Measurement of Electron Beam Oscillation in SPring-8 Storage Ring

Takashi OHSHIMA[1)], Mitsuhiro MASAKI[1)], Shigeki SASAKI[1)], Shiro TAKANO[1)], Kazuhiro TAMURA[2)],
Togo KUDO[1)] and Hideki AOYAGI[1)]

1) SPring-8/JASRI, 2) SPring-8/RIKEN

1. Introduction

The oscillation amplitude of the electron beam is one of the important characteristics of the storage ring. It is because the oscillation of the electron beam leads to the oscillation of the position of the synchrotron radiation spot at the experimental hutch and reduces the effective brightness of the radiation. We measured the oscillation of the electron beam of the SPring-8 storage ring at a frequency range below 400 Hz.

2. Experimental Setup

The measurements were carried out using the button electrodes attached to the vacuum chamber of the ring (RFBPM). Figure 1 shows the experimental setup. The signal from a button electrode was amplified after passing through a 508.58 MHz band pass filter whose band width is 20 MHz. The signal was detected and converted to the position signal by an analog operation module. The output voltages of the module are expressed as the following equations;

$$V_x = \frac{V_{UR} - V_{UL} + V_{DR} - V_{DL}}{V_{UR} + V_{UL} + V_{DR} + V_{DL}} \cdot 10$$
$$V_y = \frac{V_{UR} - V_{DR} + V_{UL} - V_{DL}}{V_{UR} + V_{UL} + V_{DR} + V_{DL}} \cdot 10 ,$$

where V_{UL} shows the output voltage of the U(pper) L(eft) button electrode, V_{DR} shows the output voltage of the D(own) R(ight) button electrode, *etc.*. The output voltage V_X (V_Y) is approximately proportional to the horizontal (vertical) beam position when the beam is near the center of the chamber. The output signals are analyzed by an FFT analyzer.

The similar observation was done using the X-ray beam from the insertion device of the cell 47 [1]. The beam position of the X-ray was measured using the current signal from the four diamond blades (XBPM).

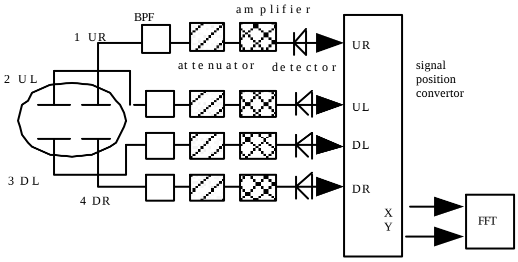

Fig. 1. Experimental set up for the observation of the beam oscillation using the button electrodes.

3. Results

3.1 Results using RFBPM

The beam oscillation was observed by using button electrodes located in two different places; cell 3 and cell 4 of the ring. The observed spectra of the horizontal and the vertical oscillation are shown in Figs 2 and 3, respectively. The frequency digit of the FFT was 0.25Hz. The oscillation amplitudes at the cell 4 are larger than those at the cell 3. The amplitude A of the oscillation is expressed by

$$A^2 = \left(\sqrt{\varepsilon\beta}\right)^2 + \left(\eta \frac{\Delta E}{E}\right)^2 ,$$

where β is the betatron function, η is the dispersion function, E is the energy of the beam and ε is a constant. The values of β and η at the position of cell 3 and 4 button electrodes are listed on the Table 1. The normalized oscillation amplitudes A^2/β are shown in Figs 2 and 3. The result of the cell 3 and that of cell 4 show good agreement. The normalized oscillation amplitudes are less than 10^{-14}m/0.25Hz. Good agreement in the normalized oscillation amplitudes between dispersive and non dispersive places indicates that the oscillation does not caused by the energy oscillation in this frequency region. And this normalized oscillation amplitude is constant over the ring at this frequency region.

3.2 Results using XBPM

Figures 4 and 5 show the observed spectra using XBPM. This oscillation amplitude A of X-ray beam can be expressed as following equation;

$$A = \sqrt{X^2 + \left(X' D\right)^2}$$
$$X = \sqrt{\varepsilon\beta}$$
$$X' = \sqrt{\varepsilon}/\sqrt{\beta} ,$$

here X is the oscillation amplitude of the electron beam position, X' is oscillation amplitude of the angle of the electron beam at the source point of the X-ray and D is the distance between the source point of the X-ray and the position of the XBPM. Using the value for ε obtained from the button electrode signal, and D as 20.3 m, we can estimate the oscillation amplitude of X-ray. We can see good agreement between this estimation and XBPM data as shown in Figs 4 and 5 below 150 Hz. The deviation above 150 Hz is because of a low pass filter (whose cut-off frequency is 150 Hz) of the current amplifier used in the XBPM.

