Estimation of Beam Instabilities and Its Cure in the SPring-8 Storage Ring

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1 Introduction

Single-bunch and multi-bunch instabilities in the SPring-8 storage ring were estimated and the possible scheme to cure them were studied using the simulation code SISR[1] and CISR[2], respectively. SISR can simulate single-bunch instabilities driven by broad-band impedance and CISR can do multi-bunch instabilities driven by narrow-band impedance.

2 The SPring-8 Storage Ring

The parameters of the ring is shown in Table 1.

Table 1. The parameters of the SPring-8 storage ring.

Parameter		Value	Unit
Energy	E_0	8	GeV
Revolution Frequency	T_0	208.77	kHz
Energy Loss per Turn	U_0	9.2	MeV
Momentum Compaction Factor	α	1.46×10^{-4}	
Radiation Damping Time (Long.)	τ_E	4.1	ms
Radiation Damping Time (Trans.)	τ_x , τ_x	8.3	ms
Betatron Tune (horizontal)	ν_y	51.22	
Betatron Tune (vertical)	ν_x	16.16	

Broad-band impedance of the ring[3] are estimated using the code MAFIA and the estimated values of the longitudinal broad-band impedance, the broad-band transverse impedance of small discontinuities and localized transverse broad-band impedance of cavities are

$$Z^{\parallel} = -9.68\times10^{-8}\,\omega\, i + 400 + 1.49\times10^{8}\frac{1+i}{\sqrt{\omega}}\quad[\Omega]\,,\ (28)$$

$$\left\langle \beta_{BB} Z^{\perp}_{BB} \right\rangle = 17.3\times\left(-2.13\times10^{5}+5.98\times10^{14}\frac{1}{\omega}\right)\quad[\Omega]\ (29)$$

and

$$\left\langle \beta_{Cav} Z^{\perp}_{Cav} \right\rangle = 10.0\times4.2\times10^{19}\,\frac{1+i}{\omega\sqrt{\omega}}\quad[\Omega]\qquad(29)$$

, where β_{BB} = 17.3m and is the averaged value of the beta functions at the small discontinuities and β_{Cav} is the value of the beta function at the cavities. Transverse instabilities are estimated only for y direction which has larger transverse broad-band impedance caused by smaller aperture of the beam pipe.

3 Single-Bunch Instabilities

Longitudinal Instabilities

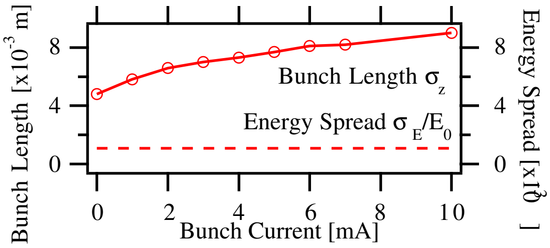

Figure 1. The bunch length and energy spread.

Figure 1 shows the dependence of the bunch length and the energy spread σ_E/E on the bunch current I_b. Because this ring is rather inductive compared to colliders which have a lot of cavities, the potential-well distortion lengthen the bunch length and the threshold of microwave instabilities can not be seen until the threshold current of the transverse instabilities which is shown later.

Transverse Instabilities

Figure 2 shows the bunch current increase vs. time used in the simulation. Figure 3 and Figure 4 show the amplitude of betatron motion of the bunch vs. time and the spectrum of betatron oscillation for chromaticity ξ=0, respectively.

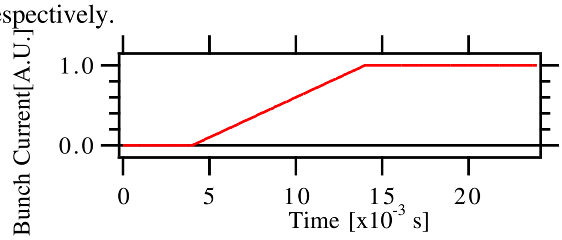

Figure 2. bunch current shape vs. time

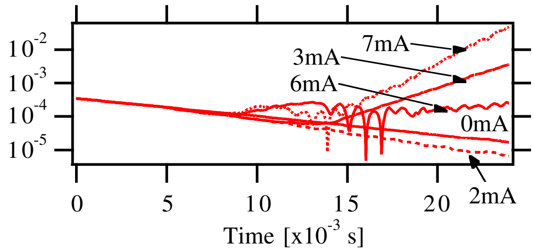

Figure 3. Amplitude of the betatron motion vs time (ξ= 0) .