FAST LOCAL BUMP SYSTEM FOR HELICITY SWITCHING AT THE PHOTON FACTORY

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Abstract

A fast local bump system for the helicity switching of a circular/linear polarized undulator (CPU) has been developed at the Photon Factory storage ring (PF-ring). The system consists of five identical bump magnets and tandem APPLE-2 type CPUs. In addition, fast correction magnets for a leakage of the bump were prepared. We designed the bump magnets with a core length of 0.15 m, a pole gap of 21 mm and the coils of 32 turns, which were excited by bipolar power supplies with a capacity of ±100 A and ±50 V since a switching frequency of more than 10 Hz and a bump angle of 0.3 mrad were required for user experiments. The bump magnets and one of CPUs were installed at PF-ring in March 2008, and the experiments for the machine development using a stored beam have been progressed. In this conference, we present the first experimental results with the bump system.

INTRODUCTION

In order to pick up the extremely weak circular and linear dichroism [1], sinusoidally deflected, left-right circularly or horizontally-vertically linear polarized undulator radiation with lock-in detection [2] is one of the excellent methods. Alternately polarized undulator radiation is made by tandem undulators and local orbit bump. The bump angle of 0.3mrad inside the undulators is necessary to separate the photons generated from two undulators. Using the lock-in detection switching frequency required at least 10Hz. The conceptual design overview is shown in Fig. 1. During spring shutdown in 2008, first undulator and bump system was installed into the ring.

OVERVIEW OF THE SYSTEM

For the purpose of orbit switching, five bump kicker magnets with five identical power supplies are adopted. To realize the angular bump of 0.3 mrad, the maximum kick angle of 2.4 mrad was required from the geometrical configuration. The main parameters are listed in Table 1 and the cross sectional view of the magnetic core is shown in Fig. 2. Two-dimensional magnetic field is calculated by POISSON code [3].

Beam position monitor (BPM) is required to measure an orbit oscillation with a frequency of more than 10 Hz. Three BPMs are located inside the bump. Other five BPMs located outside the bump. To correct the orbit leakages from bump magnets field errors and effects of undulators, four fast steering magnets are installed. When the undulator has a skew quadrupole field component, a vertical orbit leakage is generated with the horizontal bump. The effect corrects steering magnets. Static skew quadrupole magnet enables us to easily correct such orbit leakage. For user operation, a closed orbit of whole ring is reduced to be one-tenth of a beam size: a horizontal size is about 30μm and a vertical about 10μm from the reference orbit during the bump system operation.

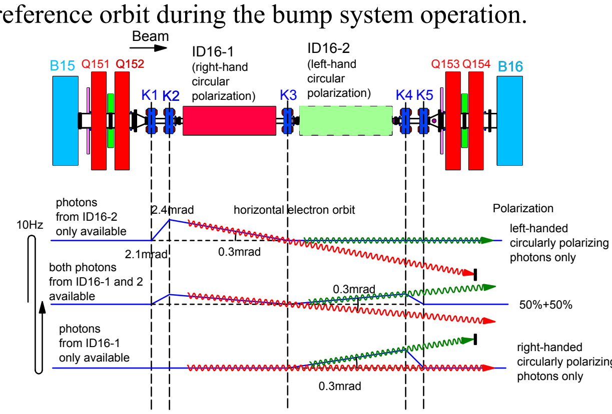

Figure 1 : Schematic drawing of the conceptual design for producing the fast helicity switching variable polarized photon.

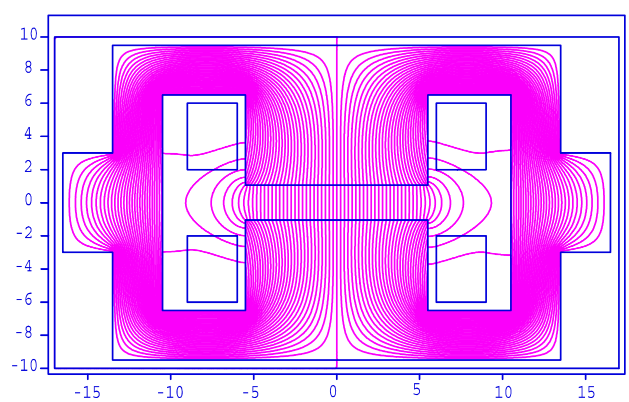

Figure 2: Cross sectional view of the bump kicker magnet. The magnetic field is calculated by two-dimensional POISSON code.

MAGNETIC FIELD MEASUREMENT

Before install, the magnetic field distribution, the excitation curve and the frequency response of all five magnets was measured by the hole probe (F.W.Bell 9500A) and the FFT analyzer (HP 3562A) for five magnets. The individual differences were less than 1×10^{-3}. Figure 3 shows a typical horizontal field distribution. The flatness of the magnetic field (ΔB/B) was smaller than

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1×10^{-3} in $|x| < \pm35$ mm. The results coincide with the results calculated by the POISSON code. Figure 4 shows a typical longitudinal field distribution .The effective length was estimated to be 183cm. Fig.5 shows phase delay between input signal and magnetic field. At the frequency of 10Hz, the phase delay of 0.9 degree was produced.

