FAST BPM DAQ SYSTEM USING WINDOWS OSCILLOSCOPE-BASED EPICS IOC

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Abstract

The KEK linac is a 600-m-long injector that delivers electron/positron beam to the four independent rings (KEKB e-/e+, PF, PF-AR). The non-destructive beam position monitor (BPM) is an indispensable diagnostic tool for a long-term stable beam operation. In the KEK linac, around one hundred BPMs with the four strip-line type electrodes are used for the beam orbit measurement. The beam orbit data is used for the beam orbit and energy feedback loops. The previous BPM data acquisition (DAQ) system consists of a VME-CPU and a digital oscilloscope, and it has been installed more than decade ago. Although the maximum linac beam repetition rate is 50-Hz, the maximum BPM DAQ rate is about 1-Hz limited by an oscilloscope performance.

Recently, we have the on-going linac upgrade project aiming a fast beam-mode switch operation, in which the fast beam position measurement of 50-Hz is strongly required. For this purpose, we developed a new BPM DAQ system using a Windows-based fast digital oscilloscope. In this paper, the system description of the new DAQ system and the results of performance test will be presented in detail.

INTRODUCTION

The KEK linac provides the beams of the different modes sequentially for the four independent rings; Low Energy Ring (LER) of KEKB (3.5-GeV/e+), High Energy Ring (HER) of KEKB (8-GeV/e-), Photon Factory (PF; 2.5-GeV/e-) and Photon Factory Advanced Ring for pulse x-rays (PF-AR; 3-GeV/e-).

For a typical beam operation, PF and PF-AR need the beam injection once and twice a day, respectively. On the other hand, the KEKB rings are always operated with the continuous injection mode (CIM) for keeping the stored current almost constant. During the CIM operation, the linac beam modes are frequently switched so that all settings of magnets, rf phases and timings are changed according to the HER and LER beam properties. In the near future, PF ring will be also operated with top-up. The injector upgrade project is going on so that the PF top-up never interrupts the CIM of KEKB [1, 2, 3].

After the injector upgrade, the linac beam pulse could be injected into the chosen ring (HER, LER or PF) in each 50-Hz pulse. A higher-performance new BPM DAQ system is strongly required since the beam position measurement should be carried out in pulse-by-pulse of 50-Hz. For this purpose, we developed the new BPM DAQ system and replaced all previous system by new one. The new DAQ control software is a Windows-based software just ported from the previous VME/OS9-based one. In the future, it will be replaced by the EPICS-IOC based control software.

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BPM DAQ SYSTEM,

Previous System

For a higher availability of beam operation, many kinds of feedback loops have been developed and utilized to stabilize the beam orbit, energy and energy spread [4, 5, 6]. These feedback loops make use of the beam position information acquired by the non-destructive BPMs [7]. About one hundred stripline-type BPMs have been installed in the KEK linac.

The twenty front-end systems have been installed in the linac klystron gallery at a nearly equal interval along the beam line. Each DAQ system controls 3-12 BPMs (12 at maximum). A schematic drawing and photograph of a previous DAQ system are shown in Figs. 1 and 2, respectively. It consists of a VME computer (OS-9 operating system with a 68060 microprocessor of 50-MHz), a digital oscilloscope (Tektronics TDS680B/C; 5-GSa/s) as a waveform 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 digitized by an oscilloscope at a sampling rate of 5-GHz. The digitized signals are analyzed by a VME-CPU in order to deduce the beam parameters (beam charge, horizontal position, vertical position), taking into account the calibration coefficients.

The trigger pulse signals, which are synchronized with the linac beam, are provided to all DAQ systems at 0.7-Hz. These signals are used to start the data taking cycle of each DAQ sysmte. The trigger rate is limited by the GPIB communication throughput between the VME computer and the oscilloscope.

