

# LONGITUDINAL AND TRANSVERSE FEEDBACK SYSTEMS FOR THE BEPCII STORAGE RINGS

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## Abstract

In order to cure the transverse and longitudinal coupled bunch instabilities caused by higher order modes of RF cavities and resistive wall impedance in the BEPCII storage rings, two type bunch by bunch feedback systems of longitudinal feedback system and transverse feedback system are used. The electronics of LFB system are digital system produced by Dimtel Company, the longitudinal kicker is drift-tube type borrowed from the SLAC. An analog bunch-by-bunch transverse feedback system was designed and used. The main components are two sets of beam oscillation detectors, betatron phase adjuster, notch filter, and stripline kicker. This paper will describe the achieved results of curing the coupled bunch instabilities by using the LFB and TFB together with current status.

## INTRODUCTION

BEPCII is an upgrade project of the Beijing Positron Electron Collider (BEPC), in which a new inner ring has been installed inside the old one. BEPCII will provide colliding beams with 910mA at the centre-of-mass energy 1.89GeV in colliding mode.

When the current reaches to 200mA, strong transverse instabilities occurred in both BEPCII electron and positron rings which limited the maximum storable currents. In order to cure these instabilities, two sets of analog transverse bunch-by-bunch feedback systems (TFB) for both rings have been developed and put into operation. The transverse feedback systems suppress the instabilities and make the beams stable to collide [1]. In colliding mode, there are more than 100 bunches in every rings, the bunch spacing is 4ns or 6ns. In the last run, over 750mA beams have been successfully stored in both rings. The colliding luminosity has been reached to  $7.08 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$ .

In the operation of BEPCII, we found that the bunch luminosity decreases along the bunch trains even the transverse instabilities were cured. Many experiments have proved that this phenomenon was caused by longitudinal instability. So in the year of 2010, we set up and commissioned digital longitudinal feedback systems (LFB) for both rings. The LFB system is composed of front-end electronics and back-end electronics (FBE-500L), signal processing electronics (iGp) and power amplifier and kicker. The electronics are bought from DIMTEL Company, USA. The longitudinal kicker is drift-tube type which borrowed from the SLAC. The longitudinal feedback system performed well and has increased luminosity up by 30%.

In this paper, we will describe the components of feedback systems and the performing results of them.

## TRANSVERSE FEEDBACK SYSTEM

BEPCII TFB system is same as the systems developed in ALS [2], PLS [3]. It consists of pickup electrodes, signal processing electronics, power amplifiers, and a stripline kicker. Figure 1 shows an overview of the transverse feedback system. Two x (or y) signals from pickups located about 90 degrees apart in betatron phase are added together with appropriate coefficients to produce a 90-degree betatron phase shift between the pickup signal and the kicker. The beam oscillation signal is detected at 1.5GHz in order to take advantage of the good sensitivity of the button pickups at this frequency. The signals then are demodulated to the baseband with heterodyne receivers. The DC offset at the pickups is removed by using a two-tap notch filter. The one-turn delay is provided by coaxial cable. In each ring there is one stripline kicker and four 75-watt power amplifiers for both directions to apply the correction kick signal to the beam.

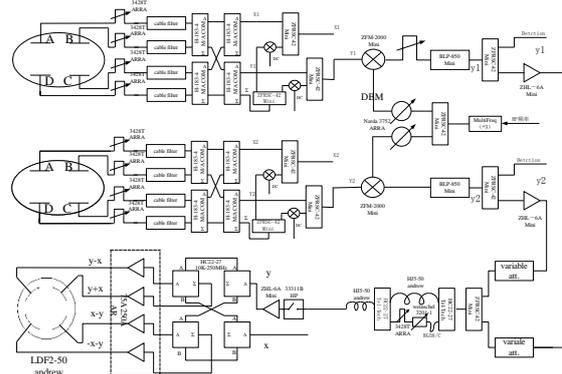


Figure.1: An overview of TFB system of BEPCII

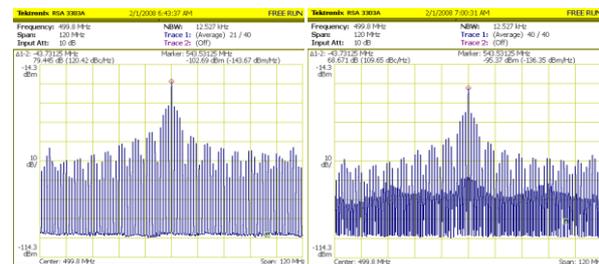


Figure.2: The sidebands of beam with the transverse feedback turning off (right) and turning on (left)

In any ring, when the beam current is over 200mA, the transverse instabilities occurred and the beam blows up. It can be seen in Fig.2 that sidebands disappear when the feedback is on. The beam profile is stable and then the beam current can be increased again, as shown in Fig.3. At last, we have stored 805mA in positron ring and 911mA in electron ring respectively. We have realized 750mA colliding beams, the luminosity is  $7.08 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$ .

