BPM DAQ SYSTEM USING FAST DIGITAL OSCILLOSCOPE

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Abstract

The KEKB Linac is a 600-m-long injector which injects the beams into four independent rings. The non-destructive beam position monitor (BPM) is indispensable diagnostic tool for the stable beam operation. In the KEKB Linac, approximately nineteen BPM's with the four strip-line type electrodes are used for the beam orbit measurement. The orbit data is used for the orbit and energy feedback loops. In the current data acquisition (DAQ) system consists of the VME and the digital oscilloscope. The maximum DAQ rate is about 1-Hz which is limited by an oscilloscope performance. It is very difficult to keep the maintenance work of these oscilloscopes because they are the discontinued products. In addition, we have the Linac upgrade plan aiming a fast beam-mode switch, in which the fast beam position measurement is indispensable. From these reasons, a new DAQ system will be installed. In this paper, the system description of the new DAQ system and the result of the performance test will be presented.

INTRODUCTION

Linac provides the beams with the different energies into four independent storage rings; Low Energy Ring (LER) of the KEKB (3.5-GeV/e+), High Energy Ring (HER) of the KEKB (8-GeV/e−), the Photon Factory (PF) (2.5-GeV/e−) and the Advanced Ring for pulse X-rays (PF-AR) (3-GeV/e−). In the KEKB modes, the single or two-bunched beams are accelerated in each rf pulse of Linac. The beam charges are about 1-nC/bunch and the maximum beam repetition rate is 50-Hz. In addition, high current electron beams (10-nC/bunch) are required to produce a sufficient amount of positrons. The PF and PF-AR modes require the 0.1-nC/pulse up to 25-Hz.

The KEKB rings are operated under the continuous injection mode (CIM), in which both of the KEKB rings can keep almost full operation currents by a frequent switch of the Linac beam mode. In the future, the PF Top-up operation will start for increasing the integrated brilliance. The simultaneous injection between the KEKB and the PF are strongly required so that the KEKB CIM and the PF Top-up can be carried out at the same time. For this purpose, the injector upgrade project has been already started in last summer [1, 2, 3]. In the future beam operation of Linac, each rf pulse of 50-Hz accelerates a different quality of beam. It is strongly required to improve the DAQ system for a fast measurement, in which the BPM data among all DAQ stations should be synchronized with the common timing signal.

DAQ SYSTEM FOR BPM

Overview

About 90 stripline-type BPM's have been installed at the KEKB Linac. The DAQ system comprises two UNIX workstations (hp Tru64 UNIX) and twenty dedicated front-end systems. For the beam-energy-spread measurement and feedback, we use the four energy-spread monitors (ESM's) with eight strip-line type electrodes [4]. The ESM's are controlled by the independent DAQ system [5].

Front-end

The twenty front-end systems have been installed in the Linac klystron gallery at a nearly equal interval along the beam line. Each front-end system controls 3–12 BPM's (12 at maximum). A schematic drawing of a front-end system is shown in Fig. 1. It consists of a VME computer (OS-9 operating system with a 68060 microprocessor of 50-MHz), a digital oscilloscope (Tektronics TDS680B/C;

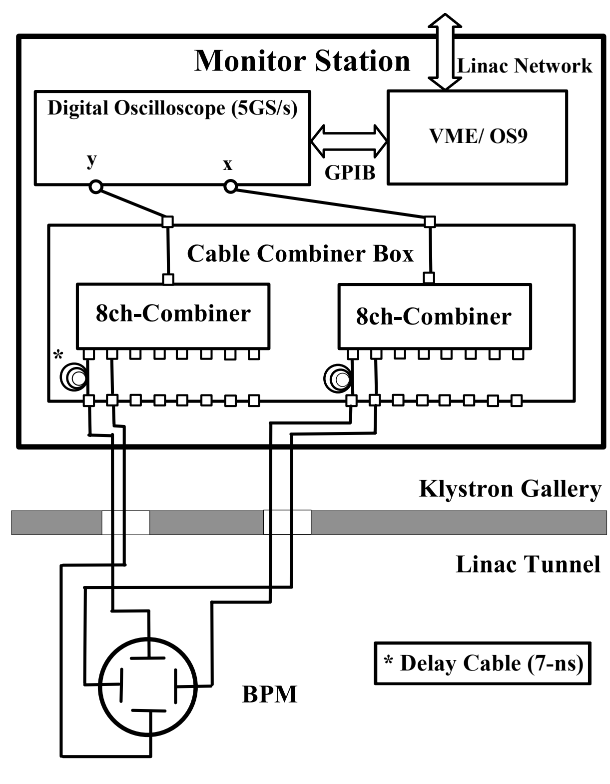

Figure 1: Schematic drawing of a front-end system.