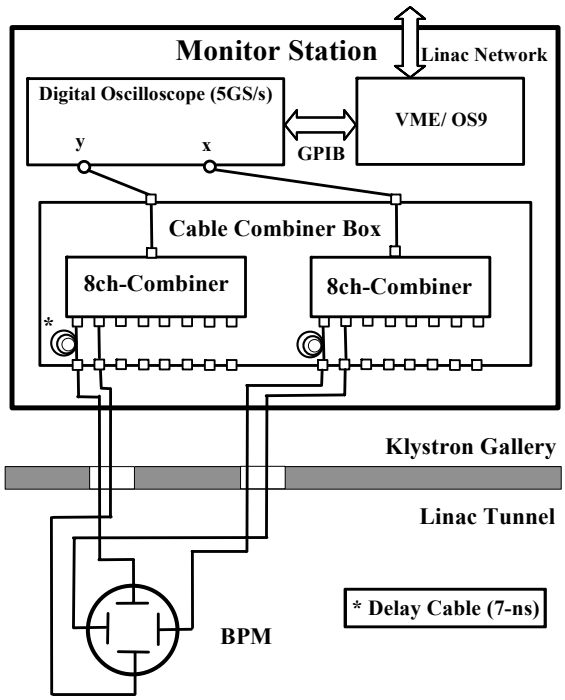

Figure 1: Schematic drawing of previous BPM DAQ system.

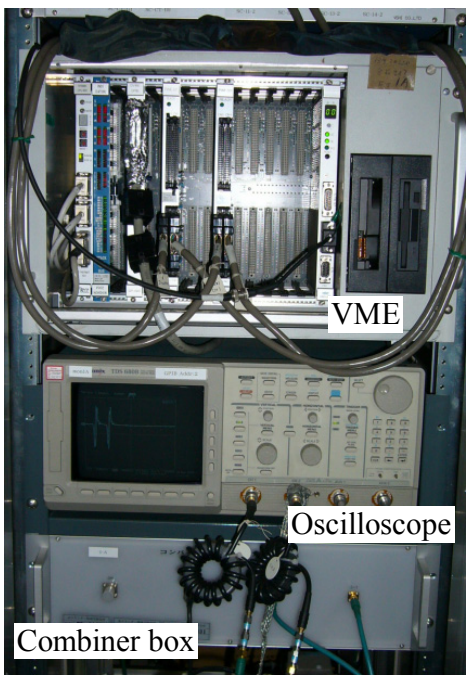

Figure 2: Photograph of previous BPM DAQ system.

New system

The new DAQ system is a WindowsXP-based fast digital oscilloscope (Tektronix DPO7104; 10-GSa/s, 4ch, 8-bits, CPU P4/3.4-GHz, Gigabit-Ethernet) as shown in Fig. 3. Because a control software developed by Windows-OS environment can be executed on the new DAQ system, the control software development can be accelerated by using the powerful software development tools. In addition, we can drastically reduce the consumed time for the waveform data transfer between a digitizer part and a CPU part in comparison with the GPIB connection of previous system. The new control software was developed by Microsoft Visual Studio 2005/C++ (MSVSC++) and the TekVisa software.

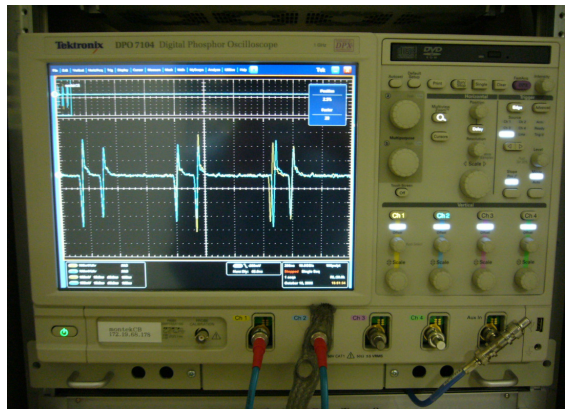

Figure 3: Photograph of new BPM DAQ system.

PERFORMANCE TEST

MSVC++/TekVisa software test

We tested the speed performance of waveform signal acquisition. The test software was developed by MSVSC++ and TekVisa environment, and the oscilloscope command of "curevestream" was used for archiving a fast repetitive waveform acquisition. In this performance test, we changed the number of used oscilloscope channel from one to four and the waveform length from 1-k to 500-k data points independently. The test software was executed on the oscilloscope. During all performance tests, the display update function of the oscilloscope was disabled for enhancing the performance of DAQ speed, and the rectangle shaped waveform of 50-MHz was used as an external trigger for an oscilloscope.

