

# UPGRADE OF READOUT SYSTEM FOR BEAM POSITION MONITORS IN THE KEKB BEAM TRANSPORT LINE

Tomohiro Aoyama, Takuya Nakamura, Kenji Yoshii

Mitsubishi Electric System & Service Co., Ltd. 2-8-8 Umezono, Tsukuba, Ibaraki 305-0045, Japan

Naoko Iida, Masanori Satoh, Kazuro Furukawa

High Energy Accelerator Research Organization (KEK), 1-1 Oho, Tsukuba, 305-0801, Japan

## Abstract

At the KEKB accelerator, electrons and positrons are injected from the KEK Linac to the storage ring through the beam transport (BT) line. KEK Linac had continuously injected each beam alternately every few minutes. In our KEK Linac, it is very important to switch acceleration devices from electron mode to positron and vice versa to keep high storage currents. To attain this, we have developed a new readout system for the beam position monitors (BPMs) at the BT line, by which the fast monitoring is possible. For the old BPM system, it had been taken a few seconds to switch the beam modes and about one second to measure the beam positions. With the new system, measuring interval was achieved to be 20 msec, including switching time, and we demonstrated that new system contributed to stable beam operation. In this paper, we will report on a detail of the fast readout for the BT BPM system including its performance.

## BPM SYSTEM OF BT AND KEK LINAC

The present beam position measurement by BT BPM catches the shape of signal waveform from each electrode of BPM, and the calculation processing of the beam position and the quantity of electric charge, etc. is done based on this. The waveform obtained from each electrode of BPM is a bipolar signal, several signals are overlaid by a combiner and are captured as a waveform, and the amplitude of each bipolar signal is calculated. The numerical result of beam position and electric charge is written in EPICS [1] records allocated for each BPM, and used from various applications. In KEK Linac, the system that used the oscilloscope as a high-speed BPM system [2] necessary for a simultaneous injection of e-/e+ was developed. It measures the waveform of BPM with the oscilloscope, and calculates the beam position and the electric charge. Then, the results are provided as EPICS records. The BPM system for BT was developed based on this system. There are four output signals in each BPM. The system of KEK Linac joins the signal of two channels. Other two channels are used to measure 100 times different changes for B Photon Factory injections. The signal is converted into digital waveform data with two channels of the oscilloscope. The beam position and electric charge are calculated by this data (Fig. 1).

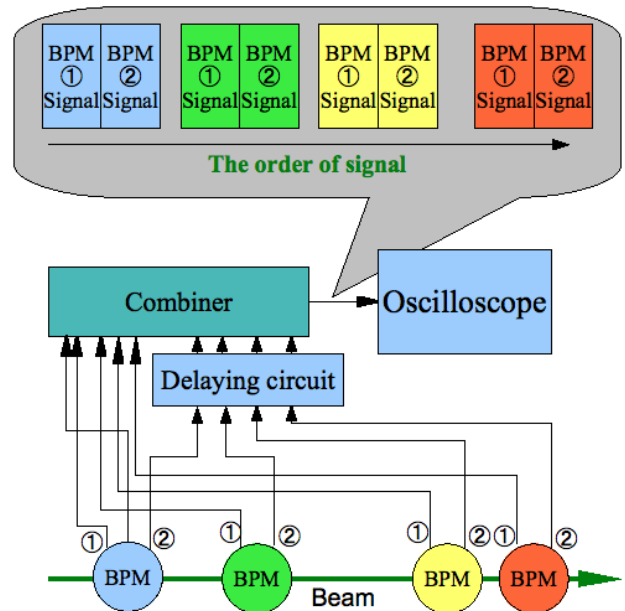


Figure 1: BPM system and signal of KEK Linac. For one channel of the oscilloscope. Four electrodes are measured with two channels.