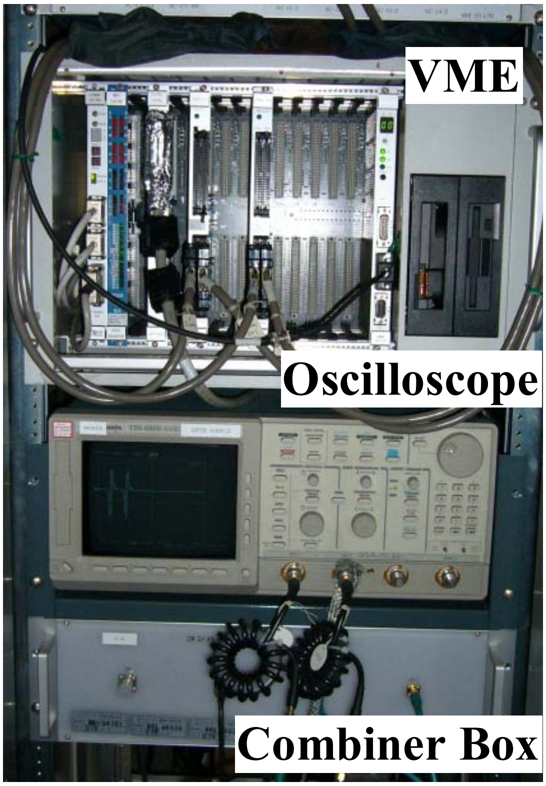

Figure 2: Photograph of a monitor station.

5-Gs/s) as a signal digitizer, and two signal combiners in a cable combiner box. The four signals coming from one BPM are fed to two signal combiners (vertical and horizontal) together with the signals from other BPMs. The delay cables (7-ns) are used to avoid waveform overlaps at the signal combiners. The two combined signals are digitalized by an oscilloscope at a sampling rate of 5-GHz. The digitalized signals are analyzed by a VME computer in order to deduce the beam parameters (beam-current, x-position, y-position), taking into account the calibration coefficients.

The trigger pulse signals, which are synchronized with the Linac beam, are provided to all front-end systems at 0.7 Hz cycle. These signals are used to start the data taking cycle of each front-end system. The trigger rate is limited by the GPIB communication throughput between the VME computer and the oscilloscope. The photograph of the front-end station is shown in Fig. 2.

Structure of Control Software

Figure 3 shows the block diagram of the control software and data flow. The calculated beam parameters at a front-end are transferred to the UNIX workstations with the UDP protocol, where data servers are available. Two data servers have been prepared to realize higher redundancy, as well as to distribute the CPU loads over the existing workstations. In order to reduce the network traffic, data transfer is done when the beam positions and currents are renewed at a front-end. As a result, the traffic rate between the front-end systems and the UNIX workstations is always constant (25 frames per second, 0.7 Hz x 18 x 2). UNIX workstations store the most recent ten data sets for each front-end in shared memory. The data server returns averaged values by using this cached data. The use of cached data greatly decreases the total amount of the network traffic and the workstation CPU load.

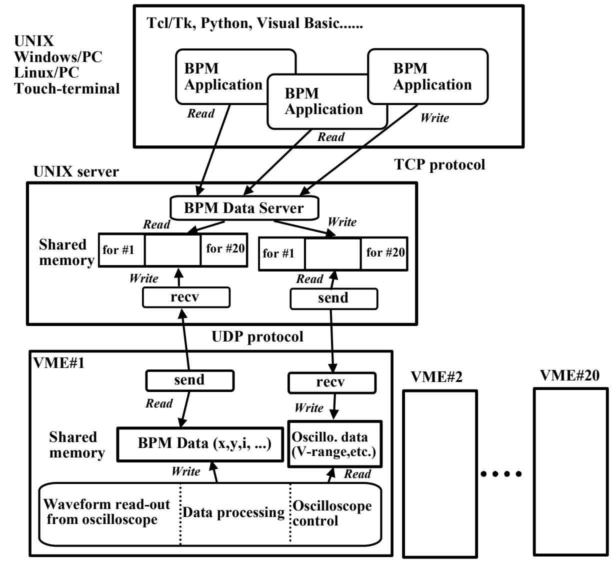

Figure 3: Block diagram of the control software and data flow.

BPM Application

All of the BPM applications receive the latest beam parameters by sending requests to one of the data servers. This communication is made with the TCP-protocol using the standard format of the Linac control system. Typical response times are 1–10 ms, depending on the CPU power of the application side computer. Some applications with real-time graphical presentation have been developed for the X-window environment. This application can show the positions (x and y) and beam-charge of the entire Linac with a refresh interval of several seconds. The BPM data is logged into EPICS Archiver for the Linac control system and KEKBLog for the KEKB-ring control system [6].

