BUNCH-BY-BUNCH MEASUREMENT AND FEEDBACK SYSTEM OF HLS*

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Abstract

In this paper, HLS (Hefei light Source) bunch-by-bunch measurement and feedback system will be introduced. This system is integrated with longitudinal oscillation measurement system, fast vector control, fiber notch filter and bunch current detection system. The detail of the two fronts will be shown. Some experimental results by this system are also present in this paper, as phase-space tracing, mode dumping rate, and feedback experiments.

INTRODUCTION

The National Synchrotron Radiation Laboratory (NSRL) electron storage ring, with a circumference of 66 meters, operates with 45 bunches in 204.035MHz RF (Radio Frequency), and contains 31 BPMs (Beam Position Monitor). Each BPM has a four-button type pick-ups mounted in a skew of 45^0. A 200MeV injection beam from linac and transport line ramps to 800MeV and operates at 200-300mA in the HLS storage ring. A multi-cycle multi-turn injection system is used for current accumulation. A wiggler is available in the HLS.

The BxB (Bunch-by-Bunch) measurement system is dedicated to observe the beam instability and works as a part of the analog transverse BxB feedback system in HLS[1]. Fig. 1 shows an overview of the BxB transverse feedback system of HLS.

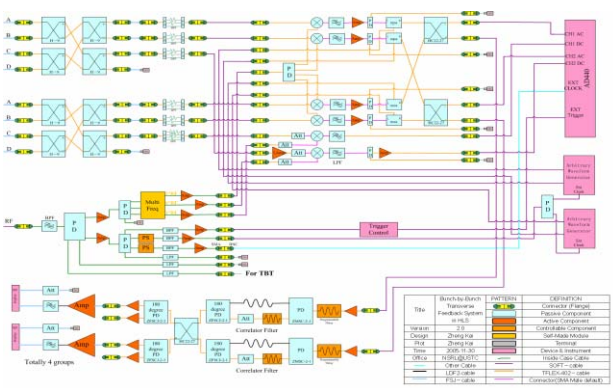

Figure 1: Layout of HLS BxB feedback system.

The HLS BxB transverse measurement system works at 612MHz ($3*f_{RF}$), the longitudinal one works at 1224MHz ($6*f_{RF}$), both of them with 100MHz bandwidth. A high speed 12-bit digitizer, up to 400 MSPS (Million Samples Per Second) and simultaneous in two channels [2], is installed in a PXI (PCI eXtensions for Instrumentation) desktop. An in-phase F_{RF} signal is used as the external clock of the ADC (Analog-to-Digital Converter), and an in-phase Revolution Frequency signal (4.533MHz) is connected with the External Trigger of the ADC [3].

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STRUCTURE OF BXB MEASUREMENT AND FEEDBACK SYSTEM

Vector Control

In our system, two BPM are selected to just the feedback signal. Attenuator is a usual resolution; DBM (double balance mixer) can supply not only a positive adjustable attenuate factor, but also a negative adjustable attenuate factor. It is a great upgrade of the flexible of this feedback system. Compare with the 90 degree adjust range, the new method can support 360 degree feedback signal vector calculating.

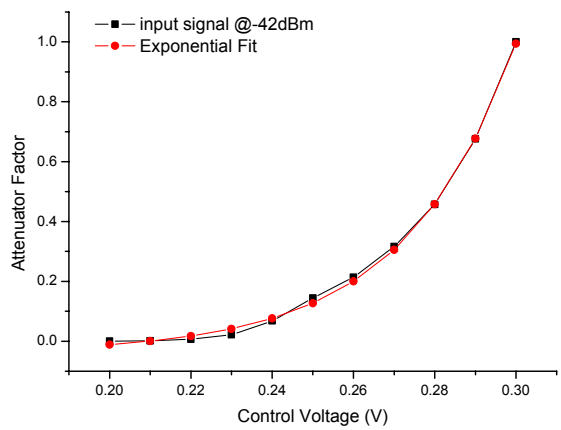


Figure 2: Relationship of Control voltage and Attenuator Factor

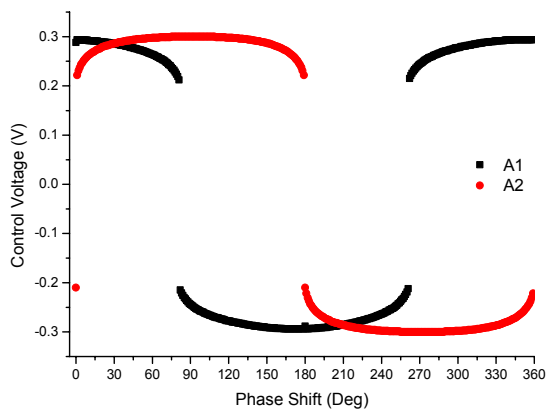


Figure 3: AFG arbitrary waveform generator

The relationship of DBM control voltage and the attenuator factor is shown in fig. 2, the control voltage and the phase adjust is shown in fig. 3.