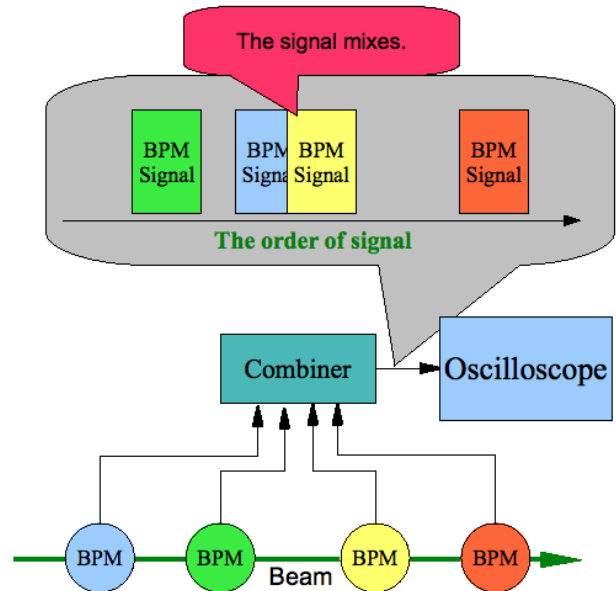


Figure 2: BPM system and signal of BT. For one channel of the oscilloscope. Four channels are used for four electrodes.

In BT, the waveform of four electrodes of BPM is measured with an individual channel of 4ch oscilloscope, and the BPM signal from four electrodes is processed. Each oscilloscope processes 32 BPMs. And, the interval of the BPM signal is not constant. Therefore, the part where the signal cannot be correctly measured can be done by collecting signals concerning two electrodes of BPM in BT. Then, the signal concerning four electrodes is individually processed (Fig. 2).

### INSTALLATION OF EPICS ENVIRONMENT ON OSCILLOSCOPE

The oscilloscope uses Windows XP as OS. The software of the oscilloscope works as an application of Windows XP. To run the BPM software on this oscilloscope, the EPICS environment was set up. Cygwin [3] was installed as development software for the EPICS environment of the oscilloscope. The version of EPICS used version 3.14.8.2 where confirming the operation of the oscilloscope was taken at KEK Linac. Moreover, because the BPM software was written by C language, MS-Visual Studio was installed.

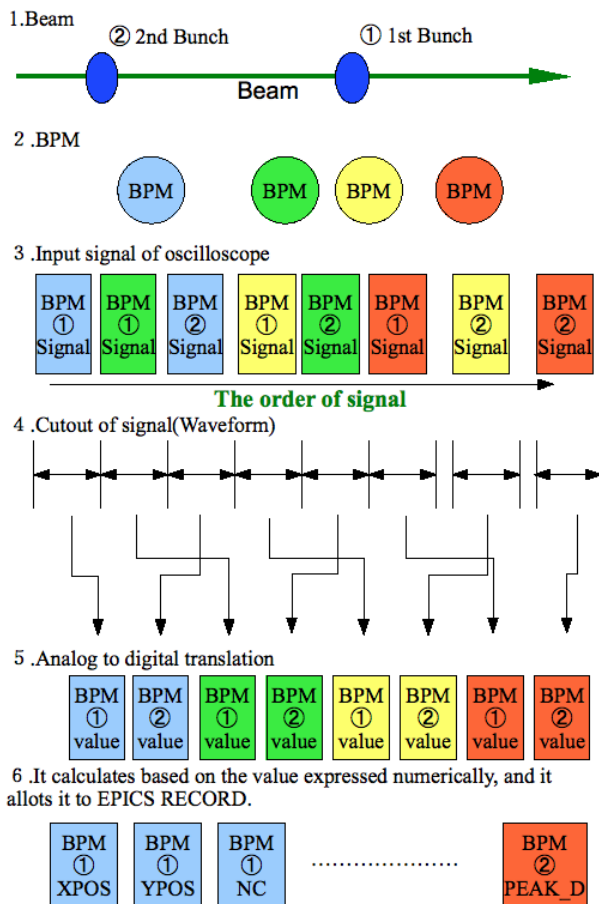


Figure 3: Process of BPM signal.

### SOFTWARE FOR BT BPM

The original software was developed for BPM of KEK Linac. Some modifications were done for BT BPM.

The changes are as follows.

- The input channel of the oscilloscope is changed from two channels to four channels.
- The maximum number of BPM that can be measured is changed to 32.
- EPICS record of the waveform data of each channel of the oscilloscope is made.
- Adjustment of position that waveform when BPM software works cuts out.

In KEK Linac, the waveform cutout position cannot be adjusted while the BPM software is working. Therefore, it was necessary to reactivate the program in the adjustment of a waveform cutout position.

### BEAM TEST

The BPM measurement examination using an actual beam was performed with software for BT changed as above. As a result (Table 1), it was confirmed not to operate normally in the beam repetition more than 25 Hz. The cause was investigated.

- In KEK Linac, four BPM signals were processed with one oscilloscope.
- The load of the calculation processing etc. rose because it processed 32 BPM signals in BT.

