A DYNAMIC LOCAL BUMP SYSTEM FOR PRODUCING SYNCHROTRON RADIATION WITH AN ALTERNATING ELLIPTICAL POLARIZATION

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Abstract

To facilitate high sensitivity soft-X-ray magnetic circular dichroism experiments, we have developed a dynamic local bump system at the SRRC storage ring. This system was devised to vary dynamically the vertical slope of electron beam in a bend magnet, producing, in the electron orbit plane, soft-X-rays with an alternate elliptical polarization. The local bump was created by using two pairs of vertical correctors located on each side of the bend magnet. Bump strength coefficient was obtained from both calculated estimation and measured beam response matrix. Control electronics for proper bump strength settings was designed to incorporate the existed orbit corrector function. Corresponding graphic user interface was implemented so that bump amplitude can be easily adjusted. Performance of this system is presented. Disturbance on the stored electron beam orbit was observed while flipping of corrector polarity during EPBM operation. A local feedback loop developed to eliminate such disturbance on other beamlines is also described.

1 INTRODUCTION

The prospect of obtaining element- and site-specific magnetic information has stimulated a good number of experiments taking advantage of circularly polarized synchrotron radiation [1]. These magnetic circular dichroism (MCD) experiments, whether performed in

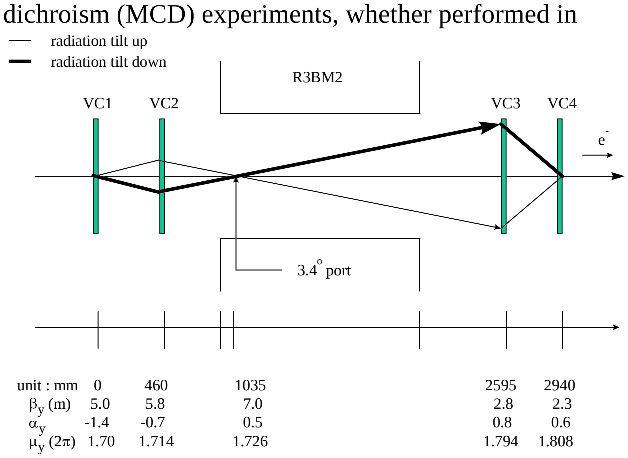

Fig.1. Operational schematic illustration of the EPBM system.

absorption or reflection, offer the possibility of determining the magnetic moment of each element in the material being investigated. It is expected to have an elliptical polarization from bending magnet (EPBM) operation mode which provides adjustable degree of polarization with polarity switching frequency of 0.5 Hz. This report describes the design and preliminary test result of a dynamic local bump system for producing synchrotron radiation with an alternate elliptical polarization.

2 TECHNICAL FEATURES

2.1 Spatial Arrangement

The schematic illustration of EPBM mode operation isshown in Fig.1. The SRRC storage ring lattice structure is a triple bend achromat with six-fold symmetry and the EPBM beamline is situated at the second bending magnet of the section three achromat. As shown in the figure, the R3BM2 stands for the second bending magnet of ring section 3. VC1, 2, 3, 4 represent vertical correction magnets associated with the EPBM local bump generation. The electron beam trajectory can be either flipped up or down depending on the bump magnet polarity chosen.

Since the EPBM configuration was new to the storage ring lattice, locations for installing extra correction magnets was limited by existing elements in the lattice structure, such as magnets, diagnostic and vacuum components. A compromised solution ends up with the arrangement given in Fig.1.

2.2 Bump Coefficient Determination

With a specified user shift machine lattice, bump coefficient and strength can be determined by matching vertical beam position and slope at the intersection of lattice beam centerline and photon beamline.

Estimated bump coefficient can be verified under DC mode operation and some fine adjustment may be practically needed. Example of an EPBM DC bump was shown in Fig.2 for illustration. A local bump in the R3BM2 region is added onto the regular user shift beam trajectory along the storage ring. One can also use the orbit difference monitoring tool to display beam orbit change before and after the AC bump was applied with persistent option. The detail of this beam instrumentation tool is described elsewhere [2].

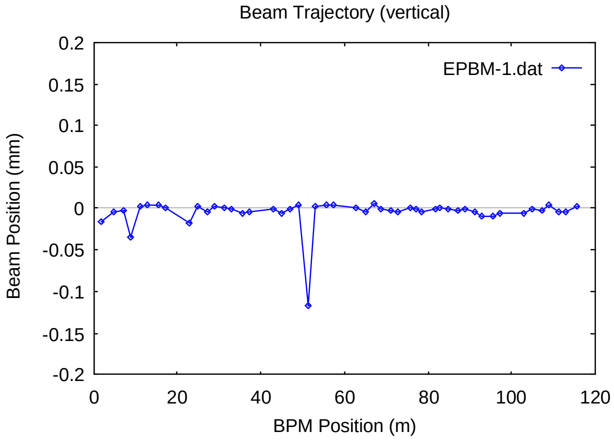

Fig.2. An EPBM local bump was generated in the storage ring section 3 under regular user shift lattice.

