AN ETHERNET BASED DAQ FOR BLM OF LINAC

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Abstract

A beam loss monitor system for Linac has been built for HLS at NSRL. It consists of tens of monitor nodes and a control PC. Each node has 4 PIN-diode detectors installed around the vacuum pipeline and a MCU based data collector. Ethernet connection is applied among the control PC and data collectors. A tiny TCP/IP stack has been designed and optimized for the MCU which gives the data collector ability to access Ethernet. The detail of the system design is given in this article.
Keywords: Beam Loss Monitor; DAQ; TCP/IP

INTRODUCTION

Hefei Light Source (HLS) is a second generation dedicated light source at National synchrotron Radiation Laboratory (NSRL),composed of a 200MeV Linac injector, an 800MeV storage ring and several photon beam lines and experimental stations. In the recent years, a Beam Loss Monitor (BLM) system has been developed and mounted on the Linac injector as a machine diagnose tool. An Ethernet based data acquisition structure is applied in this system.

DETECTOR AND FRONT-END

To measure the mixed radiation field around vacuum pipeline of the Linac injector, PIN-Diode detector manufactured by Deetee Corp. is selected for its high efficiency, radiation tolerance and small size. 12V bias voltage is applied to improve the sensitivity and the response latency. Detector output current is readout by a charge balanced Current-to-Frequency (CFC) converter, which is designed to have a dynamic range of 6 decades and a resolution of pA. Hence CFC output pulse frequency is proportional to the dose of the radiation field.

The detector and its front-end CFC circuit are sealed in a stainless steel box. Negative and positive power supplies and generated output pulses are import/exported via a 4-pin interface, which is implemented by generic USB connectors and shield USB cables. 4 detectors are installed around the vacuum pipeline at one location to form a monitor node, as shown in Figure 1.

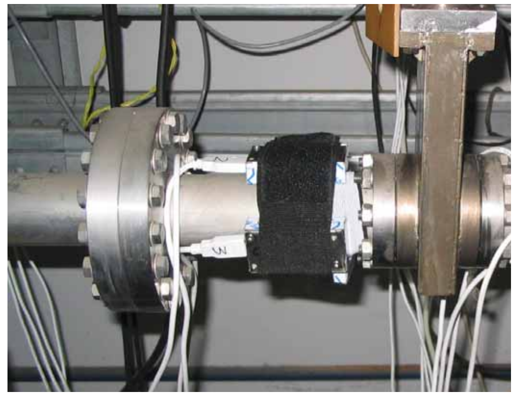

Figure1: detectors installed around the vacuum line.

DAQ SYSTEM

The data acquisition system consists of a console PC and tens of data collectors. Each data collector collects output pulses of 4 detectors at a monitor node. The block diagram of the whole BLM system and its DAQ system is shown is Figure 2.

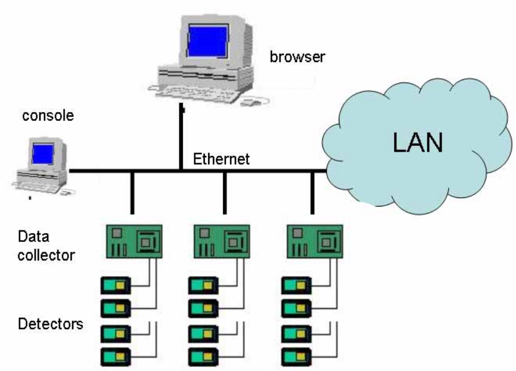

Figure2: Linac BLM DAQ structure.

Data collector

The data collector, as shown in Figure 3, is the bridge between detector and console. It counts pulses from detectors and as well communicates with the console, exchanging data and commands. The core component of data collector is a 16bit Freescale micro-controller. It has on-chip 128K Flash EEPROM and 8K RAM and thus it can works at single-chip mode, which simplifies hardware design and increases the reliability.

Figure3: Data collector for Linac BLM DAQ.

The MCU has an enhanced capture timer module which provides 4 channel 8-bit pulse accumulators. Each pulse accumulator counts the number of active edges of input pulses. It has also a buffered unit that can prevent pulse loss during the period when reading or cleaning the count register. To avoid overflow of 8-bit counter, MCU program reads and cleans counters at a frequency of 1 KHz and thus 255 KHz count-rate can be achieved, which fulfils the maxim 100 kHz output frequency of detectors. The number of pulses in every millisecond is measured and stored and we can get a current changing curve versus time. Since only during the short period when an electron bunch going through the vacuum pipeline will the radiation filed generated and be detected, a current peak can be observed.

