BEAM TRANSVERSE QUADRUPOLE OSCILLATION MEASUREMENT IN THE INJECTION STAGE FOR THE HLS-II STORAGE RING*

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Abstract

Beam transverse quadrupole oscillation can be ex-cited in the injection stage if injected beam parame-ters(twiss parameters or dispersion) are not matched with the parameters in the injection point of the stor-age ring. In order to measure the beam transverse quadrupole oscillation in the injection stage for the HLS-II storage ring, some axially symmetric stripline BPMs were designed. Transverse quadrupole compo-nent for these BPMs was simulated and off-line cali-brated. Beam transverse quadrupole oscillation has been measured when beam was injected into the HLS-II electron storage ring. The spectrum of the transverse quadrupole component showed that beam transverse quadrupole oscillation is very obvious in the injection stage and this oscillation isn't the second harmonic of beam betatron oscillation. The relationship between transverse quadrupole oscillation and beam current was also analyzed and the result shows that the rela-tionship is not linear.

Introduction

NSWhen twiss parameters and dispersion of injected beam are not matched with injected point of storage ring, some oscillaitons can be excited[1, 2]. The most obvious oscillation is beam betatron(transverse di-pole) oscillation, which can be used to measure beta-tron tune. In some machines, beam transverse quadru-pole oscillation can also be excited in the injected stage. In the HLS-II electron storage ring, beam trans-verse quadrupole oscillation can be measured based stripline BPM in the injected stage.

MEASUREMENT SYSTEM INTRODUCTION

Axially symmetric stripline BPM was used to meas-ure beam transverse quadrupole oscillation in the HLS-II electron storage ring

$$\sigma_x^2\text{-}\sigma_y^2=\frac{1}{0.0011}\begin{pmatrix} Q_{\Delta/\Sigma}+0.7870-0.0011x_0^2 \\ +0.0011\mathrm{y}_0^2-0.0006x_0-0.0004\mathrm{y}_0 \end{pmatrix}$$

$$Q_{\Delta/\Sigma}=\frac{V_R+V_L\text{-}V_T\text{-}V_B}{V_R+V_L+V_T+V_B}$$

$Q_{\Delta/\Sigma}$ is the beam transverse quadrupole signal acquired by the difference/sum method. V_{R}, V_{T}, V_{L}, V_{B} are induced voltages on the right, top, left, bottom electrode. $Q_{\Delta/\Sigma}$ can be obtained by BPM processor(Libera Brillianceplus). Beam position(x, y) can be obtained based the offline calibtated eqution. So Beam transverse quadrupole component($\sigma_x{}^2$-$\sigma_y{}^2$) can be finally obtained.

The cross-section of this stripline BPM is shown in Fig. 1. The measurement system block diagram is shown in Fig. 2.

