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COMMISSIONING OF KEKB BUNCH FEEDBACK SYSTEMS

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Abstract

Commissioning of KEKB started at the end of the last year. In the early stages of the commissioning, we observed transverse instabilities in both rings and started tuning of the bunch feedback systems. Even though the tuning is now at the initial stage, the feedback systems are contributing to an increase of the maximum storable currents in the KEKB rings. Feedback-related systems, tune meters and bunch-current monitors, are also working well.

1 INTRODUCTION

KEKB, an asymmetric electron-positron collider facility at KEK, is now in the first stage of commissioning. It consists of an 8 GeV electron ring (HER) and a 3.5 GeV positron ring (LER), both fed by a common injector-linac feeds beams. About 5000 bunches/ring will be stored and the total current will amount to 1.1 A and 2.6 A, respectively. As a part of this complex facility, bunch-by-bunch feedback systems have begun operation. Each of the feedback systems consists of (1) wide-band position detection systems, (2) high-speed digital signal processing systems with large-scale memories, and (3) wide-band kickers fed by high-power amplifiers. At the same time, betatron tune meters and bunch current monitors, which share some components with the feedback systems, have also begun operation. With the requirement that the systems be able to handle 5120 bunches/ring at a bunch frequency of 509MHz, the design of these systems is very challenging. For example, all parts of the systems have a bandwidth of half the bunch frequency, 255 MHz. The final design of the feedback systems is described in reference[1]. In this paper, we describe the initial experiences with these systems in the commissioning of the KEKB rings.

2 OUTLINE OF THE KEKB FEEDBACK SYSTEMS

For both the transverse and longitudinal planes, the feedback monitors use specially designed button electrodes and the 2GHz (4£ the rf frequency) component of the signal is used to detect the bunch position. Figure 1 is a photo of the monitor chamber installed in the LER.

For the transverse feedback, two sets of button electrodes are installed in two points in each ring. The signal from these electrodes needs to be combined appropriately to make the feedback signal.

A common digital signal processing board is used in the transverse- and longitudinal-plane feedback systems. It can work up to 500MHz bunch-frequency owning to specially fabricated high-speed de-multiplexers (FDMUX) and multiplexers (FMUX)[2]. The board works as a two tap filter[3], which is powerful for the longitudinal feedback, and a simple digital delay.

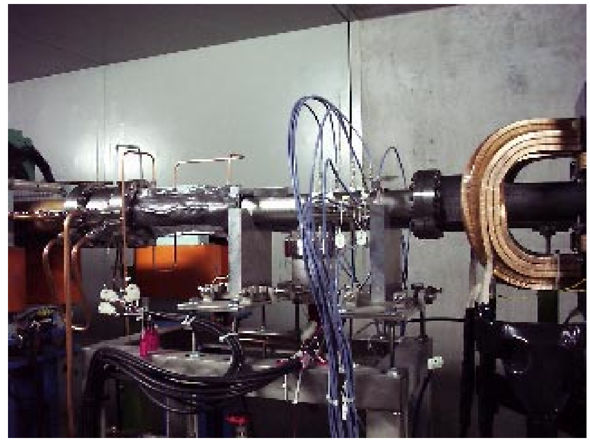

Figure 1: Feedback monitor chamber in the LER. Specially designed button pickup are used in this monitor system.

For the transverse kicker we use two types of stripline kicker: one is wide-band with a length of 40cm and the other is narrow-band with a length of 1.2m. Each electrode of the kicker is fed by a 250-Watts amplifier.

The longitudinal kicker is a low-Q cavity, which has originally been developed at FRASCATI for DA' NE[4], and we modified it to fit our parameters. As the longitudinal instability is expected to be the least serious in the HER, only 2 sets of the longitudinal kickers are installed in the LER. The photo in Fig. 2 shows these kickers.

The technology employed in the bunch feedback systems has wide a variety of applications. The most straightforward application is transverse tune measurement. The transverse kicker with the amplifiers kicks the beam and, we measure beam's proper oscillation frequency, i.e., the tune, from the response to this kick.

Another system which can be understood as a byproduct of our feedback systems is the memory board. The digital processing board of the feedback systems is modified to realize a kind of a transient digitizer. It utilizes the same mother board and the same input part (A-to-D conveter) as the signal processing board. But the output part is removed and the storage size, which was 2MBytes for the processing board, is increased to 20MBytes.