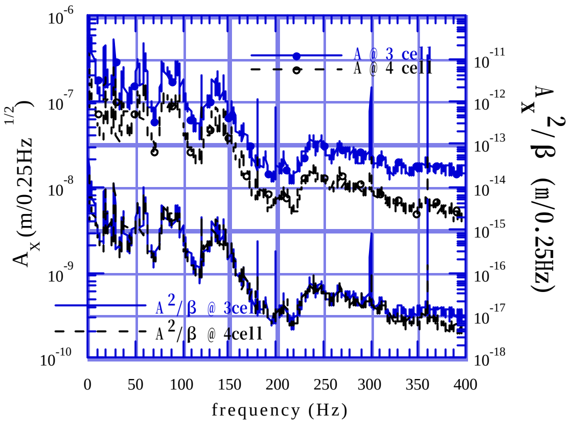

Fig. 2. Oscillation spectra for horizontal direction measured by button electrodes.

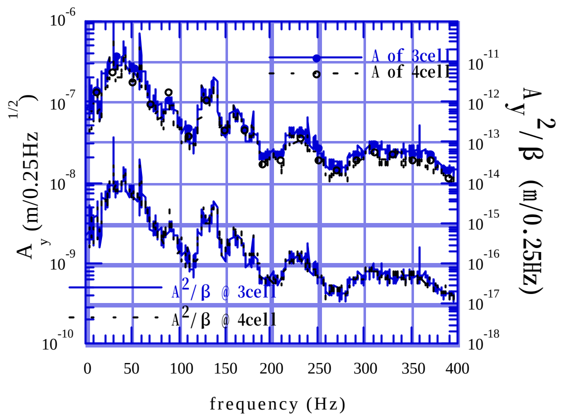

Fig. 3. Oscillation spectra for vertical direction measured by button electrodes.

place	βx (m)	βy (m)	ηx (m)
cell 3	22.5	12	39.8
cell 4	4.5	8	0

Table 1. Values of β and η

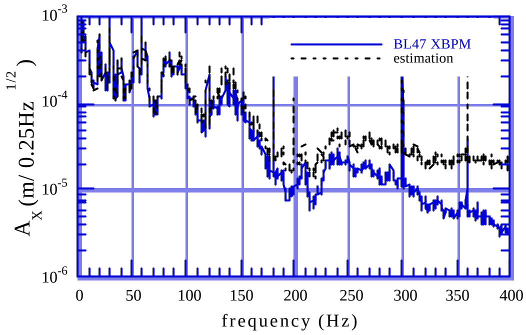

Fig. 4. Observed spectrum of the horizontal oscillation using the XBPM of BL47XU (solid line) and the estimated amplitude (dotted line).

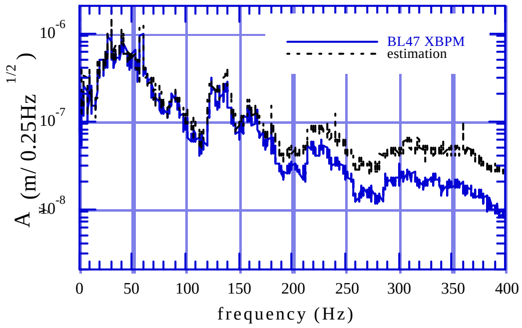

Fig. 5. Observed spectrum of the vertical oscillation using the XBPM of BL47XU (solid line) and the estimated amplitude (dotted line).

4. Conclusion

We observed the oscillation spectrum of the electron beam stored in the ring. Both the horizontal and the vertical oscillation amplitudes normalized using the value of the beta function are less than 10^{-14} m/0.25 Hz at the frequency range below 400 Hz. Using these amplitude we estimate the oscillation amplitude of the X-ray. The measured oscillation amplitudes of X-ray show good agreement to the estimation.

References

[1] H. Aoyagi *et al*., SPring-8 Annual Report 1997, 220 (1997).