The Orbit Study on the SRRC 1.3 GeV Booster Synchrotron During Ramping

T. S. Ueng, J. P. Chiou, C. S. Fann, K. T. Hsu, S. Y. Hsu, J. I. Hwang, K. H. Hwu, K. K. Lin
Synchrotron Radiation Research Center, Hsinchu 300, Taiwan

ABSTRACT

The closed orbit of electron beam of the SRRC booster synchrotron was measured during ramping from 50 MeV to 1.3 GeV. The beam position monitoring system has been completely modified such that the horizontal and the vertical beam positions can be obtained simultaneously. An HP VXI system combined with some custom made electronic devices was used to acquire and analyze the data. In this study the detailed beam orbits during ramping under specific operation conditions are investigated in order to obtain information for improving the performance of the SRRC booster synchrotron.

1 INTRODUCTION

The booster synchrotron of SRRC is used to accelerate the electron beam from 50 MeV to 1.3 GeV[1]. It has circumference of 72 m. The repetition rate of the booster synchrotron is 10 Hz. The electron beam circulating the synchrotron in 240 nsec each turn and in about 50 msec each ramping cycle. The electron beam is injected from a Linac with energy of 50 MeV and extracted at 1.3 GeV with a 3-bumper magnet system and a fast kicker. Our study will be on the electron beam orbit during ramping. We hope this study will let us understand more beam dynamic properties and also help us to improve the extraction efficiency of the electron beam to the transport line which is linked to the storage ring.

2 ELECTRONICS SETUP

The beam position monitor (BPM) in the SRRC booster synchrotron was mounted 45 degrees on the chamber at between the dipole and the quadrupole[2,3]. The lattice of the booster synchrotron is of FODO type with periods of 12. There are 23 BPMs used around the synchrotron, because one location is used as a photon port. The control electronics and its cabling for acquiring the data through the BPMs were completely modified again recently, figure 1. The new modification allowed us to measure the beam positions in both of the vertical and the horizontal directions simultaneously. The four buttons of each BPM were connected to a single multiplexer in the first stage multiplexer group. These 23 multiplexers were connected to 6 second stage multiplexers. Then, 3 second stage multiplexers were connected to one third stage multiplexer, and its output was fed into a receiver in the control electronic unit. The other 3 second stage multiplexer were also connected to another third stage multiplexer and was fed into a different receiver unit.

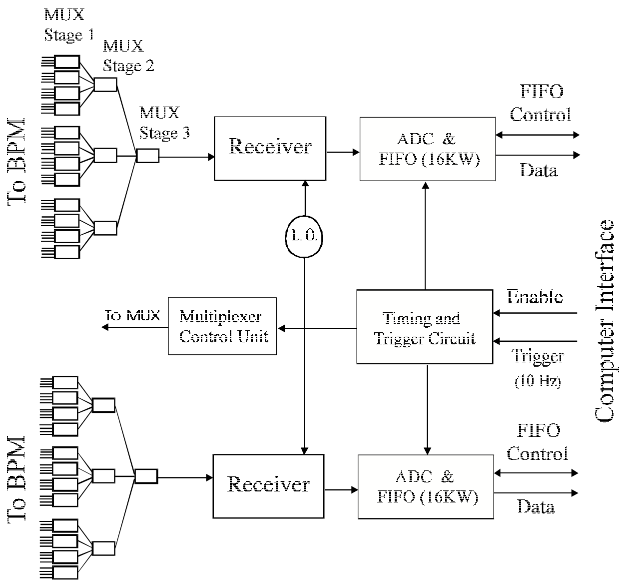

Fig. 1 Block diagram of the electronic hardware

Before the measurement, the cables between each electrode of BPM and the first stage multiplexer were calibrated and trimmed in order to have a same response at the input of first stage multiplexer. The signals corresponding to the beam position were acquired through the four button electrodes of BPM. After the 10 Hz trigger signal of the fast timing system was received by the timing and trigger circuit of the data acquisition system, the multiplexer system would be activated to process the beam position signals picked up by the electrodes of the BPM. The acquired signals passed through the 3-stage multiplexer system to the receiver and to the digitizer in the VXI crate continuously during the ramping cycle. After digitizing, the signals were stored in a FIFO of the digitizer first. Later, these data would be transferred to a VXI based HP computer for analysis.

