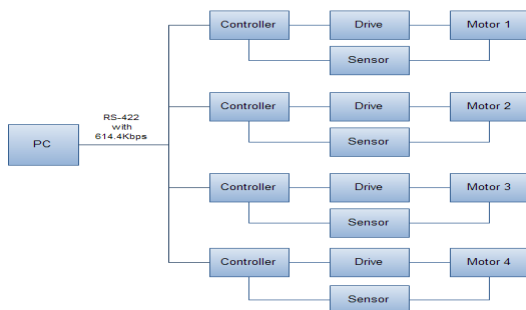


Fig. 1 The diagram of Motor Test System's structure

3. Software Design of Motor Test System

3.1. Requirement Analysis

Fig.2 is a diagram of Each module of Motor Test System.

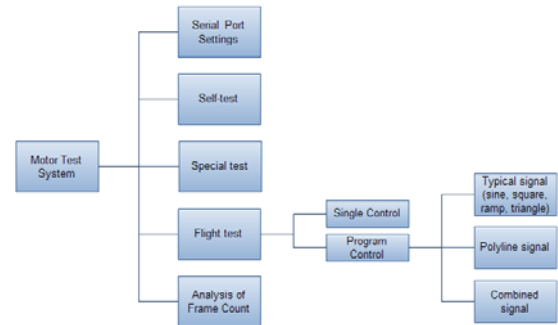


Fig. 2 Each module of Motor Test System

Serial port settings module provides many functions, which are setting number, baud rate and other serial interface attributes. Because the requirements of this system is that the baud rate 614.4Kbps, while common serial port device does not yet support such a high baud rate, so this system selected MOXA serial port board.

This system is divided into three test modules: self test, special tests and flight tests.

In the self test, the main task is to test the state of communication link. Defined test state is divided into checking, normal and abnormality. Firstly, after turning low-voltage power on, the PC sends self test commands to the four devices in round robin way and maintains a counter for each device. Secondly, if only the PC receives the next crew feedback information that indicates that this equipment is normal, the PC will make the counter of the equipment plus one. Finally, if only there are three continuous data frame that indicates the state is normal, self test will be passed.

In the special test, the main task is to test the state of the single specified motor at low speed. Firstly, after turning high voltage power on, the next crew receives from the PC's special test execution command and the motor runs 5 seconds at low speed. And the next crew timely feedback to the PC with information that indicates that the motor has begun to run and could send status query command. Then the PC send "status query command" every 10ms, the PC displays feedback that come from the controller. Finally, testers will find whether the next crew and the motor are normal or not.

In the flight test, the control can be divided into single control and program control. Single control can be controlled by modifying the interface control value; in program control, after configuring the timing command in the timing configuration module for single or

multiple motor, then start program control. The PC sends these preconfigured programmed commands at one command in 2ms intervals. For each motor, it will receive one command at each 8ms. After receiving command data, the next crew will follow the commands to complete control and feedback status information to the PC.

After the test, the PC can save data and do further analysis offline. The PC supports to analysis for frame count in order to count the number of loss frames, heavy frames frame, frame loss rate, and heavy frame rate⁴.

3.2. Design of Main Modules

3.2.1 Flight Test Module

Round robin mode has a clear structure, clear program flow, fast response. But if a single control does not occur, the round robin mode will still check the flag variable, which will be a great waste of CPU. On the contrary, the event structure is not only to reduce the CPU load, but has a timely response. More importantly, it uses queue to store time of the trigger mode, thus which avoids missing any events. Different from a single control, once program control is launched, it will be necessary to send one command in 2ms interval. There are two schemes could be used. One is to generate a command and to send it to controller immediately, the benefits of which is to need less memory space but requires CPU to read and write memory operations. The other is to generate all the commands before sending the data and to store the commands into disk file. Once the program control is start, the commands will be read into memory one time from disk file and be sent one by one, the benefits of which can greatly reduce CPU's load during transmission greatly, which is because the commands has been read in contiguous memory space. It guarantees the timing requirements of 2ms. At the same time, because the data stored in the hard disk file, you can also reuse the same program control. In comparison, the second solution is clearly better.

By using one or more queues, multiple threads issue is solved in elegant and safe way. Producer thread insert elements to the queue, the consumer thread and remove them. Using the queue can safely pass data from one thread to another thread. Blocking queue can not only accomplish this task, but if elements are tried to add to the full queue, or to remove from the empty queue, thread will both be blocked. This will further improve the utilization of the CPU. Fortunately, LabVIEW has integrated producer consumer model based on blocking queue into its own development environment. This is producer-consumer recycling based on data or event⁵.

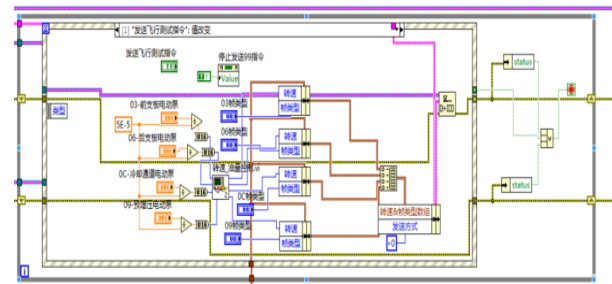


Fig. 3 The producer loop based event

As shown in Fig.3, the outermost layer is a while loop, whose inside is the event structure. Event structure in a while loop can handle a mouse click, keyboard pressing and many other events until the end of the loop. After a single control event and the program control event occurs, the system will both place commands in the queue. And each consumer loop fetches command from the queue and sends it to controller. The flag variable should be set in the respective event branch, which make that consumer loops will not affect each other.

