DEVELOPMENT OF THE PHOTON BEAM POSITION MONITORS FOR THE TLS

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Abstract

Several types of the non-destructive photon beam position monitors (PBPM) are developed for the Taiwan Light Source (TLS) in SRRC. The PBPM, installed in the front ends, measures the photon beam positions by photoemission current on the blades. The 2-blade type of PBPM, measuring the vertical position of photons emitted from both bending magnet and insertion device, reveals a resolution better than 0.5 μm. The PBPM of multi-blade, including 4-blade and 12-blade, measures the positions of photon beam from the undulator in both horizontal and vertical directions. In addition to the high-resolution positional measurement, other features for inspection the systematical instability of the light source and the intensity profile change of the undulator at different phase can be analyzed from the blade signals in high sensitive way.

1 INTRODUCTION

The photon beam position monitor (PBPM) is widely used in many synchrotron light source facilities[1-4]. Usually the PBPM is installed in the front end system to directly measure the synchrotron radiation photons without blanking-off the part of the photon beam that the beam line will accept. So the PBPM should be operated in non-destructive way, and be capable to absorb the heat load on itself. The blade-type PBPM that measure the photons by photoemission method is promisingly useful to meet the requirement, especially in case of the undulator synchrotron light. In SRRC, a prototype of the 2-blade type PBPM that measures the vertical movement of the undulator light has been successfully developed[5]. A positional resolution of < 1μm has been achieved.

2 PBPM SYSTEMS

2.1 Front Ends

The front ends for the TLS are compact. Fig. 1 illustrates the layout of front ends for (a) Insertion Device (ID), and (b) Bending Magnet (BM) sources. The aperture, part (a), constraints the synchrotron radiation (SR) photons passing through the front end without irradiating the downstream components. The PBPM, part (b), locates behind the aperture subjects only the minimum heat load from the penetrated photons. The absorber, part (c), absorbs a total power of < 200 W for BM-front ends, and < 2.5 kW for ID-front ends for TLS operating at 200 mA of electron beam current in 1.5 GeV beam energy. The front ends are fixing to the ground within a < 0.2 μm vibration level.

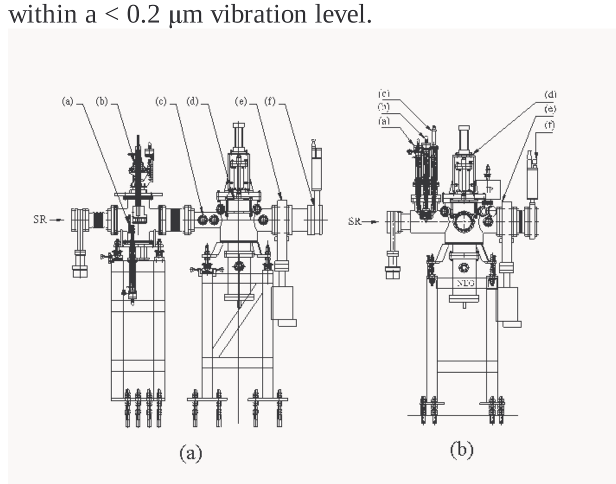

Figure 1: Layout of front ends for (a) Insertion Device (ID), and (b) Bending Magnet (BM) sources for the TLS. The main components for the front ends contain (a) aperture, (b) PBPM, (c) absorber, (d) safety shutter, (e) metal gate valve, and (f) fast closing shutter.

2.2 Design of PBPM

Typically, the blade type PBPM measures the peripheral photons of the photon beam in non-destructive way by the photoemission method. The material of the blade is A1050 aluminum alloys, which is low atomic number one and provides high thermal conductivity. The holder for mounting the blades, made by aluminum alloys, is cooled by the De-Ionized water flow into the center of the holder. A bias of +130 V is applied on a collector surrounded the blades to attract the scattered photoelectrons.

Figure 2 and fig. 3 illustrate the schematic partial drawings of the PBPM for ID-front ends and for BM-front ends, respectively. Part (a) in fig. 2 and fig. 3 shows the side view of a 2-blade type PBPM, while (b), (c), and (d) illustrate the front view of various types of PBPM in 2-blade, 4-blade, and 12-blade, respectively. The 2-blade PBPM measures only vertical position of photons. The 4-blade and 12-blade types PBPM are capable to measure both the horizontal and the vertical positions of photon beam. The arrangement of the 12 sets of blade is uniformly distributed in radial directions, and separately mounted to neglect the cross-talk effect.