3 RESULTS AND DISCUSSION

The closed orbits of electron beam during ramping from 50 MeV to 1.3 GeV in both of the horizontal and the vertical direction were obtained simultaneously with this newly installed acquisition system. This system had measurement accuracy about 300 μm. The acquired horizontal orbit is shown about the same as what we have measured before[2]. The vertical closed orbit distortion of all 23 BPM during ramping without turning on the extraction bumpers is shown in figure 2.

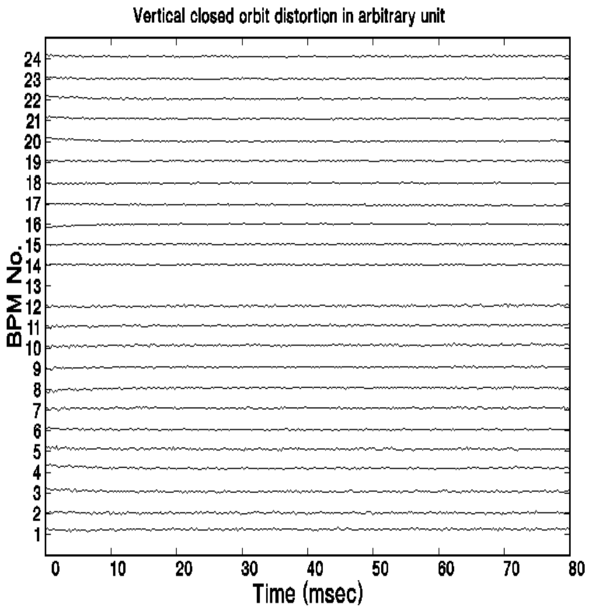

Fig. 2 Vertical closed orbit distortion during ramping when all 3 extraction bumpers were turned off. The distance between two ticks is 15 mm. The tick marks on both sides also mark the ideal orbit of the corresponding BPM.

The vertical closed orbit distortion was also compared with those when a single bumper or multiple bumpers were turned on. There is no difference can be seen. Obviously, it showed that the orbit in the vertical direction was not affected by the bumpers. The detailed closed orbits at 4 beam position monitors are shown in figure 3. There was a small change in the vertical orbit at the first 15 ms of the ramping cycle, then the beam position become stable and shows no significant change. In the figure, one can also see that the vertical beam position is very close to the ideal orbit. On the contrary, most of the horizontal beam positions measured by the BPMs showed that they were much further away from the ideal orbit. At the beginning of the ramping cycle, the correctors were used to adjust the orbit in order to obtain a stable beam during the injection process. But, it also showed that the correctors affected the orbit at lower beam energy much more. As the beam energy increased, the effect of the correctors disappeared and the orbit became stable.

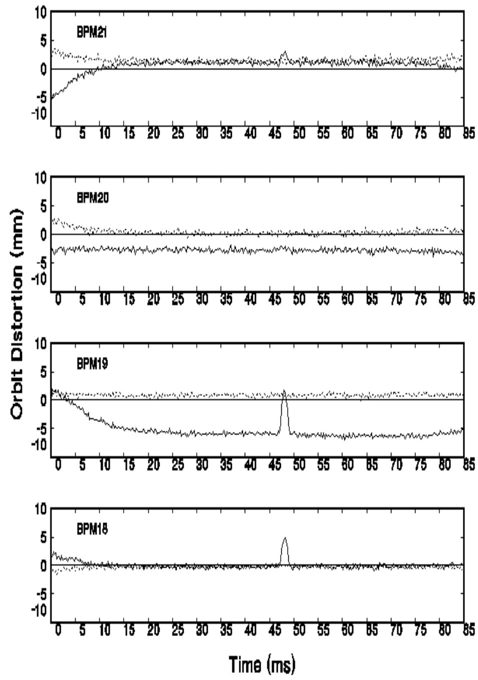

Fig. 3 The horizontal and vertical beam closed orbit distortion during ramping. The extraction bumpers were turned on with the routine operation condition. In the figure the horizontal beam positions are connected by solid line, and the vertical beam positions are connected by dotted line.

