Compensation Scheme of Elliptical Polarization from Bending Magnet at SRRC

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ABSTRACT

A prototype elliptical polarization from bending magnet (EPBM) system with a dynamic local bump has been implemented at the SRRC storage ring. The local bump is created by using two pairs of vertical correctors located on each side of the bending. The bump strength coeffieient was obtained from measured beam response matrix. Disurbance of stored electron beam orbit was boserved while flipping the corrector polarity during EPBM operation. It was determined that beam orbit disturbance was caused by bump phase mismatch among bumper magnets. Measured result of this phase mismatch among bumper magnets. Measured result of this phase mismatch and its compensation by using wavefrom generator is presented in this report.

1 INTRODUCTION

The observed orbit disturbance outside the local bump was reduced by introducing compensation circuit to one of the bump correctors [1]. However, further investigation showed that local bump leakage at different power supply polarity, different power supply response time and vacuum chamber eddy current effect are all contribute to this orbit disturbance. Consequently, a programmable compensation technique was applied in this study in order to solve these problems. .

2 SYSTEM CONFIGURATION

2.1 Waveform generator

The system block diagram is shown in figure 1. As shown in the figure, these dynamic local bump magnets can also be used as correction magnets. In switching the local bump polarity , a ramp generator was applied so as to keep polarity transient duration longer then the magnet response time of 25 ms. Tuning of bump amplitude, which is directly related to the degree of polarization, was achieved by using an eight independent channel with 16 bit waveform generator in 6U VME form factor. Every channel supports 32 K SRAM memory in each channel which is programmable so that the module can be tailored to the application. The DAC is clocked from a programmable external clock or an internal programmable crystal controlled clock with maximum speed of 100 KHz. To provide versatile operation the start address can be set and active length selected in single scan or repeat mode provides the user maximum control of output generation.

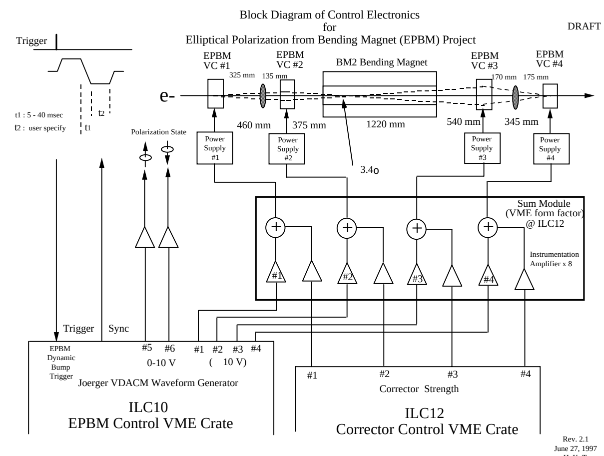

Figure 1: EPBM system block diagram.

This system is triggered by external TTL signal in per 100 millisecond, and then generates four trapezoid waveforms with different amplitude. The waveform pattern is shown in figure 2.This is a modified trapezoidal pattern with smoothing in transient state to reduce eddy current effect of vacuum chamber.

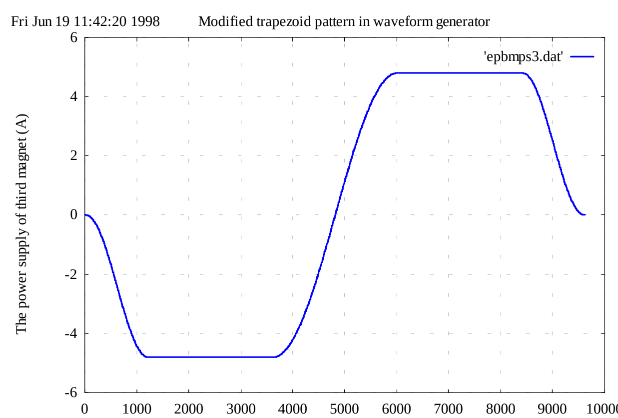

Figure 2: Current waveform of the 3rd EPBM corrector. (10 µs/count) or (80 µs/count).