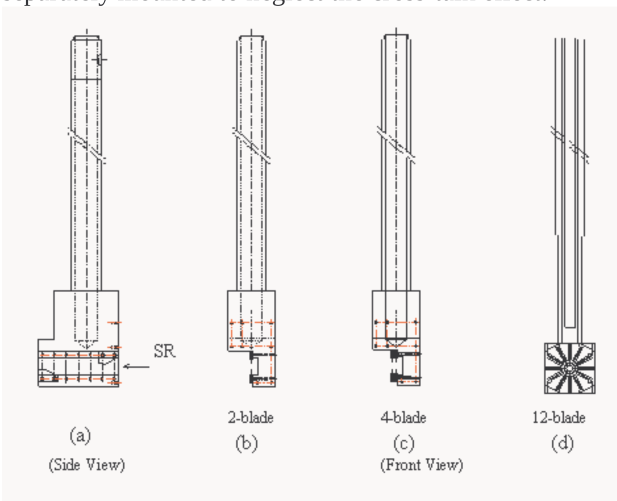

Figure 2: PBPM for ID front ends.

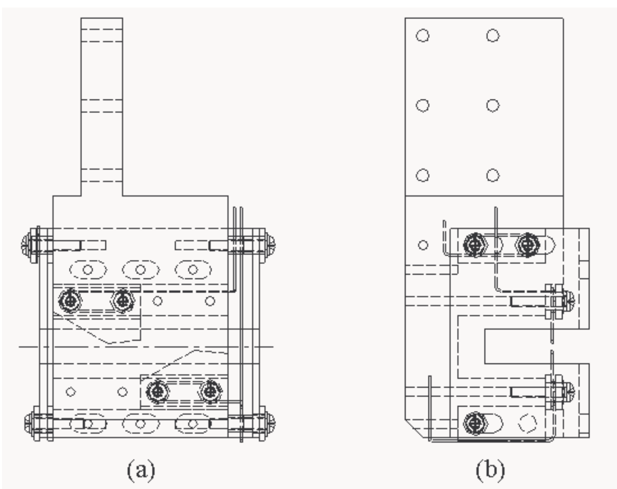

Figure 3: PBPM for BM front ends.

2.3 Data Acquisition Systems

The signals of blade current are retrieved by the Keythley picoameters. Calibration of the position in both vertical and horizontal directions is done by driving the stepping motors for the PBPM through the personal computer (PC). Figure 4 illustrates the calibration of a 4-blade PBPM in vertical direction. The current of each blade during the movement of PBPM in vertical, y, direction is plotted in fig. 4(a). The calibration factor, Ky, is obtained from the slope of the linear fitting of the curve in fig. 4(b). The positions of the PBPM in both y and x direction are calculated according to the following equations,

$$Y(\mu m) = K_Y [\Sigma(I_U) - \Sigma(I_D)] / [\Sigma(I_U) + \Sigma(I_D)] \quad (1)$$

$$X(\mu m) = K_X [\Sigma(I_R) - \Sigma(I_L)] / [\Sigma(I_R) + \Sigma(I_L)] \quad (2)$$

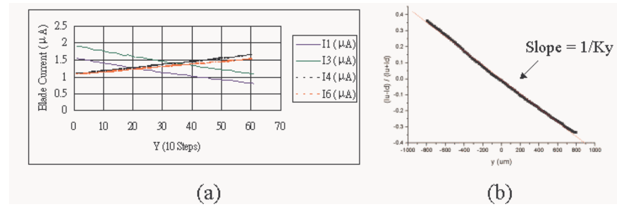

Figure 4: Calibration of Ky factors for 4-blade PBPM, (a) the curves for the four blades during the vertically moving of PBPM, (b) the curve of the differential blade current vs. the PBPM movement.

3 DATA ANALYSIS

3.1 Contaminations from BM light

The curves of Ky factor for a 4-blade PBPM for undulator U5 at various open gap is shown in fig. 5. The result shows a constant Ky value of ~ 1600 μm if PBPM is located at beam center and subtracting the BM light, as the curve shown in fig. 5(d).