During the routine operation the strength and the timing of the 3 extraction bumpers were adjusted in order to have a largest bump at the extraction point for beam extraction. The resultant bump is the product of the combination of the strength of three extraction bumpers. In order to compare the effects of each bumper on the beam orbit, we have varied the timing between the bumpers to see how the orbit appear. This will separate the effects coming from each bumper at the same ramping cycle. The horizontal closed orbit of separating first and third bumper with 4 msec is shown in figure 4. In figure 4, the peaks created by these 2 bumpers are clearly separated. Also, from the first BPM to the last BPM, the peaks from both bumpers indicate approximately a period of 4. It is close to the horizontal tune of the booster synchrotron, 4.15. The positions of the peaks agree approximately with the theoretical phase advance also. From our result we know that the 3-bumper system in our booster does not create a true local bump. This is not a major concern if the booster is used only for accelerating and extracting the electron beam to the storage ring. But if a true local bump can be created as the original design, it will increase the efficiency of the booster. At the same time a understanding in the beam dynamics of our booster can be obtained.

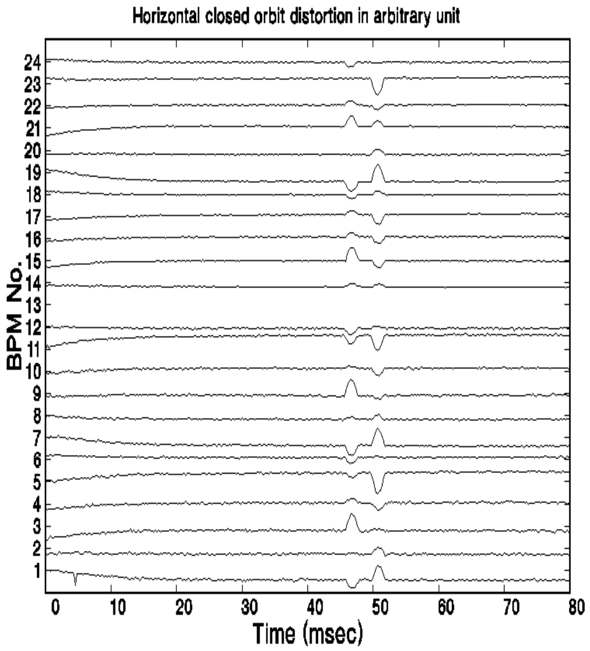

Fig. 4 Horizontal closed orbit during ramping when the first bumper and the third bumper were turned on, and the timing was separating by 4 msec. The distance between two ticks is 15 mm. The tick marks on both sides also mark the ideal orbit of the corresponding BPM.

4 CONCLUSION

Since our closed orbit acquisition system has just completed recently, several modification is still underway in order to improve its accuracy. In the near future, we intend to use the result obtained to compare with the theoretical calculation. This will help us to adjust the strength of each extraction bumper and, if necessary, make the modification on hardware in order to find a true local bump in the orbit during the extraction. We will also study the effects of correctors on the orbit in order to obtain an optimized closed orbit during ramping. At the same time, the efforts for studying the turn-by-turn behavior of electron beam during ramping is in progress. All of our efforts are to increase the extraction efficiency of our booster synchrotron.

5 ACKNOWLEDGMENTS

The authors would like to thank Prof. Y. C. Liu for his encouragement in studying the beam dynamics of the SRRC booster synchrotron.

REFERENCES

[1] K. K. Lin et al., “Performance of SRRC 1.3 GeV electron booster synchrotron”, Nuclear Instruments and Methods in Physics Research, Section A 361 (1995).

[2] T. S. Ueng et. al., “The closed orbit measurement of SRRC booster during ramping”, to be published in Proceedings of 1995 Particle Accelerator Conference (1995)

[3] T. S. Ueng et. al., “Turn-by-turn beam position measurement for 1.3 GeV booster synchrotron”, to be published in Proceedings of 1995 Particle Accelerator Conference (1995)