Table 1: Principal Parameters of the System

Max. beam energy	E [GeV]	3
Max. kick angle	θ [mrad]	2.4
Max. magnetic field (3GeV)	B [T]	0.16
Vertical pole gap	h [mm]	21
Horizontal pole width	w [mm]	110
Magnet core length	l [mm]	150
Coil turn number	N [turns]	32
Inductance	L [H]	1.0×10^{-3}
Maximum magnetic current (3GeV)	I [A]	83.5
Resistance	R [Ω]	0.1
Design bump frequency	f [Hz]	10
Max. voltage for 10Hz operation	V [V]	13.7
Silicon steel thickness	t [mm]	0.5
Power supply capacity	I [A]	±100
	V [V]	±50

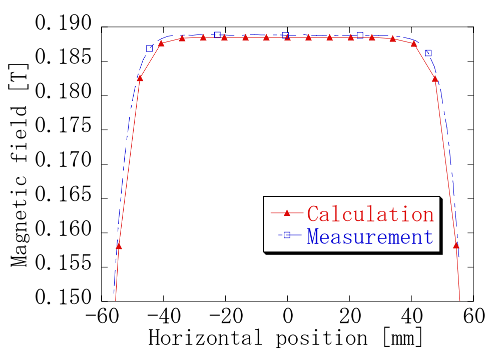

Figure 3: Typical horizontal distribution of the magnetic field. Solid blue line and red crosses show the results of the measurement and the calculation, respectively.

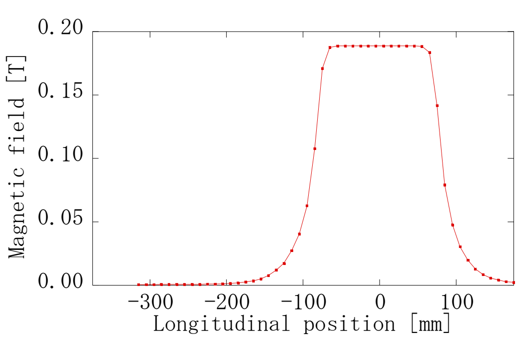

Figure 4: Typical longitudinal field distribution of the magnetic field.

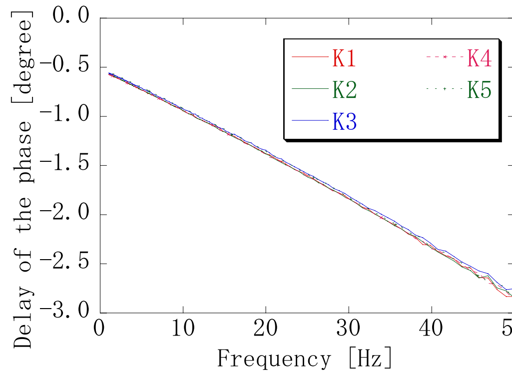

Figure 5: Phase delay as a function of the frequency. These lines represent the phase delay between input signal and magnetic field.

RESULTS OF PRELIMINARY MACHINE STUDY

After the commissioning, the machine studies to switching local orbit bump were conducted. Fig.6 shows monitor and magnets layout and schematic drawing of the angular bump.

For beam position measurement, a digital BPM system "Libera" manufactured by Instrumentation Technologies [4] was used. When the bump is ideal, measured bump height would be 0.99mm at FPM001, and FPM003 and 0.057mm at FPM002. Bump height was measured to be about 0.9mm at FPM001 and FPM003. Fig.6 shows beam position at a Switching frequency of 10Hz. So, we confirmed that the bump switching up to 70Hz successfully was realized.

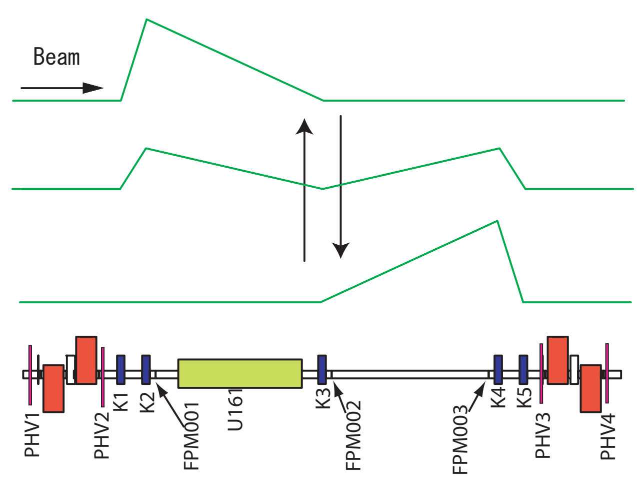

Figure 6: Schematic drawing of the angular bump and magnets and BPMs layout. The bump sinusoidally switched.