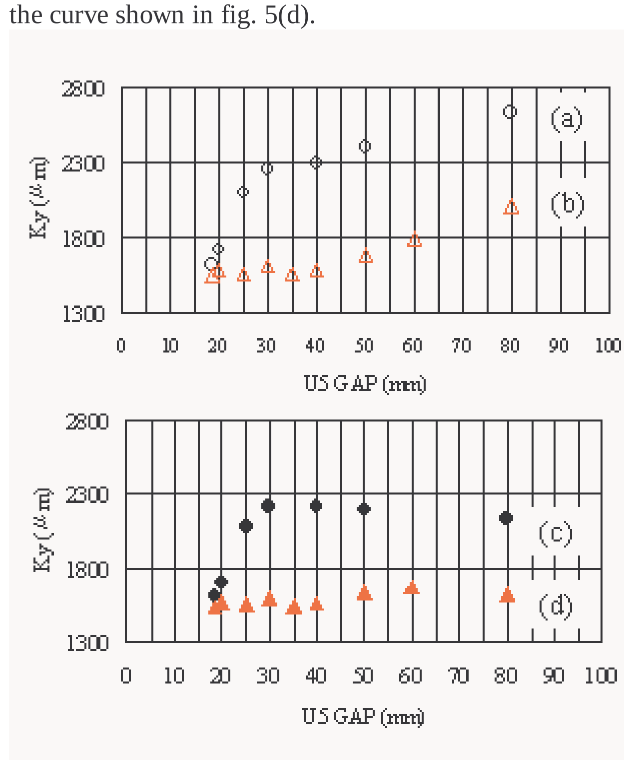

Figure 5: Curves of Ky factors for 4-blade PBPM for U5 undulator at various open gaps. Where curves (a) and (b) are Ky obtained without subtracting the BM light when PBPM is located ~ 4 mm offset and at the beam center, respectively. Curves (c) and (d) are Ky obtained with subtracting the BM light when PBPM is located ~ 4 mm offset and at the beam center, respectively.

3.2 Resolution of PBPM

A measurement of the 2-blade PBPM for a BM light is shown in fig. 6. The curves in fig. 6 illustrate a resolution of position is better than 0.5 μm.

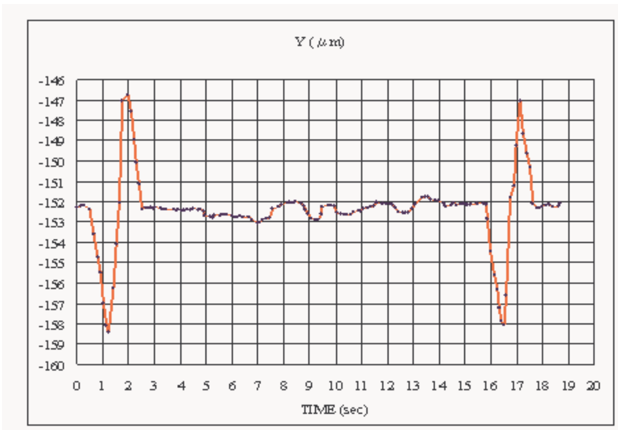

Figure 6: Curves of vertical position, Y, measured at a BM-front end when the electron beam subjected an anomalous periodically driving force.

3.3 12-Blade PBPM

The group signal of 12 sets of blade current normalized to the e-beam current is shown in fig. 7, (a) the radar plot, and (b) the individual current. The blade current of I_1 is small due to the shadow effect from another PBPM in front of this PBPM. Curve in fig. 7(b) is obtained from a periodical change of the cooling temperature of one RF cavity intuitively. It is found the corresponding changes for the blade current of I_3, I_5, I_8, and I_{10}, which illustrate a vibration of the photon source along the direction in 45°.

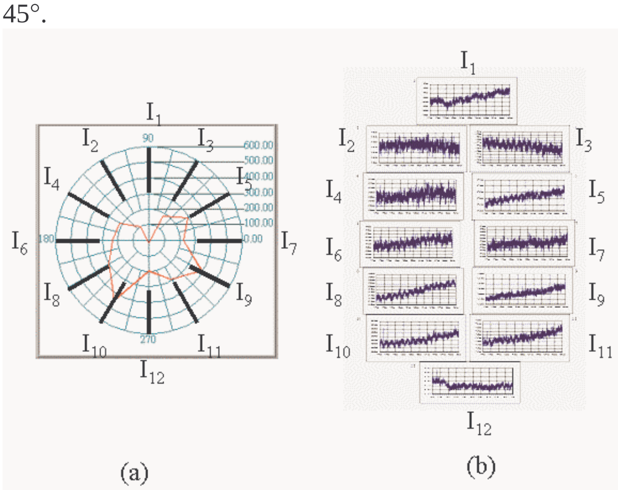

Figure 7: Curves of the group signal of 12 sets of blade current normalized to the e-beam current, (a) the radar plot, and (b) the individual current.

4 SUMMARY

The PBPM of blade type is promisingly useful for photon position monitoring. There have been 6 sets of PBPM installed in BM front ends, and 4 sets of PBPM in ID front ends. The resolution of position is < 0.5μm in Y-direction. The Ky factor of PBPM for insertion device is gap-independent if BM-light is subtracted and location is near the horizontal center of photon beam. The 12-blade PBPM is capable to measure the variation of beam profile. The data acquisition system will be improved for measuring the higher-frequency motion of the photon beam.

5 REFERENCES

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