2.2 Corrector power supply control

There are four correctors in the EPBM system. One of the correctors is used in the routine operation no matter EPBM is on or not. The synthetic device of signals is configured to ILC12 from original independent unit in the second corrector and is compatible with storage ring control system. In another crate, the host computer controls waveform generator, data processing and compensation process. The correction table is established by compensating the distorted orbit. Network file server (NFS) sends this information to ILC10. The data sampling is synchronized by per millisecond system timing from BPM node [2]. The ILC10 is correction node, which handles waveform generator control and EPBM compensation calculation.

3 COMPENSATION ALGORITHM

There is a different type chamber in the third corrector from others. The eddy current effect is different between bellow and normal aluminum chamber. Besides, power supply control is critical, such as power supply tracking, power supply offset and nonlinear magnet field. These effects will cause bump leakage. It is complicated in compensation process in order to control four independent power supplies. The correction table is created, by measuring response matrix [2] in the hope to compensate the eddy current effect, power supply offset, and tracking regulation at the same time.

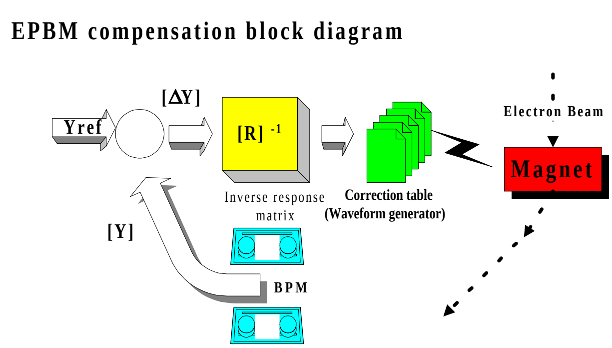

Figure 3: EPBM compensation block diagram.

$$[\Delta P] = [R]^{-1} * [\Delta Y] \quad (1)$$

$$[P']_{ILC12} = [P]_{ILC12} + k \times [\Delta P]_{ILC10} \quad (2)$$

The compensation block diagram is shown in figure 3 and algorithm is shown in equation 1. This is an open loop system, where [ΔY] is orbit distortion when the polarization of EPBM is switching. Its switching period is programmable. The [R] is the response matrix of storage ring. The [ΔP] is the correction table for corrector. The P' is the final power supply setting value, as given in equation 2, where k is a compensation factor.

4 PERFORMANCE OF COMPENSATION

The R6BPM7 is the largest response matrix element, located outside of the EPBM bump, was picked up to monitor orbit disturbance caused by EPBM operation.

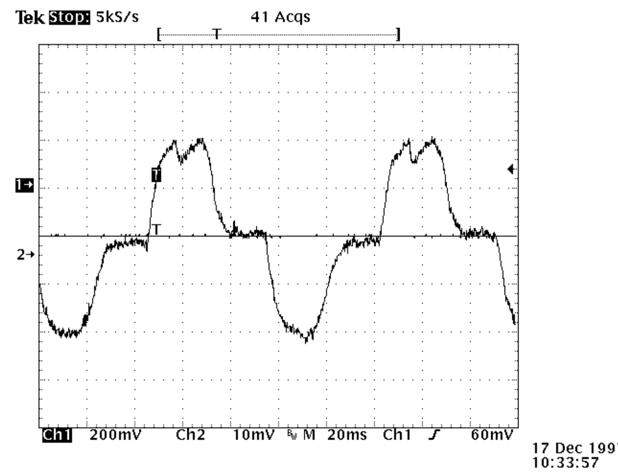

Figure 4.1: R6BPM7 disturbances in EPBM action with no compensation.

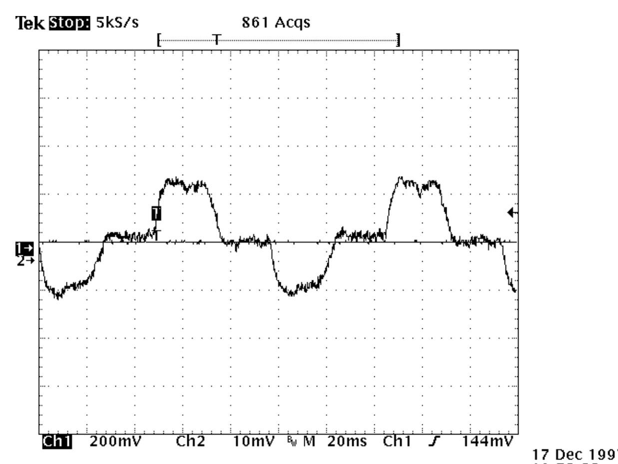

Figure 4.2: 3 times iteration compensation.