2.3 Beam Response Matrix

Another method to determined bump coefficient is using the measured beam response matrix [3,4]. The details of determining this EPBM local bump is described elsewhere [5]. This bump shape adjustment provides capability of convenient tuning in the future beamline commissioning, therefore the measured response matrix method was used for producing EPBM bump in this experiment.

3 IMPLEMENTATION AND TEST RESULTS

3.1 Control Electronics

Functional block diagram is given in Fig.3.

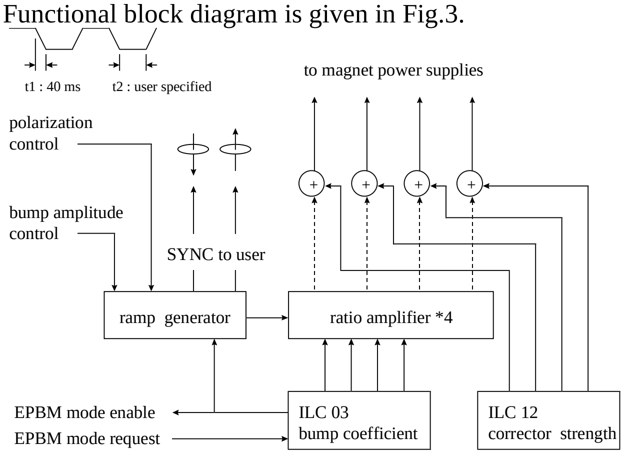

Fig.3. Functional block diagram of EPBM control electronics.

As shown in the figure, these bumpers act also as correction magnets. Consequently, the EPBM control electronics was designed to be able to provide independent corrector strength adjustments for both routine orbit correction and EPBM local bump generation. In switching the local bump polarity, a ramp generator was applied so as to keep polarity transient duration longer than the magnet response time of 25 ms. Tuning of bump amplitude was achieved by adjusting the bump amplitude control knob and the polarity switching frequency is determined by an external square wave function generator.

3.2 Graphic User Interface (GUI)

The EPBM graphic user interface was designed to provide easy adjustment of degree of polarization. The EPBM control page is shown in Fig.4.

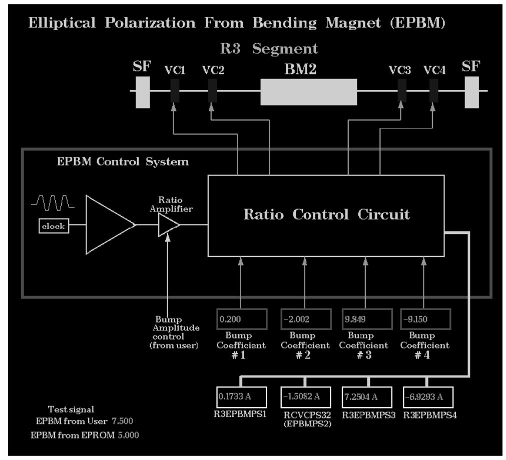

Fig.4. Display of present EPBM graphic user interface.

Tuning knob settings of bump coefficient for four magnets were determined from measured response matrixes. These values have also been cross-checked through simulation and will be determined during EPBM beamline commissioning.

3.3 Mismatch of the Eddy Current Effect due to Bellow in the Third Corrector And Its Phase Compensation

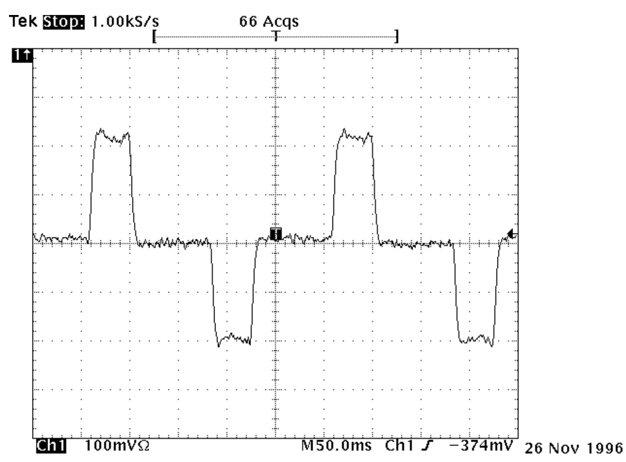

Fig.5. A 40 ms beam orbit shift was observed during EPBM bump polarity transient period.

