BEAM INJECTION EFFICIENCY MONITOR IN NEWSUBARU

Satoshi Hashimoto# and Ainosuke Ando,
Laboratory of Advanced Science and Technology for Industry, University of Hyogo
NewSUBARU, 1-1-2 Kouto, Kamigori, Akougun, Hyogo, 678-1205, JAPAN

Abstract

In order to measure injection efficiency of an electron beam transported from the SPring-8 Linac to the NewSUBARU storage ring [1], an injection efficiency monitor has been developed. This system is based on PXI (PCI eXtensions for Instrumentation) and LabVIEW real-time operating system (RT OS). Injection efficiency is calculated from both the beam current per pulse measured by CT in beam transport line, and the increment of stored current measured by DCCT in the ring. The measurement and calculation are performed synchronizing with 1Hz signal and injection trigger signal with high accuracy. In addition to injection efficiency, information on machine operation status such as stored current and beam lifetime are delivered through local area network (LAN). The system has been operating with high reliability and plays an important role in machine operation.

INTRODUCTION

In the NewSUBARU storage ring the top-up operation has been performed in user time. Though the injection efficiency exceeds 90% in usual operation with fine-tuning, the efficiency is likely to decrease because of the drift of betatron tunes or the closed gap of 11m long undulator [2]. When the efficiency is less than 40 % on the average, the top-up operation must be stopped or synchrotron radiation users should be evacuated from the experimental hall because of the self-imposed restraint on radiation safety. Thus it is important to measure injection efficiency with high reliability for operation of the NewSUBARU storage ring. The efficiency should be displayed in the control room so that operators can watch machine status.

It is important to acquire injection trigger signal without failure. Though we previously developed an efficiency monitor based on PC with Windows OS, the system was not time-critical and sometimes failed to acquire signals because of background tasks. So the development of the new system with high accuracy and high reliability has been needed.

To comply with these requests we have developed the real-time system based on PXI and National Instruments LabVIEW RT OS. The system requires deterministic real-time control, high performance and high reliability with low development time and costs.

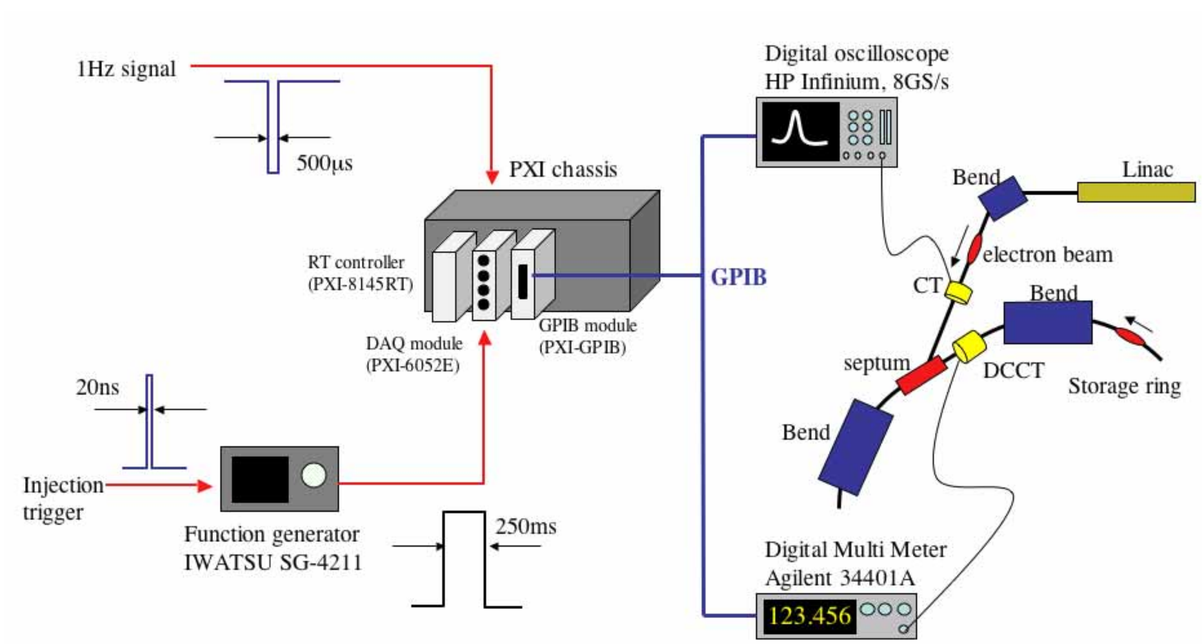

Figure 1: Hardware configuration of beam injection efficiency monitor.

