

Communication Technology in the CompactRIO

You Bin^{1, a}, Li Ming^{2, b}

¹ School of Mechanic and Electronic Engineering, Nanchang University, Nanchang 330031, China

² School of Information Engineering, Nanchang University, Nanchang 330031, China

^abinyou2013@163.com, ^bLiming@ncu.edu.cn

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Abstract. In order to solve the communication problems involved in acquisition system based on CompactRIO. Analysing data collection from FPGA terminal to RT terminal and elaborate RT terminal and PC terminal communication method. Comparing the merits of the single point polling acquisition model and collection of DMA FIFO model, Explaining the application of shared variables、TCP/IP、networkflow in CompactRIO. We choose the right communication method to design vehicle electrical data acquisition system. Through experiments, verifying ComactRIO data acquisition systems have better real-time, high precision, and good scalability.

Introduction

Things technology is used to promote the development of artificial intelligence. The traditional manual testing is gradually replaced by automated testing. Vehicle electrical data acquisition system is also extended to the direction of automation. NI's CRIO system, Which has high acquisition accuracy、high sampling rate、small size、good anti-jamming and good seismic performance, its software uses a graphical programming language LabVIEW or LabWindows, developing data acquisition system cycle is short, Currently more popular in the automotive data collection field. This paper presents a data acquisition system based CRIO.

Data collection method from FPGA terminal to RT terminal

Single point polling acquisition model: FPGA terminal get the data from I/O channel and set interrupt, RT terminal trigger the corresponding interrupt and through reading node to acquire the underlying data, it is similar to the direct acquisition. The advantage of this approach is collecting data faster, small memory usage, small FPGA resource overhead and easily to implement. However, for the part of the high sampling and large throughput of the vehicle electrical performance signal, the single point of real-time data acquisition will be insufficient to reach the acquisition requirements.

DMA FIFO model: FPGA terminal is bundled with I/O channel data and stores the data into a memory which can be accessed by upper terminal and lower terminal, RT terminal use DMA method node to read the data in the cache. This acquisition mode is possible to adjust the cycle synchronization. PCI bus arbitration share resources scheduling, so that the collection of data in a row, without distortion. To ensure high throughput real time data transmission to RT side, while on the host side is also configured large enough shared memory.

Both acquisition mode processes are shown in Figure 1.

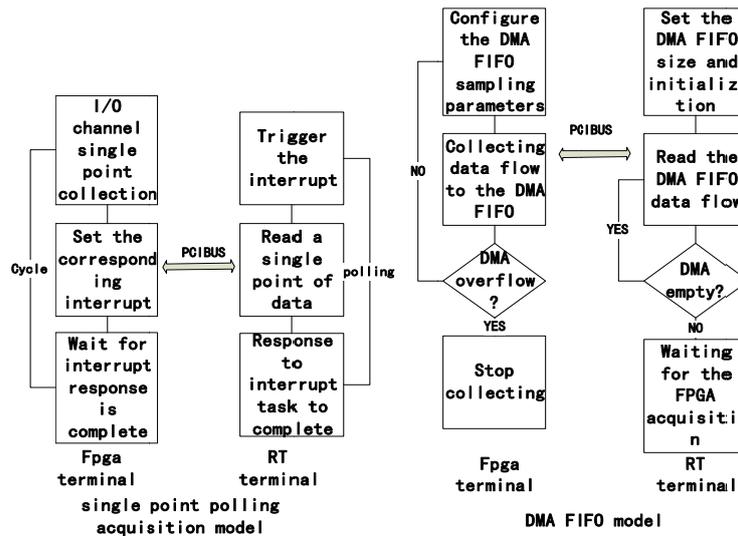


Fig.1 Data collection process

Communication mode between the RT terminal and PC terminal

Real-time system as the lower computer, can only be deployed in hardware, does not provide the user interface. Therefore, collection monitoring and data stored should be completed in PC side. NI provides a variety of communication methods: shared variables, TCP / IP and network flow.

There are three types of shared variables: single-process, real-time and network-published. NI publish-subscribe protocol (NI-PSP) is used to optimize the network protocol of network-published shared variables. The bottom of the protocol has been redesigned to use TCP/IP, and we have made debugging according to desktop systems and NI's RT targets performance. Shared variable engine makes shared variables can exist in more than one node in a distributed system. As shown in figure 2, with shared variables method transmit BCM controller voltage data to PC terminal.