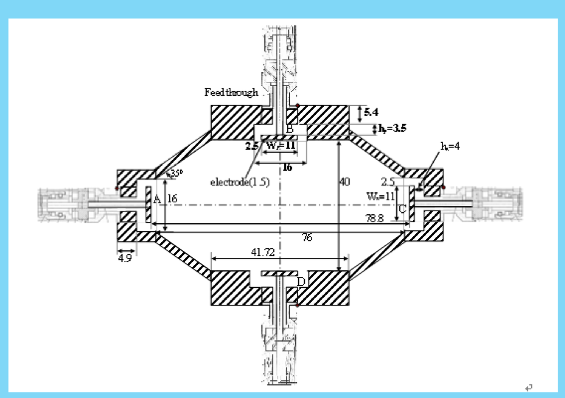


Figure 1: The cross-section of this stripline BPM

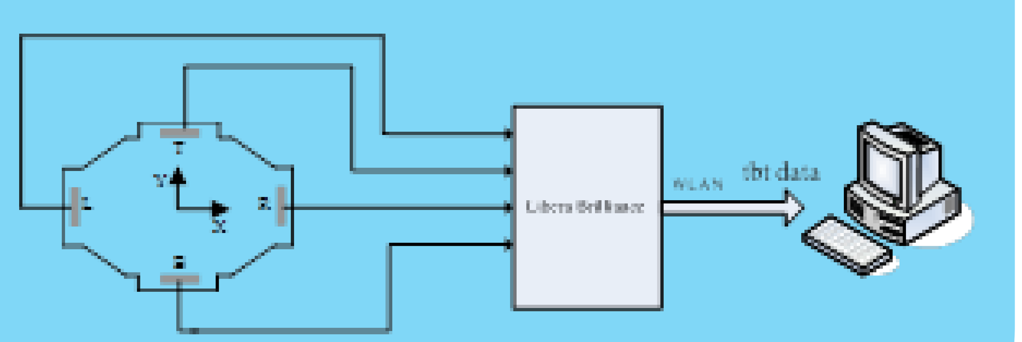


Figure 2: Measurement system block diagram

RELATIONSHIP BETWEEN BEAM TRANSVERSE QUADRUPOLE COMPONENT AND BEAM CURRENT

The relationship between *SNR* and BPM RF frequency *f* when *I* is 200 mA and electrode radius *r* is 3mm is shown in Fig. 6 and the relationship between *SNR* and electrode radius *r* when *I* is 200 mA and BPM RF frequency *f* is 400 MHz is shown in Fig. 7. The relationship between beam transverse quadru-pole component (σx2-σy2) and beam current in the in-jected stage was obtained and is shown in Fig.7. Since duration turn number of beam transverse quadrupole oscillation is not too long(about 1000 turns), interpo-lated FFT method was used to improve frequency do-main measurement resolution. As is shown in the Fig.7, the relationship between beam transverse quadrupole oscillation and beam current is nonlinear.

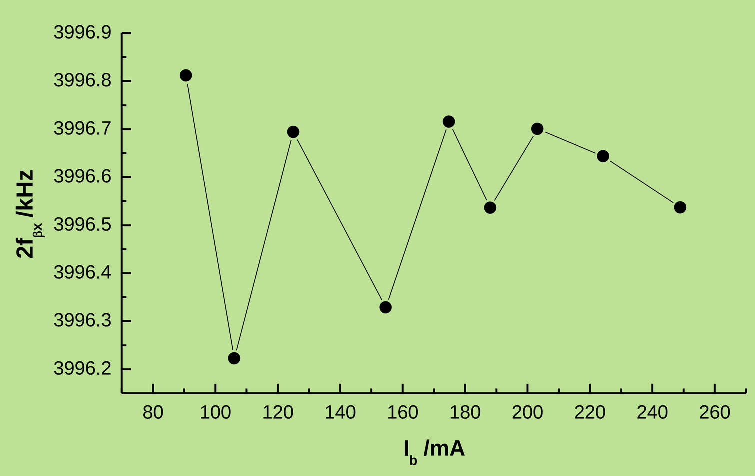
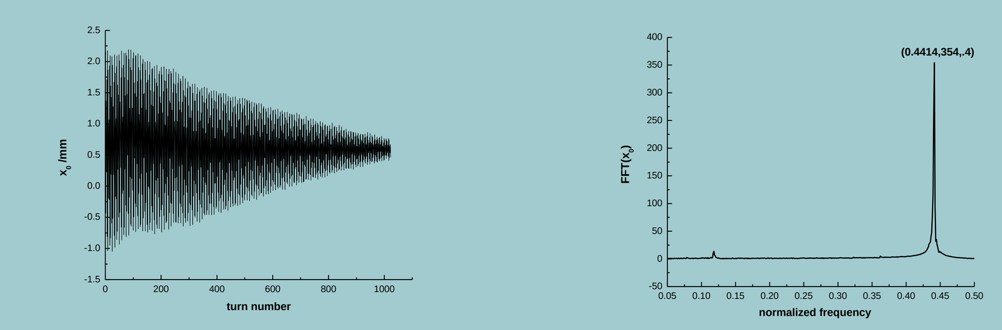


Figure 7: The relationship between beam transverse quadrupole component ($\sigma_x{}^2$-$\sigma_y{}^2$) and beam current in the injected stage