#hashi@lasti.u-hyogo.ac.jp

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The signal from current transformer (CT) in beam transport line is measured by digital oscilloscope and the injected beam charge is estimated by peak height and width of its waveform. The increment of stored current is measured by direct current CT (DCCT) and digital multi meter. Injection efficiency is defined as a current increment in the ring divided by an injected beam current. In our ring the efficiency usually reaches more than 90% due to stable operation of SPring-8 Linac and fine-tuning of the ring.

Hardware

The hardware configuration is shown in Fig. 1. PXI is a PC-based platform for measurement and automation. In our system, PXI chassis (PXI-1002) has the data acquisition (DAQ) module (PXI-6052E), the GPIB module (PXI-GPIB) and the real-time embedded controller with Pentium MMX and Ethernet port (PXI-8145RT). LabVIEW RT OS is running on this controller.

The digital oscilloscope (Hewlett Packard, Infinium oscilloscope, 8GS/s) measures the fast signal from CT and its waveform data is sent to the RT system by GPIB. The stored current is measured by DCCT (Bergoz MPCT) and the digital multi meter (Agilent 34401A), whose output is also sent to RT system by GPIB.

Timing of data acquisition

The control system of SPring-8 and NewSUBARU has 1 Hz timing signal and the beam injection is performed in synchronous to 1 Hz signal. The maximum repetition frequency of beam injection is 1 Hz.

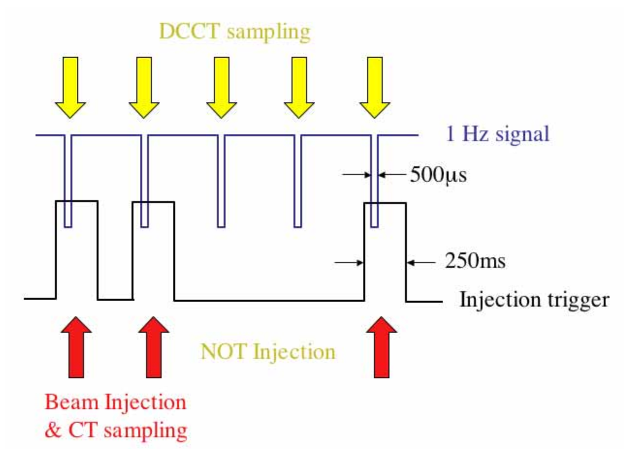

Figure 2: Timing of data acquisition.

Both the 1 Hz signal (pulse length of 500μs) and the injection trigger signal are measured by DAQ module (16bit, 333kS/s). The pulse length (20ns) of the injection trigger is expanded to 250ms by the function generator (IWATSU SG-4211) to overlap these two signals in time.

With 1 Hz signal as a trigger, the PXI real-time instrument samples DCCT voltage through GPIB and also measures voltage of the injection trigger signal as shown in Fig.2. If the injection trigger is in high level, that is, a beam is injected, then the system reads the waveform data of CT from the digital oscilloscope through GPIB.

Software

The RT system must be deterministic or time-critical. So that the communication by TCP/IP and GPIB is not time-critical, loops including these routines have to be separated from the time-critical loop including data acquisition. The data transfer between time-critical loop and TCP/IP or GPIB loop is performed through FIFO (First In, First Out) method. The outline of software is shown in Fig.3. Several parameters such as bunch current, stored beam current, beam lifetime and injection efficiency are calculated in time-critical loop of the RT system. Using TCP/IP these data is transferred from the PXI system to the host PC (Windows OS) by communication program developed by LabVIEW and updates for every second. The code running on the RT system is developed in the host PC and is downloaded to the RT system to execute.

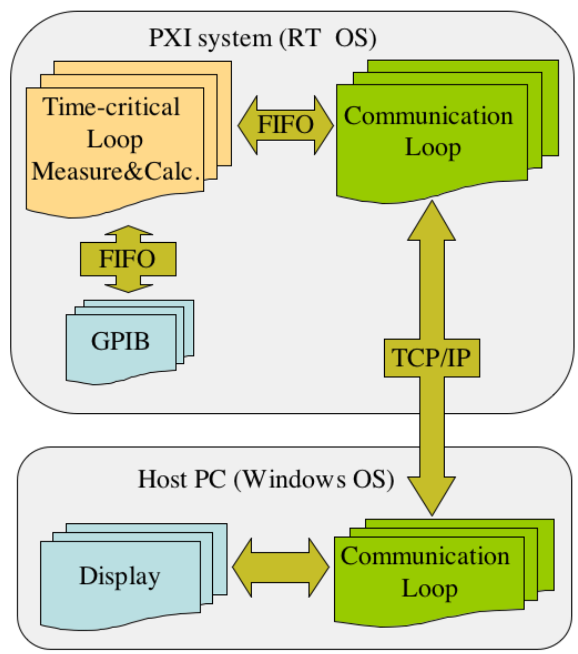

Figure 3: Software outline of RT system and host PC.

