BEPCII Transverse Feedback System

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2008, Apr. 14
Including three parts:

• The main parameters of BEPCII
• The coupled bunch instability
• The bunch by bunch feedback system
## I : Some Parameters of BEPCII

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Energy, $E$</td>
<td>GeV</td>
<td>1.89</td>
</tr>
<tr>
<td>Circumference, $C$</td>
<td>m</td>
<td>237.53</td>
</tr>
<tr>
<td>Total beam current, $I_0$</td>
<td>A</td>
<td>0.91</td>
</tr>
<tr>
<td>Bunch current, $I_b$</td>
<td>mA</td>
<td>9.8</td>
</tr>
<tr>
<td>Revolution frequency, $f_0$</td>
<td>MHz</td>
<td>1.2621</td>
</tr>
<tr>
<td>RF frequency, $f_{RF}$</td>
<td>MHz</td>
<td>499.8</td>
</tr>
<tr>
<td>Harmonic Number, $h$</td>
<td></td>
<td>396</td>
</tr>
<tr>
<td>Tunes, $v_x/v_y/v_z$</td>
<td></td>
<td>6.57/7.61/0.034</td>
</tr>
<tr>
<td>Radiation damping times, $\tau_x/\tau_y/\tau_z$</td>
<td>ms</td>
<td>25/25/12.5</td>
</tr>
<tr>
<td>Number of Bunches, $B$</td>
<td></td>
<td>93</td>
</tr>
<tr>
<td>Bunch spacing, $S_b$</td>
<td>m</td>
<td>2.4</td>
</tr>
<tr>
<td>Bunch frequency, $f_b$</td>
<td>MHz</td>
<td>125</td>
</tr>
</tbody>
</table>
The high beam current (0.9 A) and the large number of bunches (93 bunches) will cause the coupled bunch instabilities (CBI) in BEPCII.

Fastest growing time in the case of 99 bunches and 9.8 mA per bunch:

<table>
<thead>
<tr>
<th></th>
<th>HOMs</th>
<th>Resistive wall</th>
<th>ECI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transverse (ms)</td>
<td>26.6</td>
<td>4.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Longitudinal (ms)</td>
<td>12.8</td>
<td></td>
<td></td>
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</tbody>
</table>

- Two source
  - The higher order modes (HOMs) of RF cavities
  - The resistive wall impedance

- Active feedback systems are required to suppress CBI
Three set of analog system. BEPCII will operate on colliding mode and synchrotron mode. So our transverse feedback will have three sets: electron ring, positron ring, and synchrotron ring.

- The electronics bandwidth should be at least half of the bunch frequency
  - colliding mode 62.5MHz
  - synchronous radiation mode 250MHz

- The damping time of transverse feedback system is 0.5ms
Transverse feedback system located in the storage ring
The Transverse Feedback System

- Schematic diagram
- Front-end electronics
- Signal processing system
- Kicker and power amplifier
- Parameters of Transverse Feedback System
- The experiments of BEPCII TFB
The Schematic Diagram of TFB System
The local station of the Transverse Feedback System
Transfer the signal whose bandwidth is 500MHz at the center frequency of 1.5GHz to base band.

- Detection frequency is 1.5GHz, triple of RF
- The local DC rejection circuit in fixed-voltage mode
Signal processing system

Full analog system simply using the cable line

- Three functions
  - Making the 90 phase shift
  - Rejection the closed orbit signal
  - One turn delay

- Realization
  - Two manual attenuators for 90 phase shift control
  - Notch filter rejection the revolution frequency
  - The time delay by cable
Signal processing system –

Phase shift and Notch Filter

phase-shift control
attenuator
x1
RSA-3530D

x2
RSA-3530D

10K-250MHz
HC22 27
SRC-SMJ-205
BMA-3511
LDF4-50A
Andrew
RG233
HC22
27
10K-250MHz
Kicker and Power Amplifier

• Four strip line electrode as kicker

(considering it is easy to realize, so the kicker length is 600mm just for every other bunches)

• One kicker per ring because the limited space

• Model 75A250A power amplifier is selected.

• Two 75A250A are connected in the differential style
## Specifications of the TFB system

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<table>
<thead>
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</thead>
<tbody>
<tr>
<td>RF frequency</td>
<td>MHz</td>
<td>499.8</td>
</tr>
<tr>
<td>Bunch spacing</td>
<td>ns</td>
<td>8</td>
</tr>
<tr>
<td>Feedback damping time</td>
<td>ms</td>
<td>0.5</td>
</tr>
<tr>
<td>Detection frequency</td>
<td>GHz</td>
<td>1.5</td>
</tr>
<tr>
<td>Number of kickers per plane per ring</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Kicker shunt impedance (at 125MHz)</td>
<td>kΩ</td>
<td>4.0</td>
</tr>
<tr>
<td>Total damping voltage per turn</td>
<td>V</td>
<td>800</td>
</tr>
<tr>
<td>Kicker power for 800 V</td>
<td>w</td>
<td>106</td>
</tr>
<tr>
<td>Number of power amplifiers per plane per ring</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Bandwidth of power amplifier</td>
<td>MHz</td>
<td>250</td>
</tr>
</tbody>
</table>
Beam profiles with TFB turning off and on

Electron ring

Positron ring

Synchrotron ring
Sidebands suppressed by TFB system

Transverse instabilities in full bandwidth of 125MHz suppressed by TFB system with beam current 243mA with 99 bunches in positron ring. 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.
Summary

• The transverse feedback systems of BEPCII have been installed and played an important role during the commissioning of BEPCII double rings. It can suppress the strong multi-bunch instabilities at the higher beam current of over 500mA. In the next stage, we need careful tuning the system and make sure of suppressing the transverse instabilities at more higher current. In addition, remote control and damping time measurement will be completed.
Acknowledgement

I would like to express my sincere appreciations to M. Tobiyama and E. Kikutani for helpful suggestions and thoughtful discussion.
Thank you very much for your attention!