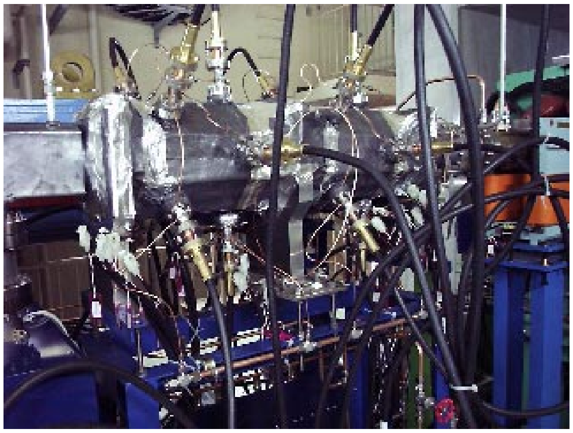

Figure 2: Two longitudinal kickers installed in the LER. Each kicker has four input ports and four output ports. The Q -value of the kicker lowered to about 5.

3 PRESENT STATUS OF THE MACHINE COMMISSIONING

We started the commissioning[5] of the HER at the beginning of December 1998 and the LER at the beginning of this year. Since then, the storable currents of the rings increased rapidly. At present (middle of March 1999), the highest stored currents are 240 mA and 370 mA for the HER and the LER, respectively. The minimum bunch spacing is 10 ns (HER) / 4 ns (LER).

In both rings we observe transverse instabilities, though we find some difference between them. In order to suppress them we started to operate the transverse feedback systems. On the other hand, up to present time, we have not observed longitudinal instabilitiy and we have not started to operate the longitudinal feedback system.

4 THE FIRST EXPERIENCE WITH THE TRANSVERSE FEEDBACK SYSTEMS

4.1 Hardware configuration

At present, we are operating the transverse feedback systems not with the final configuration but with some simplified one.

The signal process system is working as a simple digital delay, not as the two-tap filter, because the two-tap filter approach is complicated when the optics parameter is not completely known to us. When the optics become well under the control, we might be able to operate it with the two-tap filter mode.

Out of two sets of the kickers, we started to operate the feedback system only with the wide-band systems, which cover the frequency range of 100 kHz to 250 MHz. By this simplification, we are free from the complexity coming from unwanted effects in the overlapped band. However, this system is less powerful for lower-mode dominant instabilities such as the resistive wall instability.

4.2 Performance with the present hardware

In order to check the performance of the feedback systems, we compared the frequency spectra of the signal from a pickup, with the feedback on and off. When the feedback is off, a large peak (> 40dB higher than the noise level) was observed at the tune-frequency, as shown in the left photo in Fig. 3, while with the feedback on, this peak has disappeared (comparable with the noise level), as showin in the right photo. This phenomenon is more or less common to the both rings and the both planes (horizontal/vertical).

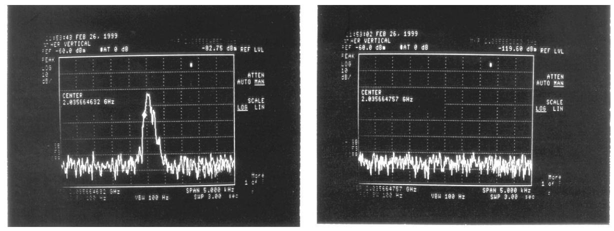

Figure 3: Frequency spectra of the signal from a pickup of the HER (vertical). The center frequency was adjusted to the frequency correnponding to the tune. In the left photo a peak is found, which showed us the instability occured. On the other hand, in the right photo, we found no peak at this frequency.

In addition, when the feedback system was turned off with stored current higher than 250mA in the HER, non-negligible fraction of the stored beam was lost and the beam current was decreased to about 60% of the original one. In this case the fill pattern, i.e., bunch-current distribution, got irregular. Particularly, particles in buckets close to the tail of a train have more chance to be lost, in a bunch-train operation.

We can estimated the damping time of the feedback systems from the several parameters, sensitivity of the monitor, gain of the power amplifiers (gain 53dB, maximum power 250 Watts), shunt impedance of the kicker (order of 10k›), and losses in cables etc. and betatron function at the monitor and the kicker (10m» 25m). Estimated damping times (at present stage) are summarized below:

	horizontal	vertical
HER	1.2 ms	2 ms
LER	1.3 ms	1.8 ms

More precise esitmation of the damping time with actual measurements will be done in near future as explained later. Shorter damping times will be realized by tuning the power balances in the systems.