Network

The data measured and calculated at the RT system is transferred to the host PC through the private LAN. In the host PC, bunch current, stored beam current, beam lifetime and injection efficiency are calculated and displayed every one seconds. These data is also immediately transferred to a PC, which acts as a firewall

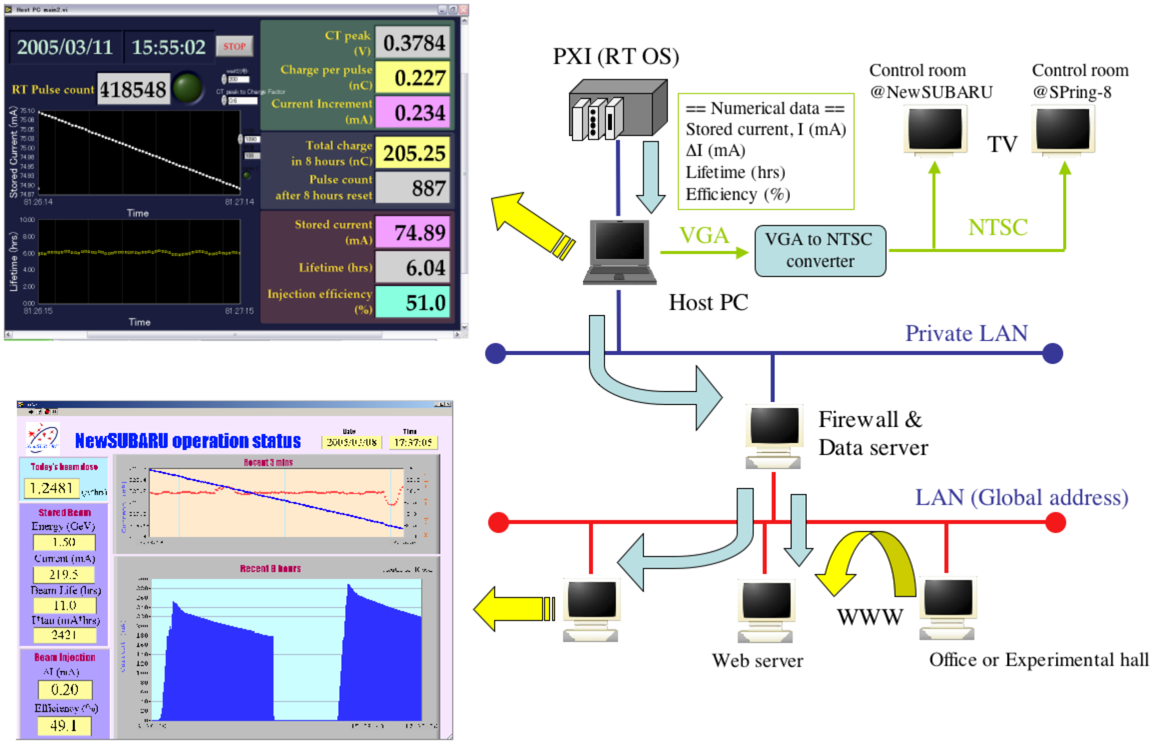

Figure 4: Network of PXI RT system and host PC.

between the private LAN and LAN with global address for network security. This firewall acts also as a data server and the other PCs in LAN can get these numerical data from the server. WWW server also receives these numerical data and makes web contents on operation status in hypertext. Accelerator staff and SR users can watch operation status of the ring by WWW in their room or experimental hall. In preparation for network stop by trouble, VGA output of the host PC is converted to NTSC video signal and transmitted to control rooms of both NewSUBARU and SPring-8.

CONCLUSION

The newly developed RT monitor system for beam injection efficiency, which is based on PXI and LabVIEW RT OS, has been operating with high reliability. There has been no trouble such as crash for the operation period of one year and more. The beam injection efficiency measured with this system has an important role in the machine operation. And the information on machine status evaluated with this system can be delivered all around NewSUBARU facility through LAN.

REFERENCES

[1] A. Ando et al., “Isochronous storage ring of the NewSUBARU project”, J. Synchrotron Radiation 5 (1998) p.342.

[2] M. Niibe, et al., “Characterization of light radiated from 11 m long undulator”, Synchrotron Radiation Instrumentation, 8th International Conf., p. 576.