The graphic part of the application is generated by using the resources of the SAD computers at the KEKB-ring control system. More important applications of the BPM are feedbacks of the energies and the orbits. The feedback applications have been developed in order to suppress beam instabilities over long-term operation. There are roughly 20 feedback applications, and among them 10 are always running during normal operation.

NEW SYSTEM

Overview

In the new DAQ system, the current system (a VME and a digital oscilloscope) will be replaced by a fast digital oscilloscope, which is a Windows-XP/based oscilloscope with a sampling rate of 10-GS/s and Pentium-IV microprocessor of 3.4-GHz. It has a Gigabit

Ethernet port for fast network communication. A photograph of a new DAQ system is shown in Fig. 4.

Performance Test

In order to evaluate the performance of the new DAQ system, the data acquisition speeds were measured in the different conditions, in which the test program was executed on the oscilloscope and another PC for the local and remote access test, respectively. In the remote access test, the oscilloscope was controlled via VXI-11 protocol, and the measured waveform was transferred to a Windows-PC. In these tests, we vary the number of channels and data points with a display-off mode. The external trigger of 1-MHz was used for the digitize timing. It is enough fast in comparison with the acquisition speed.

The results of remote and local access tests are shown in Figs. 5 and 6, respectively. In the case of 10-k points, the acquisition speed of local access is about 15% higher than that of remote access. In our system, local access will be used, and only two channels will be used for the waveform measurement for the present. The results are good enough for the 50-Hz measurement.

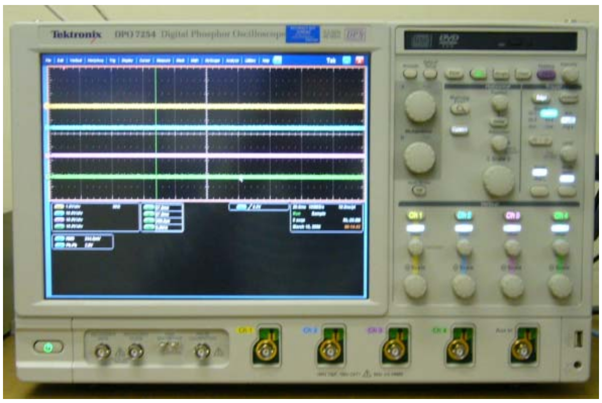

Figure 4: Photograph of a new DAQ system.

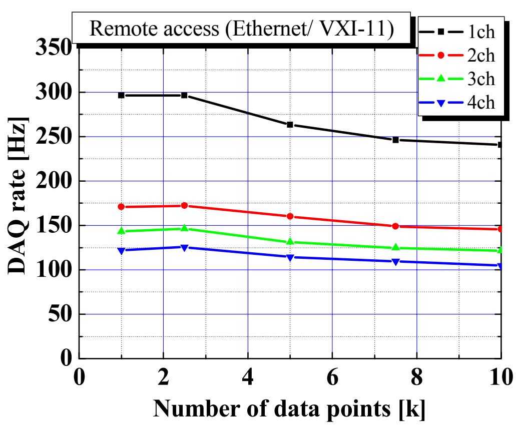

Figure 5: Result of the data acquisition speed by a remote access.

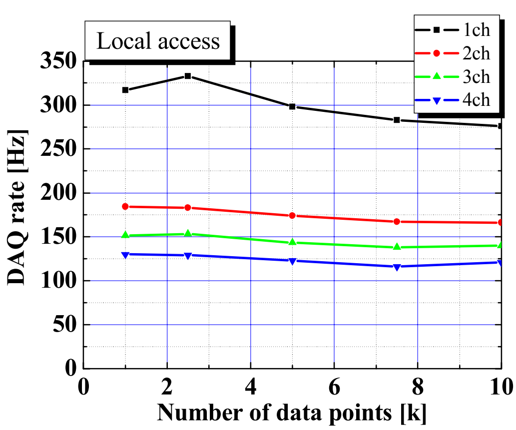

Figure 6: Result of the data acquisition speed by a local access.

SUMMARY AND PUTURE PLAN

In the injector Linac upgrade, it is indispensable to perform the synchronized measurement of the beam position up to 50-Hz. For this purpose, we will replace the current DAQ system, which consists of VME and old model of a digital oscilloscope by the fast digital oscilloscope. The performance tests show the feasibility of 50-Hz measurement.

In this summer, half of the current DAQ system will be replaced by new one, and they will be test under the realistic beam operation. The software porting works from OS-9 to Windows is going on for keeping the structure of the upper layer software. In the near future, we will implement the functionality of the synchronized measurement among all DAQ stations. The EPICS support software will be also developed soon.

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