Figure.2 shows the beam sidebands with the transverse feedback turning off and on. It was measured by a spectrum analyser when the positron ring operated on the colliding mode at 243mA with 93 bunches. The background frequency lines are revolution frequency harmonics and the dark-coloured lines are instability sidebands. We can see that the magnitude of instability sidebands is attenuated more than 30dB when the feedback is on.

Figure.3 shows the beam profiles with the transverse feedback turning off and on.

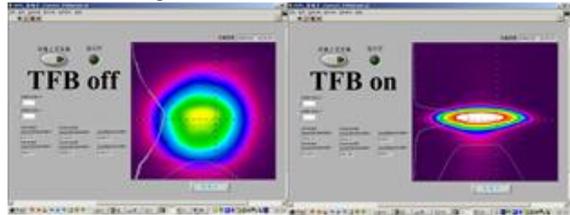


Figure.3: Beam profile with TFB turning on (right) and turning off (left)

### LONGITUDINAL FEEDBACK SYSTEM

Transverse feedback system performs well on BEPCII, but when the current increases, we found that the luminosity don't increase with the current up. The severely longitudinal sidebands were found on the frequency spectrum. At the same time, beam signals on oscilloscope and beam size measured by gated camera both pointed out that the beams are unstable in longitudinal direction, we also measured the rise time used the digital feedback system [4].

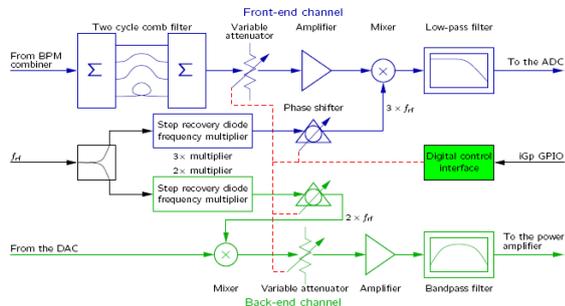


Figure.4: The front-end and back-end electronics

The BPM sum signal was processed and detected by the FBE-500L RF signal processor which includes front-end and back-end channels. The detailed information is illustrated in Fig. 4. The BPM sum signal was sent to attenuator and amplifier, and then to the Mixer to transfer the signal to baseband, the detection frequency is 1.5GHz. Baseband output signal from the front-end was sampled by the iGp-396F bunch by bunch feedback processor at the RF frequency. IGp-396F generates analog bunch by bunch kick signal after 16-tap FIR processing, then this digital signal be input to back end channel, to be up-converted the baseband longitudinal kick signal to the kicker frequency for driving the power amplifier and the kicker.

The kicker is drift-tube type which was borrowed from SLAC, as shown in Fig.5. We also used absorptive filter to protect the amplifier.

LFB systems performed well. When LFB system turns on, the longitudinal sidebands were eliminated

and the bunch luminosity became almost same along the bunch trains, as shown in Fig.6 and Fig.7



Figure.5: Drift-tube kicker

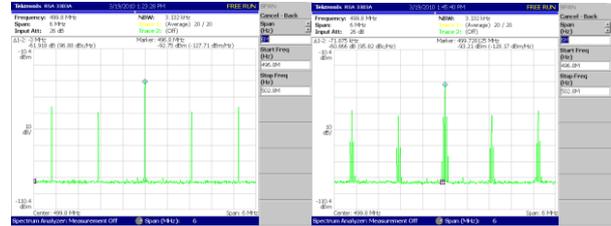


Figure.6: Sidebands on the spectrum when LFB turns on or not

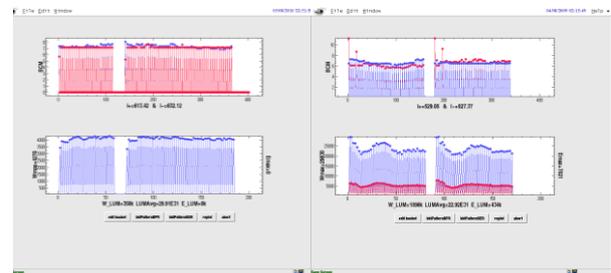


Figure.7: Bunch luminosity when LFB turns on or not

### SUMMARY

The transverse feedback systems and longitudinal feedback systems of BEPCII performed well and played an important role during the running of BEPCII double rings. They can suppress the strong multi-bunch instabilities at the higher beam current of over 750mA. In the last run of BEPCII, we have stored 805mA in positron ring and 911mA in electron ring respectively. 750mA colliding beams have been realized.

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