4.3 A problem to be solved

At present, the KEKB rings are suffering from unwanted drift of closed orbit, particularly in the vertical plane. The stationary change of the beam position is seriously harmful for the feedback systems, since it wastes the dynamic range of the A-to-D converter whose resolution is 8-bit. In order to use this dynamic range effectively, we must subtract the DC component from the detected signal. A simple high-pass filter approach does not work well, because output of the filter depends not only on the DC-component but also on the bunch-filling pattern, which is essentially the duty factor of the pulses corresponding to the beam positions.

We are planning to introduce a DC-canceling circuit which detect “real” DC-component with a relatively high-speed sample/hold circuit. This circuit is now under tuning and will be included in our systems, in near future.

5 RELATED SYSTEMS

We have started to operate two feedback-related systems, the tune meters and the bunch current monitors. At present, the tune-measurement systems are operated with the narrow (lower band) amplifier/kicker systems. The signal source for the kicker is a spectrum analyzer equipped with a tracking generator. The kicking frequency is swept around 2-GHz, and this signal is down-converted to the base-band of the tune, roughly from 5kHz to 500 kHz. Figure 4 schematically explains the tune measurement system.

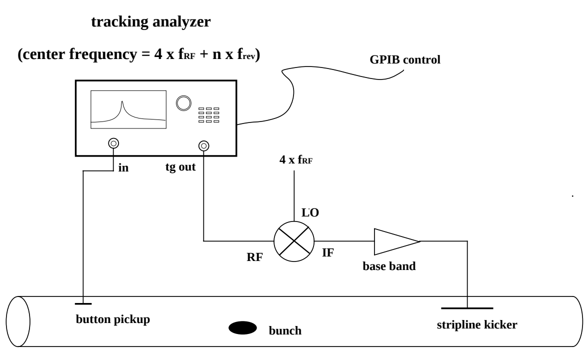

Figure 4: Blockdiagram of the tune measurement system. Relatively higher frequency components, about 4 times of the RF frequency, is used for this system. This choice enable us to increase the S/N ratio in the measurement.

We are operating the bunch current monitor consisting of a front-end detector circuit, which is essentially the same as the longitudinal position detector, and the memory board with a fast-read-out interface. Blockdiagram of the system is shown in Fig. 5.

The bunch-current is measured every 20ms (i.e. 50 Hz), and obtained bunch-current distribution is transferred to the injector linac to be used by the bucket selection system of the KEKB rings[6]. Simultaneously, the bunch-current distribution is graphed out in a display in the main control room.

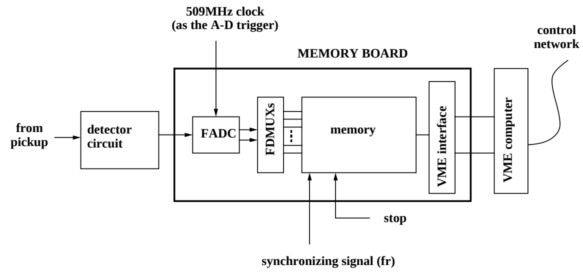

Figure 5: Blockdiagram of the bunch-current monitor. Output of the bunch-current detector circuit is A-to-D converted (509MHz sampling rate) and stored in the memory board. The contents of the memory is read-out via the VME bus.

6 PLANS IN NEAR FUTURE

The following items are our targets which should be realized in near future.

† As we mentioned, we are using only wide-band kickers (the short kickers) fed by the wide-band amplifiers. In the next step, we must employ the lowest-band long kickers, which should be effective to suppress the instability caused by the resistive wall impedance.

† The next theme is an operation of the large-size memory board which can store 20MBytes of data, that corresponds to 4096 turns of 5120 bunches. This is a very powerful beam-diagnositic device for the investigation of the instabilities observed in the rings. It is also useful for measuring the damping time of the feedback systems, by catching the beam behavior just before/after the feedback system ON and OFF.

† The third theme is the operation of the longitudinal feedback system, particularly the study of the longitudinal kicker. As described first, we have not observed the longitudinal instability. However, the surveying the performance of the longitudinal system is a very important study-issue for us.

7 ACKNOWLEDGMENTS

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