A DC voltage control IF port of DBM can supply a stable attenuator, and a programmable high speed voltage, which is synchronization with beam movement can change each bunch's motion at will, such as bunch-by-bunch kick-out, feedback or simylation.

An arbitrary waveform generator AFG3252 is adopt in our system, which can output any pre-designed waveform up to 120MHz. [4]

Longitudinal Oscillation Measurement

We also care about the longitudinal oscillation; a longitudinal oscillation measurement facility was integrated in HLS BxB system by using the LA (limited amplifier).

As we know, the phase modulated longitudinal oscillation signal always combines with AM (amplitude modulation). We must get rid of the AM disturbing.

By using LA, we can obtain same output signal amplitude from -24dBm to 20dBm input, shown in fig. 4. and we can scale our measurement result up to 150ps longitudinal oscillation.

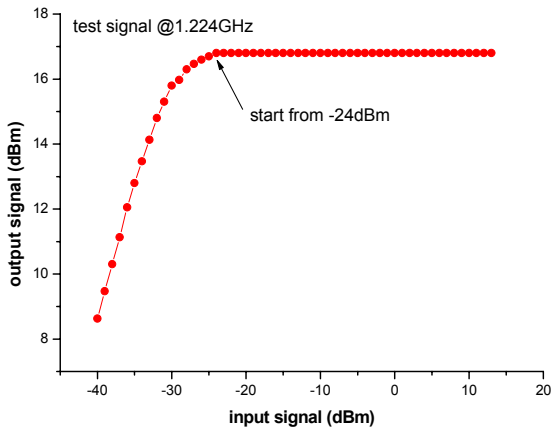


Figure 4: Amplitude response of limiting amplifier

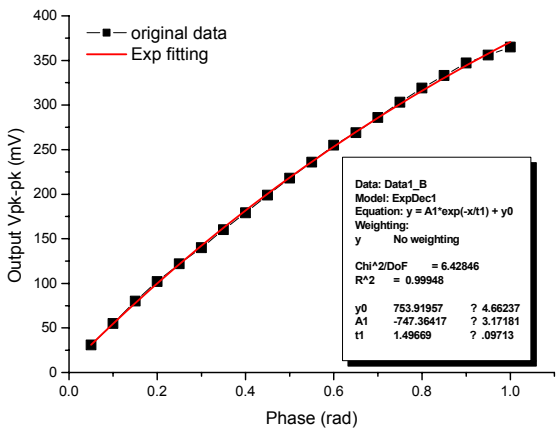


Figure 5: Offline scale result

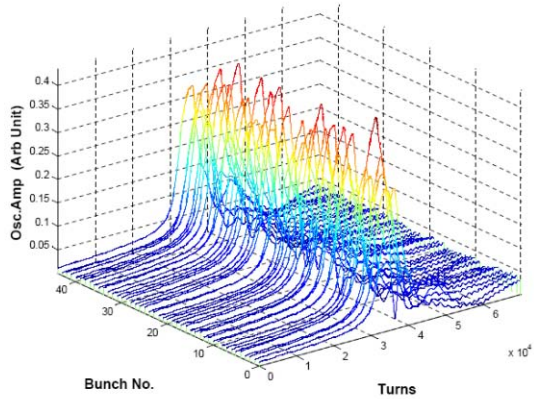


Figure 6: Oscillation record in time domain

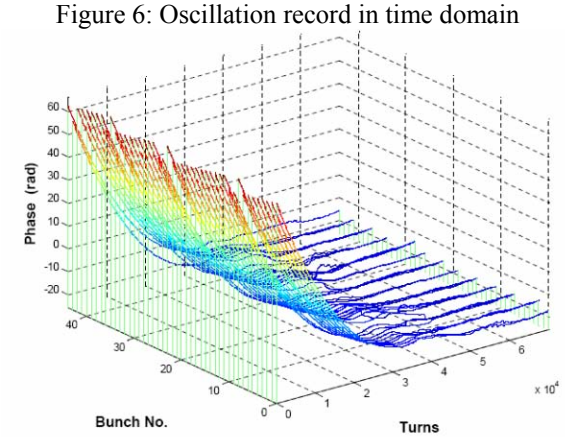


Figure 7: Phase tracing in time domain

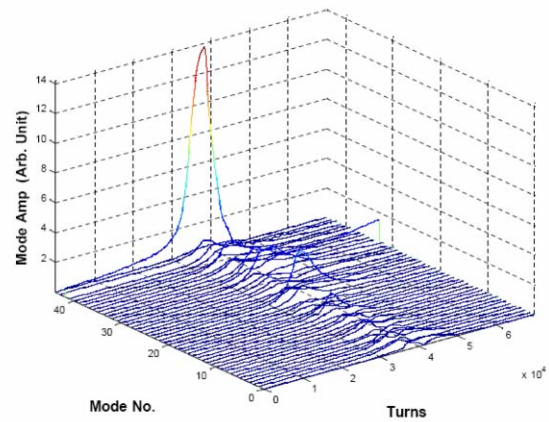


Figure 8: mode tracing in time domain

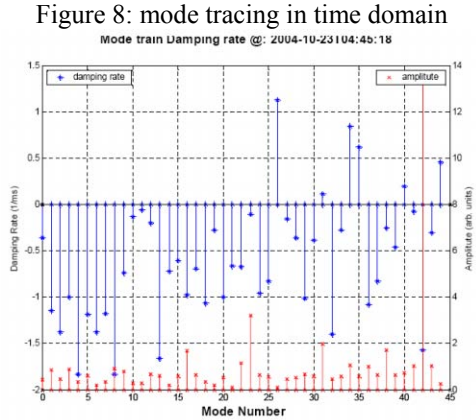


Figure 9: mode damping rate

EXPERIMENT RESULT OF MEASUREMNET SYSTEM

Base the bunch-by-bunch measure system, we can observe bunch current and bunch vibration in both transverse and longitudinal direction. If we adopt space reconstruction method which based in Hilbert transform, we can track bunches' motion in phase space, that would be more interesting and more helpful [5, 6].

We would like to show a typical experiment which was carried out in HLS. We record the stimulating and damping progress in the transverse direction.

From fig. 6 to fig. 9, we can observe a complete analysing result by HLS diagnose system. At first, we record the observation data by ADC; secondly, we get the phase information by Hilbert transform; thirdly, we describe the bunch motion in mode space; at last, we fit the mode tracing map to describe damping rate.