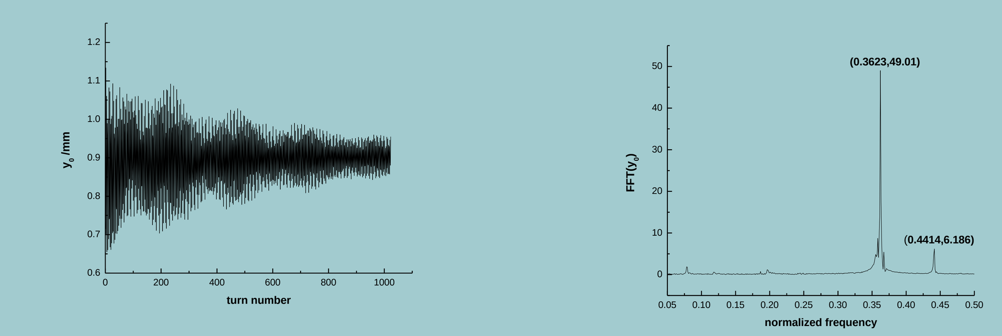
EXPERIMENT AND DATA ANALYSIS

Based on boundary element method and matlab code, the HALS Button BPM model can be acquired, which is shown in Fig. 3. Horizontal sensitivity S_x is 0.1396 mm^{-1} and sensitivity curve for the HALS BPM is shown in Fig. 4.(The same for the vertical sensitivity curve). The range of linearity for the HALS BPM is [-2 mm, 2mm].



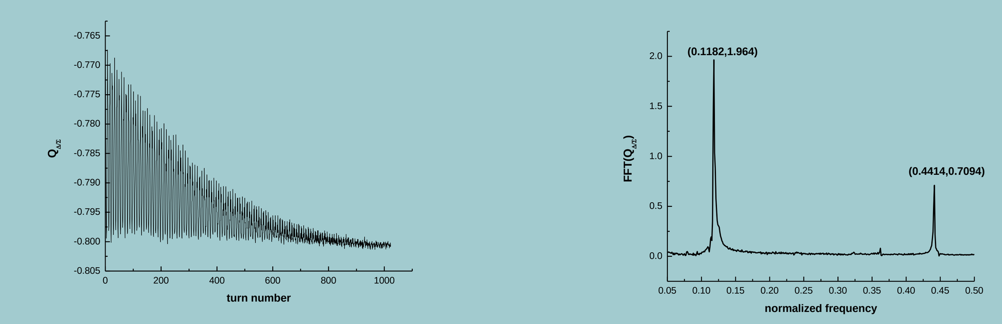
(a) (b)

Figure 3: Horizontal position and corresponding spectrum in the injected stage



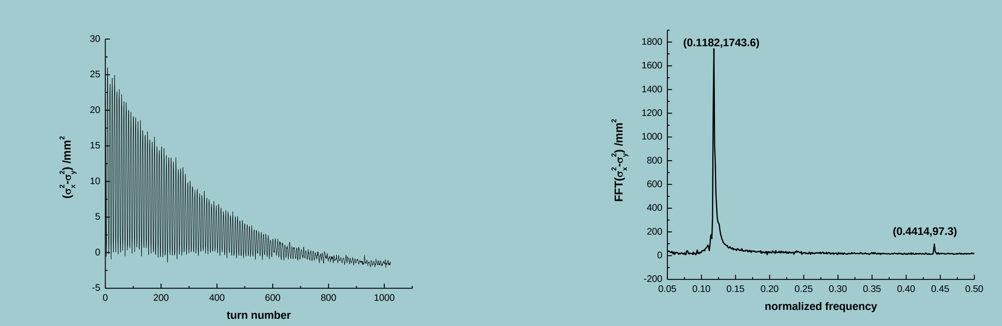
(a) (b)

Figure 4: Vertical position and corresponding spectrum in the injected stage



(a) (b)

Figure 5: Vertical position and corresponding spectrum in the injected stage



(a) (b)

Figure 6: transverse quadrupole component and corresponding spectrum in the injected stage

As is shown in Fig.3, Fig.4 and Fig.5, machine tune $\Delta\nu_x$=0.4414, $\Delta\nu_y$=0.3623. The fraction part tune $\Delta\nu_Q$ of beam transverse quadrupole oscillation can also be obtained and is equal to 0.1182. $\Delta\nu_Q$ is equal to (1-2*$\Delta\nu_x$). From the result of Fig.6, the spectrum peak of beam transverse quadrupole component is very obvious. Since contribution of beam position to ($\sigma_x{}^2$-$\sigma_y{}^2$) is eliminated, the effect of beam position for ($\sigma_x{}^2$-$\sigma_y{}^2$) is very small.

CONCLUSION

Based on the stripline BPM, beam transverse quad-rupole oscillation can be measured. The relationship between beam transverse quadrupole component ($\sigma_x{}^2$-$\sigma_y{}^2$) and beam current was also obtained. In the future, beam transverse quadrupole oscillation for different bunches will be excited by stripline transverse quad-rupole kicker.

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