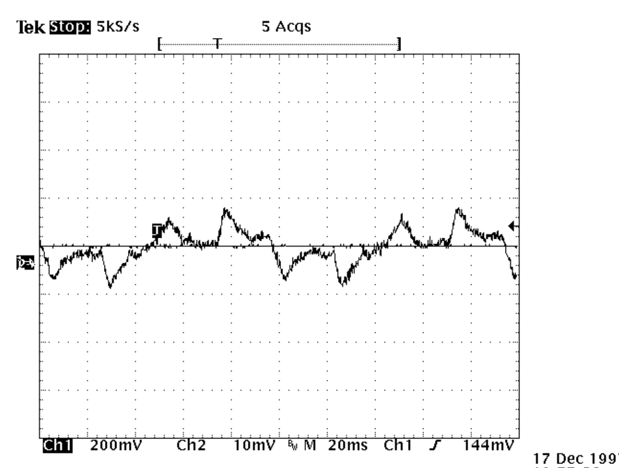

Figure 4.3: R6BPM7V result after several iteration compensations.

The tested switching rate of EPBM is 10.35 Hz and the results is shown in figure 4. Figure 4.1 gives orbit disturbance of about 70 µm, peak to peak, obseved in R6BPM7Y. The asymmetry on the beam centerline is probably caused by power supply tracking problem. After compensation process was applied to the corrector driving mechanism, the orbit disturbance was reduced to about 25 µm, peak to peak, as shown in figure 4.3. The switching frequency at 1.3 Hz also has been tested with the achieved orbit disturbance of about 10 µm, peak to peak. The result is shown in figure 5.The system performance difference between 1 Hz and 10 Hz operation is basically due to the following limitation. The BPM reading system timing is in 1 ms step which is different from the waveform generator resolution of 10 µs or 80 µs. Linear interpolation between these two systems is necessary. The reading system noise and interpolation error contribute to the performance difference between these two modes. Effort to eliminate the error sources is in progress.

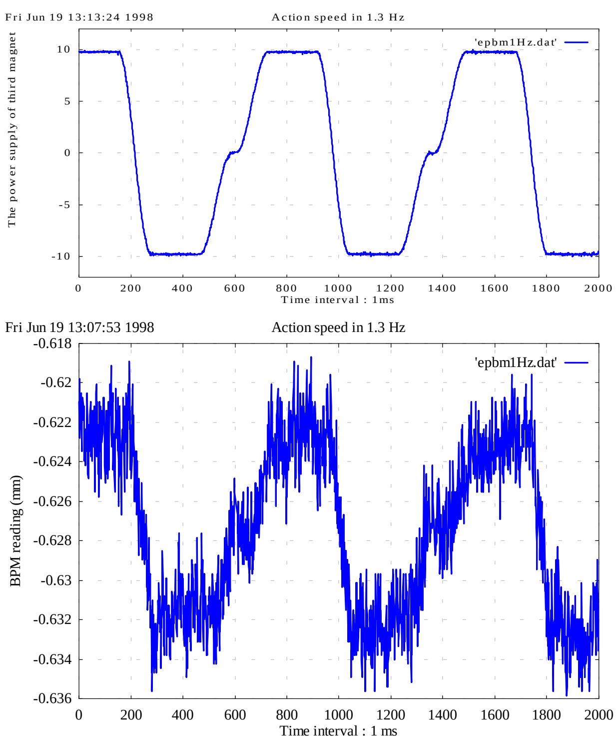

Figure 5: The compensation performance in the largest bump leakage location under 1.3 Hz operation.

The local feedback system (LFB) [5] also has been used in suppressing EPBM bump leakage after compensation at 10 Hz. The result is close to 10 um.

5 CONCLUSION

Performance of the EPBM compensation system will be further improved as we gain operation experience and hardware upgrade. The BPM data acquisition system for EPBM will be synchronized with waveform generator to reduce power supply tracking error for compensation operation. Futher study is needed in order to reduce transient duration of polarity switching to 10 ms .

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