3.2.2 Analysis frame count module

This system uses serial communication at 614.4Kbps baud rate and bus connections. High-voltage power affecting for baud rate and seizing bus are likely to be the weak part that affects for the stability of the system. Therefore, it is necessary to detect and analyze the frame count. In internal communication protocol of the system, frame count field is an 8-bit unsigned integer type, ranging from 0 to 255. Under normal circumstances, due to data overflow will become 0 and then continue to accumulate the feedback information in the next crew; the frame count field will accumulate from 0 to 255, and then continue to accumulate. Therefore, the quantity of loss frames can be got by the following formula:

$$m = \begin{cases} n_2 - n_1 + 1 & , n_2 > n_1 \\ 255 + n_2 - n_1 & , n_2 < n_1 \end{cases} \quad (1.1)$$

n_2 represents current frame count, n_1 represents previous frame count.

As shown in Fig.4 and Fig.5, it is single motor/ multiple motors frame count analysis under the high-power supply. In anyone of these charts, the vertical axis is the difference between the current frame count and frame count of the previous frame. Normally, if the overflow does not occur, the difference will be 1; if the overflow occurs, the difference will be -255.

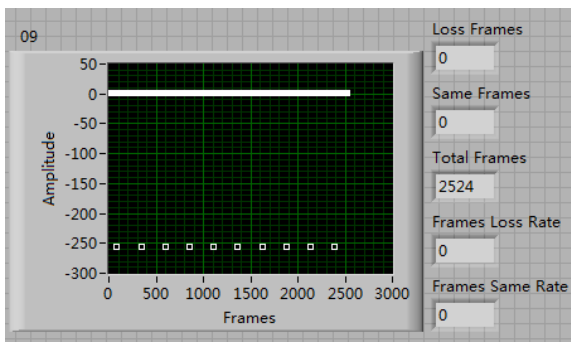


Fig. 4 Frame count analysis for single motor

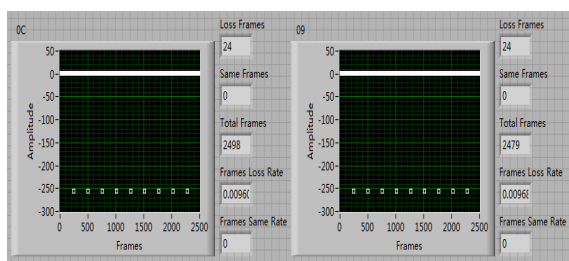


Fig. 5 Frame count analysis for two motors

As shown in Table 1, when there is only one running motor, even if in the case of high baud rate, communication would not have dropped any frame. When multiple motors are running simultaneously, because of bus connection, the data will seize the bus to result in dropped frames. However, frame loss rate is less than 1%, so communication is very reliable.

Table. 1 The analysis of frame count

Type	Motor_ id	The total number of frames	The number of loss frames	Frame loss rate
Single	09	2524	0	0.00%
Multiple	0C	2498	24	0.960%
	09	2479	24	0.968%

3.2.3 Timing Transfer Modul

Programmers rack their brains to pursue the goal that is to control precisely for timing. Regrettably, because of the absence of a hardware timer cases, The highest timing accuracy under Windows operating system is 1ms. And the 1ms talking about here refers to the computer system time maintained by a battery. After LabVIEW 7.x version, there is emerging a new timing structure - timing loop, which is available as a Windows operating system to improve the accuracy of the program effective means of time control. However, the timing loop will take up more system resources⁶.

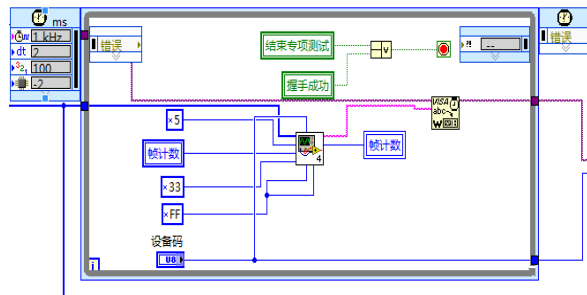


Fig. 6 Timing loop

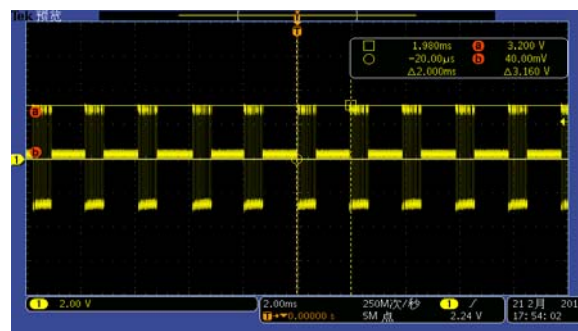


Fig. 7 Sending interval measured by oscilloscope

As shown in Fig.6, the main task in the timing loop is to send data through the serial port every 2ms. As shown in Fig.7, in the actual testing, the time measured by oscilloscope to send data through the serial port is 2ms, and no frame loss.

4. Conclusion

This test system uses LabVIEW as a development platform. The code is clear, easy to be maintained, reused and expanded. This system has achieved the serial communication, motor control, data acquisition, preservation and analysis for frame count. In addition, the motor control module of the system is able to execute more precise time control on top of the operating system. Testers can not only enjoy the convenience of the operating system, but can use the system to complete high precision timing test tasks. Test system described here provides a solution for coping with high real-time and high baud rate serial communications, and can provide certain references to the college labs or enterprises in building up testing systems based on virtual instrument.

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