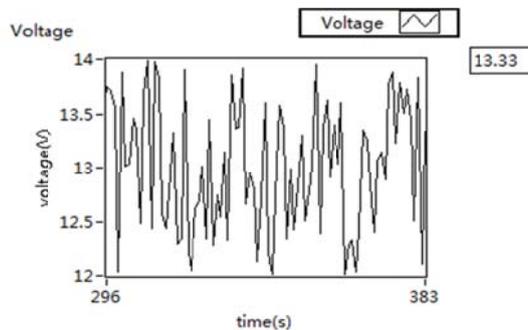


Fig.2 Network-published variable values

TCP / IP technology is widely used in CompactRIO. There are a series of TCP/IP interfaces on the RT terminal, including monitoring、open、read and write. As a connection-oriented communication protocol, end-to-end transmission makes data with high reliability. Figure 3 shows transmit data from the RT terminal to PC terminal with TCP/IP method. The RT terminal is used as TCP/IP server and the PC terminal is used as TCP/IP client. Data is written to the data stream as a string, that length and content written separately, each time four bytes read.

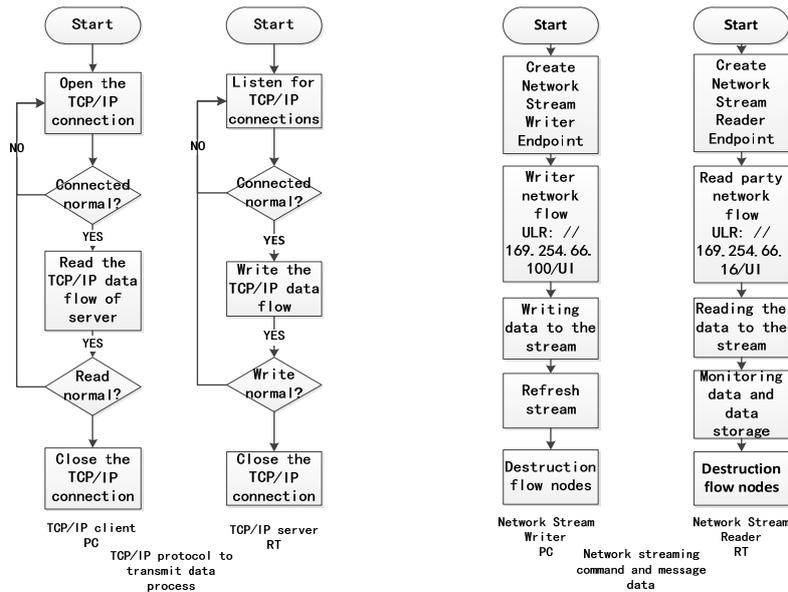


Fig.3 Communication process of RT terminal and PC terminal

Network flow is an easily to be configured, tightly integrated dynamic communication method. It is suitable for the data transfer between applications and its throughput and delay characteristics comparable with TCP. Network flow enhanced connection management, if due to network failure or other system failures lead to disconnection, network flow can automatically restore the network connection. This method can transmit any type of LabVIEW support data, and the data stream can be lossless high throughput type. However, it can only make a one-way transmission, can't realize full-duplex communication. Figure 3 shows how to send commands and message data from PC to RT with network flow.

Design data Acquisition System

As an embedded distributed data acquisition system, CompactRIO can be flexibly configured and easily expanded and updated. The CompactRIO controller, data acquisition and FPGA(C Series) modules are designed according to the type of vehicle electrical performance: NI-9068 is the controller chassis, which uses Xilinx Artix-7 FPGA architecture to match the dual-core 667 MHz ARM Cortex-A9 processor. NI-9853 get CAN signals, NI-9229 collect voltage signals, NI-9213 gather thermocouple temperature signals, NI-9205 acquire current signals. The whole system is powered by 35 Ah lithium batteries which have small size and high integration features. The power Management IC is used to allocate the required voltage of each module to work normally. The wireless router can manage the network communication of RT terminal and PC terminal. The entire test system is shown in Figure 4.