When the number of BPM measured was experimentally reduced by half to 16, it operated at 50 Hz.

However, the number of BPM is returned to 32 because the number of BPM cannot be decreased, and it looks for the item that decreases processing in actual operation.

Table 1: Verification Outcome at Operation Speed

Before improving software	It operates by 27 Hz or more
Before improving software (Half of BPM)	It operates by 50 Hz or more
Deletion of unnecessary EPICS RECORD	It operates by 36 Hz or more
Deletion of processing not used in present BT.	It operates by 37 Hz or more
Both are executed.	It operates by 47 Hz or more

Table 2: e-/e+ Beam Repetition when in Operation. And processing of BPM software. (Before improving software.)

	e-: 0 Hz (None)	e-: 1~5 Hz	e-: 12.5 Hz	e-: 25 Hz	e-: 50 Hz
e+: 0 Hz (None)	△	○	○	△	△
e+: 1~5 Hz	△	△	△	△	—
e+: 12.5 Hz	○	◎	◎	○	—
e+: 25 Hz	○	◎	◎	△	—
e+: 50 Hz	△	—	—	—	—

Operation frequency of repetition of beam injection  
 ◎: It uses it frequently.  
 ○: It uses it.  
 △: It uncommonly uses it.  
 —: not applicable.

Processing of BPM software  
 Normal performance  
 It is not possible to follow. (No mistake)  
 It occasionally makes a mistake.  
 not applicable.

### IMPROVEMENT OF BPM SOFTWARE

The following items were found that were able to cut down processing. Therefore, software was modified and operation speed was verified (Table 1).

- Deletion of unnecessary EPICS record  
 There are EPICS records that are not used because it processes e-/e+ as another BPM. The number of EPICS records becomes about half by deleting those EPICS records. However, the calculation processing doesn't change.
- Deletion of processing that is not necessary in present BT.

It is a deletion of the item not used in BT though uses in BPM of KEK Linac. The number of EPICS record, the calculation processing, and the number of data are reduced by about 45 % by doing this reduction.

Both of two items are performed as a result of verifying operation speed (Table 1). At this time, it is possible to use it by 37.5 Hz (e+: 25 Hz + e-: 12.5 Hz) that is the total of the repetition frequency of the beam used when frequently driving. Under such a condition, it improves it using it to operation.

Table 3: e-/e+ Beam Repetition when in Operation. And processing of BPM software. After improving software.

	e-: 0 Hz (None)	e-: 1~5 Hz	e-: 12.5 Hz	e-: 25 Hz	e-: 50 Hz
e+: 0 Hz (None)	△	○	○	△	△
e+: 1~5 Hz	△	△	△	△	—
e+: 12.5 Hz	○	◎	◎	○	—
e+: 25 Hz	○	◎	◎	△	—
e+: 50 Hz	△	—	—	—	—

<p><b>Operation frequency of repetition of beam injection</b></p> <p>◎: It uses it frequently.</p> <p>○: It uses it.</p> <p>△: It uncommonly uses it.</p> <p>—: not applicable</p>	<p><b>Processing of BPM software</b></p> <p>Normal performance</p> <p>It is not possible to follow. (No mistake)</p> <p>It occasionally makes a mistake.</p> <p>not applicable</p>
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### FUTURE R&D

It reached in the state that was able to be used in operation though a part of the problem had been left. Hereafter, it works on residual problems, and a further improvement is continued. It aims at the achievement of the problem aiming at the commencement operation of autumn.

- Accuracy improvement of operation.  
 For acquisition mistake of waveform signal of e-/e+.  
 e-/e+ can be distinguished in the waveform, and it does not write it in EPICS record when different from the beam signal (event system [4]) from KEK Linac.
- The BPM software starts by the automatic operation in turning on the oscilloscope.

It starts at the start-up by the latest set value in the automatic operation. (The configuration file is generated with the automatic operation.)

- Automatic recovery at trouble.  
 Reboot of the oscilloscope is done by the automatic operation when reboot of no network recognition etc. is necessary. However, continuous reboot is not done. If reboot is not done from last reboot longer than the fixed time (tens of minutes or more), reboot is done. Moreover, the software freeze is detected, and reboot of software is done by the automatic operation.
- Improvement of speed.  
 Upgrade of firmware of oscilloscope.  
 (Maker schedule: The middle of October)
- Simplification of adjustment panel.  
 Because the operation of the adjustment etc. is complex, the procedure of the panel operation is made easy.

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