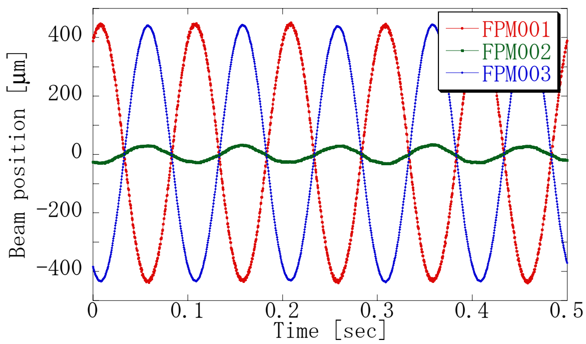

Figure 7: Horizontal beam positions at a switching frequency of 10Hz. Monitors were placed inside the bump section.

Leakage of Bump

Next, we measured amplitude of closed orbit oscillation caused by bump magnets, for example, leakage of bump. Horizontal and vertical closed orbit oscillation amplitude with some particular state of undulator was shown in Fig. 8 and Fig. 9. When undulator gap was closed, the vertical orbit oscillation was increase for skew quadrupole effect. The undulator doesn't affect horizontal oscillation amplitude. When switching frequency was 0.1Hz, variation of closed orbit was suppressed with using fast steering magnet PHV2 and PHV3 for vertical direction. Beam position variation of vertical direction was approximately 2µm (RMS).

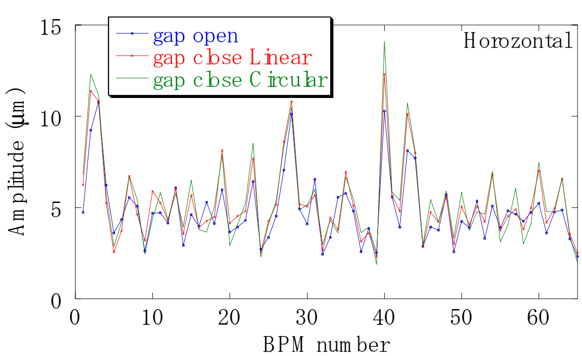

Figure 8: Horizontal oscillation amplitude at a switching frequency of 0.1Hz. Monitor was placed whole ring out of bump section.

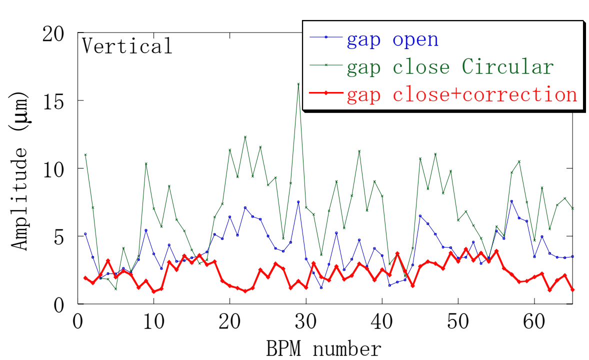

Figure 9: Vertical oscillation amplitude at a switching frequency of 0.1 Hz. Monitor was placed whole ring out of bump section.

Switching frequency varied from 10 to 50 Hz. Leakage of bump increased with switching frequency. Fig.10 and Fig.11 shows horizontal and vertical amplitude of orbit oscillation respectively. FPM013 has large horizontal amplitude. The place is sensitive to disturbance of ID16 straight section. Vertical oscillation also grows up by virtue of correction mismatch. The correction was matched to 0.1Hz switching.

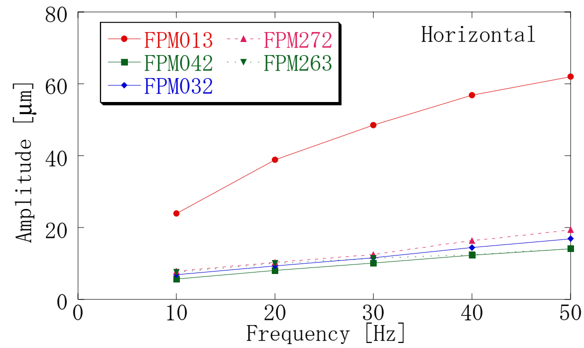

Figure 10: Horizontal oscillation amplitude as a function of the switching frequency detected using five Fast BPMs.

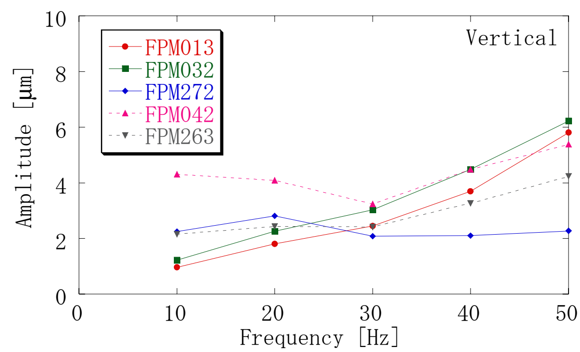

Figure 11: Vertical oscillation amplitude as a function of the switching frequency detected using five Fast BPMs.

CONCLUSION

After the magnetic field distribution and frequency response measurement one of the undulators with fast local bump system for the polarization switching was installed into a south long straight section. And we have succeeded bump switching up to 70Hz, and variation of closed orbit was suppressed at a switching frequency 0.1Hz. However, we found that the leakage of bump increased with the switching frequency increase. Next machine study we will correct variation of closed orbit by fast steering magnet.

REFERENCES

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