When EPBM was tested in AC mode, beam orbit disturbance was observed outside the EPBM local bump. After careful examination, it was found that the beam orbit disturbance was occurred during the transient of bumper polarity change. As shown in Fig.5, the vertical position of the electron beam monitored at one of the

BPM located outside the EPBM bump gives about 50 μm beam position shift for 40 ms. This 40 ms period corresponds to the transient duration set by the control electronics and was caused by bump phase mismatch of the third bumper magnet. The vacuum chamber, where the third bumper magnet is located at, is a bellow type which is different from what the other three bumper magnets are associated with, a 5 mm thick aluminum chamber, was responsible for this bump mismatching. A compensation circuit was then built into the control electronics for the third magnet channel in order to compensate the mismatch due to eddy current.

3.4 Beam Test Result with Local Feedback Loop

Although the compensator in the EPBM control electronics provides reduction of orbit disturbance on the beam orbit during polarity transient period, further improvement is still desirable. In order to fulfill this requirement, a local feedback loop on the beamline of interest was put to test in stabilizing beam trajectory at upstream of the beamline. As illustrated in Fig.6, with EPBM control electronics operating at 0.5 Hz, a local feedback loop was setup for stabilizing beamline of R2BM3, whereas EPBM beamline is located downstream of R3BM2.

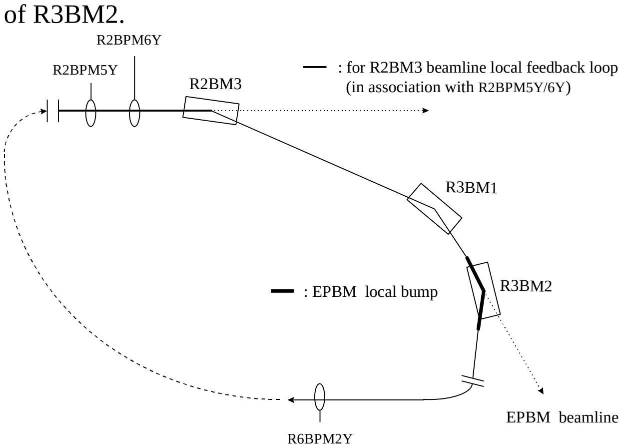

Fig.6. Schematic layout of the test run of EPBM with local feedback loop.

As shown in Fig.7, beam position monitors within the region of applied feedback loop (R2BPM5Y, R2BPM6Y) and the outside one (R6BPM2Y) give beam position during this experiment. At the beginning of this experiment, beam position readings were recorded under normal operation mode. Then, the EPBM control electronics was turned on in order to observed its influence to the beam position fluctuation at upstream BPMs of a selected beamline. The local feedback loop was turned on three minutes later in order to suppress beam position fluctuation induced by EPBM operation. This experimental result indicates that with EPBM in operation, other beamlines may be disturbed by EPBM local bump mismatch during flipping of correctors polarity [3]. Beam position fluctuation of 40 μm (R2BPM5Y), 70 μm (R2BPM6Y), 30 μm (R6BPM2Y) were observed while EPBM was operating. This implies that beamlines located downstream of (R2BPM5Y/R2BPM6Y) and that of R6BPM2Y were greatly disturbed by this EPBM operation. However, when local feedback loop installed in the region where (R2BPM5Y/R2BPM6Y) located was turned on, the beam position was stabilized to have fluctuation within 15 μm, 15 μm, and 25 μm, correspondingly.

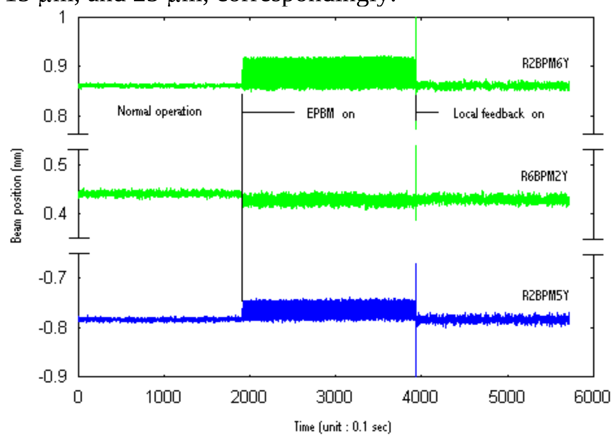

Fig.7. Monitoring beam position fluctuation while EPBM is operating and then is suppressed by local feedback loop.

This indicates that installing the local feedback loop at the beamlines of interest can do a great help in stabilizing beam position at its upstream.

4 CONCLUSIONS

In order to fulfill a dynamic EPBM local bump operation requirement, a control electronic system has been developed for this purpose and the test results are presented. The EPBM bump coefficients were determined based on the measured response matrix and calculation. Beam orbit disturbance was observed due to phase mismatch among bumper magnetic field. It is shown that this phase mismatch can be greatly reduced with a built-in compensator in the control electronics. The residual orbit disturbance on other beamline can be further suppressed in cooperation with an associated local feedback loop.

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