Figure 4 shows the results of performance tests. Each dot means the DAQ speed averaging over 100 times measurements. In the practical beam operation, we use two channels of oscilloscope and 20-k data points. From Fig. 4, it corresponds to the DAQ speed of around 150-Hz. Even taking into account the computation time, we confirmed that the new DAQ system has enough high performance for the 50-Hz beam position measurement.

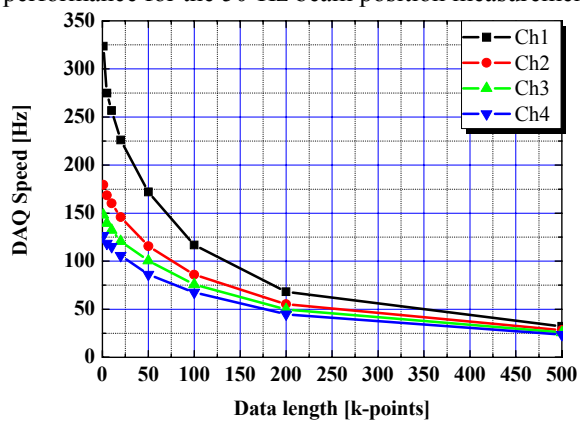

Figure 4: DAQ performance by MSVC++/TekVisa.

EPICS IOC Test

The KEK Linac control system has been originally developed by using the homemade library software based on the TCP/UDP communication and Remote Procedure Call (RPC). On the other hand, the control systems of other ring accelerators have been implemented with the wide use EPICS system.

In order to enhance a share of beam operation data between the linac and the rings, we have already implemented the EPICS based control environment [10]. Therefore, it is very effective to develop the EPICS-IOC based BPM DAQ control software, and we developed the test EPICS-IOC for the evaluation of new DAQ system. The test software was built by using MSVSC++, TekVisa and EPICS R3.14.8.2 library.

Figure 5 shows the test results of EPICS-IOC DAQ performance. All of test conditions are completely the same with MSVC++/ TekVisa test. In comparison with Fig. 4, we confirmed that the EPICS-IOC result is also enough high speed for our purpose.

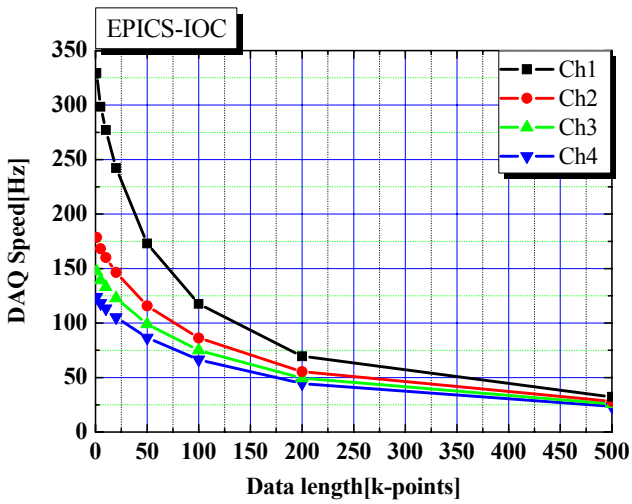

Figure 5: DAQ Performance by EPICS-IOC.

SUMMARY AND FUTURE PLAN

In the KEK injector linac, the upgrade plan is going on for performing the KEKB CIM and PF top-up at the same time. For this purpose, a BPM DAQ system upgrade is strongly required for the fast beam position measurement up to 50-Hz. The previous BPM DAQ system has about 1-Hz data acquisition performance because of the oscilloscope performance and the GPIB connection. In addition, the maintenance of the previous BPM DAQ system is very difficult since it has been installed more than decade ago and an already discontinued product. For these reasons, we developed the new BPM DAQ system, which is a Windows-based fast digital oscilloscope. The test result of repetitive DAQ speed is enough fast for our purpose of 50-Hz beam position measurement. In addition, the test EPICS-IOC was developed and tested. Its result is also satisfactory for our purpose.

In the near future, we will develop the EPICS-IOC software for a daily beam operation. Furthermore, we are aiming for the synchronized beam position measurement among different DAQ systems. After the realization of the synchronized measurement, we will be able to analyze the correlation between the beam position and the other beam parameters up to 50-Hz. It will be strongly useful for the quick discover of a beam orbit perturbation source and its correction. These results will be reported elsewhere.

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