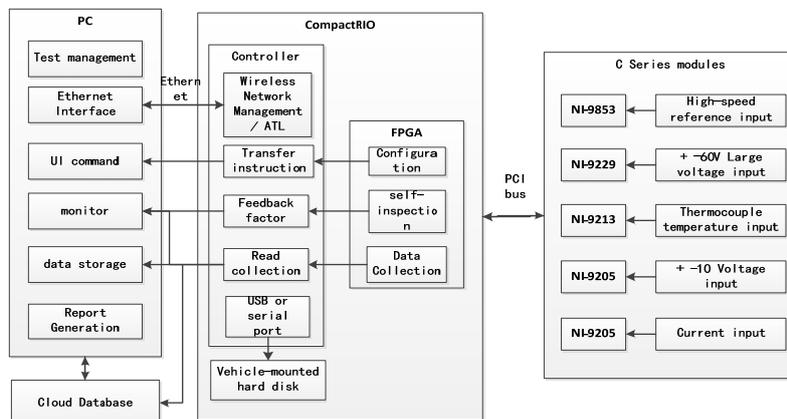


Fig.4 Vehicle data acquisition system

We select the appropriate acquisition mode according to the type of vehicle electrical performance signals. The single point polling acquisition model is used to acquire temperature signals, which change slowly and have low sampling rate. CAN bus signal can also be acquired by single point polling acquisition model, because LabVIEW provides the corresponding XNET to handle CAN message. However, at the moment of vehicle load startup, current and voltage signals change frequently and the sampling data is intensive, so the single point acquisition can't be used. We should use the DMA FIFO to gather the signals. This design can not only satisfy the sampling precision, but also ensure the data's real-time. The network flow can be accurately transmitted UI command and the TCP/IP can be safely transmitted the collected data.

The data collection module, wireless network management and automotive drive data storage module are added to the system to facilitate vehicle test.

Experimental data acquisition

The electrical properties of a Geely car are tested after the installation of test systems. The data acquisition system is tested through a single load test and vehicle power distribution test.

BCM instruments single load test data:

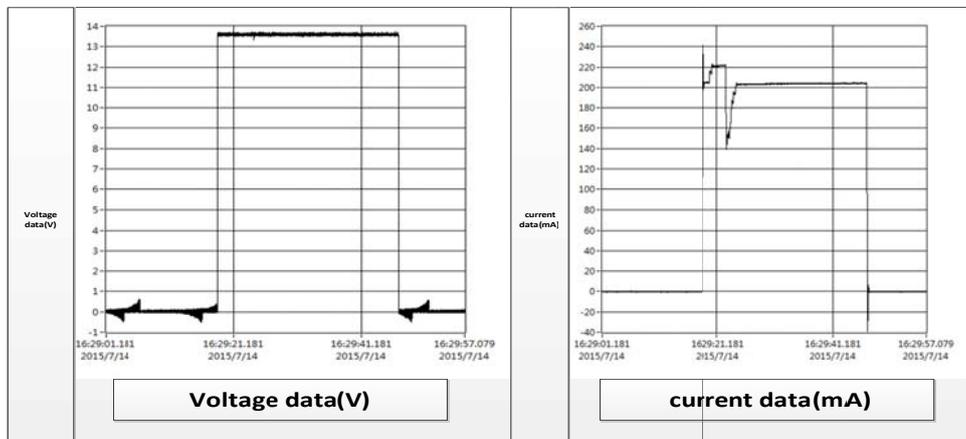


Fig.5 BCM instruments data

Table.1 BCM instruments data (Average)

BCM Voltage(V)	BCM current(A)	Battery current(A)
13.72045	0.208132	13.51243

When BCM instruments startup, the max value of current data is 0.2415572A, the min value of current data is 0.1412343A, the average value of voltage is 13.72045V. The test fuse is not damaged, and the measurement peak value does not exceed the current limit, so the singles are loaded qualified.

DC-DC output current and battery charge and discharge currents:

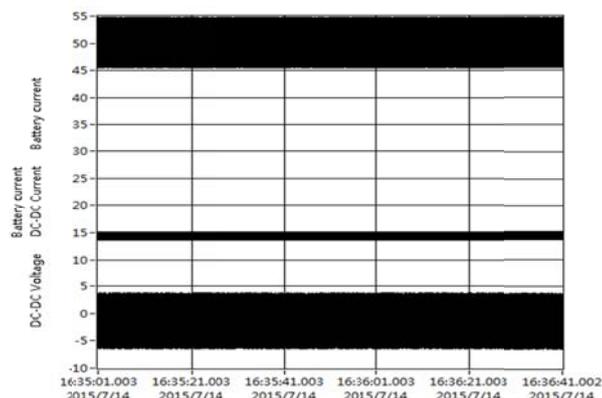


Fig.6 Power balance data

Table.2 Power balance data(Average)

DC-DC Voltage(V)	DC-DC current(A)	Battery current(A)
28.0192	49.8342	-6.1538

DC-DC terminal voltage is 28.0192v, DC-DC terminal current is 49.8342A, and battery charging current is -6.1538A. DC-DC can ensure the normal power of vehicle electrical system (battery is still in the state of charge), and there is not reaching the limit current of DC-DC, so that vehicle power allocation is reasonable.

By the result, acquisition system with high real time and the data error is small.

Conclusion

This article suggests how to research the development of data acquisition system. Based on the communication obstacles encountered in the development, the communication technology and collection methods are analyzed. We make Vehicle performance data acquisition experiments to verify CompactRIO data acquisition system have the advantages of strong stability, good real-time and high safety.

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