EXPERIMENT RESULT OF FEEDBACK SYSTEM

We pay more attention on the feedback system; to restrain CB (coupled bunch) instability is our final target. We have serial experiments to test our system.

200 MeV Operation

Fig. 10 shows the experiment result in 200MeV, the left picture is captured without feedback system, and the right one is acquired during feedback system operation.

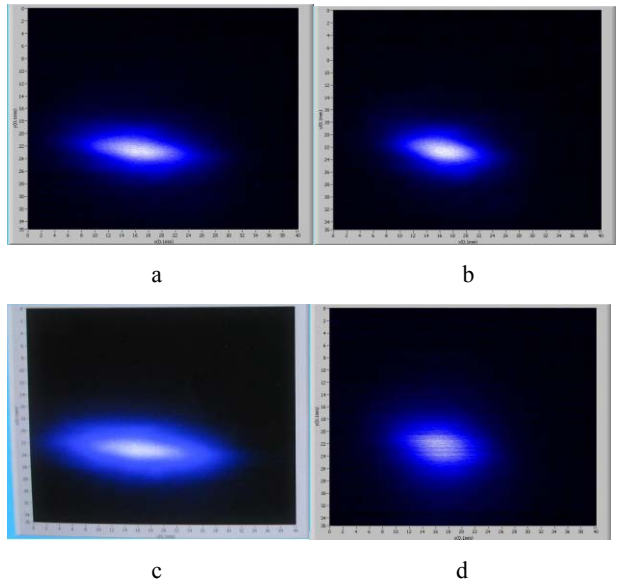
Figure 10: Feedback system experiment during injection

800 MeV Operation

This system also works well in 800MeV operation, we try to reduce the current of sextuple, extraordinary phenomenon was observed with an optical system. The display of optical system shows in figure 11 and experiments condition and related data record presents in table 1.

Table 1: Emittance during feedback experiments

Picture	Feedback Status	Sextuple current	Transverse emittance	Longitudinal emittance
A	Off	71, 35 A	323.2 nmrad	5.72 nmrad
B	On	71, 35 A	198.3 nmrad	5.67 nmrad
C	Off	60, 30 A	495.9 nmrad	6.92 nmrad
D	X-on Y-off	50, 25 A	215.3 nmrad	10.94 nmrad



a b c d

Figure 11: Feedback system experiment during 800MeV operation

FUTURE WORK

After the succeed experiments of the BxB feedback system. We would like to dedicate in application of arbitrary waveform generator, in order to test oscillation damping and increasing rate or accomplish arbitrary kick-out commission.

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REFERENCES

[1] W. H. Huang, H. S. Kang, D. T. Kim, J. Y. Huang and S. H. Nam, "Transverse Feedback System for PLS Storage Ring," Proc. of APAC, Beijing, China, 2001, pp 302-304.

[2] User Manual of 12 bits Digitizers by Acqiris.

[3] Jianhong Liu, "The development of Bunch-by-Bunch measurement system and the research of instability in HLS," thesis for Doctor Degree of University of Science and Technology of China.

[4] User Manual of AFG 3252 by TEK.

[5] S. Prabhakar, "New Diagnostics and Cures for Coupled-Bunch Instability", thesis for Doctor Degree of SLAC, 2001.

[6] R. T. Burgess, "The Hilbert Transform in Tracking, mapping and multi-turn beam measurements", SL-Note-99-048-AP, 1999.