Ethernet interface

To support the Ethernet connection, the collector is equipped with a popular dual-duplex Ethernet controller - RTL8019AS, which is compliant to Ethernet II and IEEE 802.3 10BaseT standards and supports UTP and BNC links. It has a jumper-less mode which can greatly simplify the mode setting thus is suitable to be connected to a micro-controller. The RTL8019AS is build in with 16K-Byte SRAM in a single chip. It is designed not only to provide more friendly functions but also to save the effort of SRAM sourcing and inventory.

Ethernet connection

To connect data collectors and the console, Ethernet is selected but not other popular field buses like CAN, Profi-bus or LonWorks.

The field bus connection is not directly supported by commercial Person Computers thus a translation is indispensable which is always implemented by a VME system or a field bus adapter. The BLM for NSRL is a separated system and to implement such a translation layer will increase the cost and the structure will be more complicated. Ethernet connection is comprehensively supported by PC both in hardware and software. Beside this it can also provide some other advantages compare to the field bus:

- No appropriative cable is needed to reach each collector. Ethernet connection is available anywhere around the accelerator.
- No terminator (UTP) needed, the topology is flexible to change.
- High transmit speed that can reach 10Mbps and higher

TCP/IP protocol stack

Besides the Ethernet interface, a protocol TCP/IP stack is indispensable for a data collector to connect to the LAN.

We have implemented a lightweight TCP/IP protocol stack intended for the 16-bit Freescale micro-controllers. It provides the necessary protocols for Internet communication, with very small code size on the order of a few kilobytes and RAM requirements on the order of a few hundred bytes.

The ARP/ICMP/IP/UDP/TCP protocols are implemented to support applications like tftp, HTTP and so on. The UDP protocol is used to transfer data and commands among data collectors and console while the TCP is used by the HTTP service.

The data collector is set to actively send UDP package to console, which contains the pulse count numbers during the last integral period. A clock-stamp is attached in each data package that the control PC can sort the data from all nodes according to the time they are generated, discarding the influence of network delay. Since the un-reliability of UDP protocol, a data redundancy mechanism is also used to prevent any possible data loss. The console can also configure the collectors via the UDP, like to set the integral period, set the collector's MAC and IP address, set the UDP port number, etc.

The data collector also acts as WEB server that can be accessed by any PC in the same local area network via any web browse software.

Console

The console is a Personal Computer running windows2000/XP. It is placed in the control room with an Ethernet connection. The MAC address and IP address of the console have been programmed into the collectors as constant parameters to guarantee that only from the console can the setting of collectors be modified. To change the console, all the collectors must be reprogrammed through a local serial link.

The DAQ software, as shown in Figure 4, developed with Visual C++, records each collector's count number and plots them. The data from each collector can be displayed with histogram or curve. It is also the interface to configure each collector.

Only the console can set each collector but not only the console can read the collector. Each collector is designed to acts as a web server that can be accessed from any computer connected in the local area network.

Several HTML pages are provided that contain the current count data of the node, shown in figure 5; a history log of the node and a link list to all collectors in the system. The pages are dynamically updated when accessed. A self-refresh mechanism is added to make the web browser keep up with the latest data.

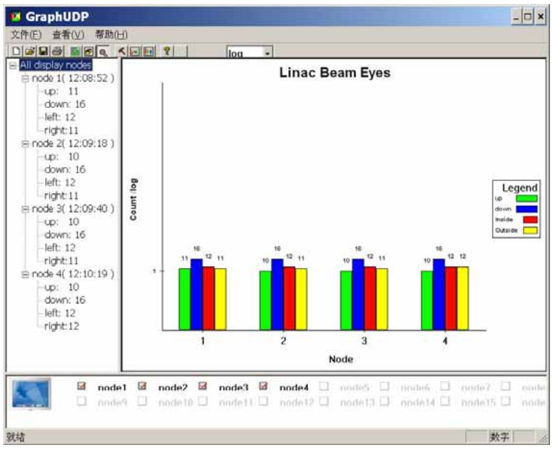

Figure 4: An example of DAQ software.

Figure 5: WEB page get from the collector.

CONCLUSION

The BLM system for Linac has run for nearly a year and proved to be reliable. The usage of Ethernet technology has made it easier and more flexible to build and maintain.

REFERENCES

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