The Closed Orbit Measurement of SRRC Booster During Ramping

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Abstract

The SRRC booster synchrotron is used to accelerate the electron beam from 50 MeV to 1.3 GeV. The closed orbit of electron beam during ramping was measured. The signals corresponding to the beam positions were picked up by the 23 BPMs around the synchrotron. A control electronic unit was made to control a multiplexer system in order to collect and digitize the signals. During the 50 ms ramping period, the digitized signals were saved into a FIFO in the control electronic unit. Then, these signals were transferred to an IBM/PC for analyzing. The result of measured closed orbits is presented in this report.

1. INTRODUCTION

The booster synchrotron of SRRC was commissioned in 1992. The main purpose of this synchrotron is to accelerate the 50 MeV electron beam extracted from the Linac to 1.3 GeV for the storage ring injection. The lattice is the FODO type, which has circumference of 72 meters and periodicity of 12 [1]. A one turn on axis injection is used. The extraction scheme is to use a 3-bumper magnet system to get the shortest possible closed orbit bump. This will move the beam close to the extraction septum for a fast kicker to kick the beam to the entrance of septum, which will direct the beam to the transport line. At present, the nominal beam current in the synchrotron is about 5 mA for multi-bunch beam and 0.3 mA for single bunch beam. We expect the closed orbit study of this booster synchrotron will provide us the related information about improving the electron beam injection efficiency from the Linac and the extraction efficiency to the transport line, which will thus increase the injection efficiency to the storage ring.

II. THE MEASUREMENT SYSTEM

In the SRRC booster synchrotron, the beam position monitors (BPM) are located in between the dipole and the quadrupole, except one location is used as photon port, see Fig. 1. Thus, there are 23 BPMs mounted around the ring for the beam diagnostics purpose. These BPMs were designed and manufactured originally by Scanditronix AB. The calibration of these BPMs was done at SRRC by K. T. Hsu. The four-button electrodes in the BPM were mount 45 degrees and were connected as two pairs for acquiring the signal. These 23 BPMs can be arranged to collect horizontal beam position data or vertical beam position data at a time by switching the cables.

The original electronics for the BPMs was basically the same as that developed by ESRF, except a different RF frequency was used at SRRC. In the original Scanditronix's design, 11 BPMs were used for measuring the horizontal beam positions, and 12 used for vertical beam positions. The signal from each BPM button was multiplexed and amplified in an RF-MUX electronics, then fed to a multiplexer-mixer unit. The signal which represents the voltage acquired was displayed with a digital oscilloscope. The selection of BPM signal was done manually.

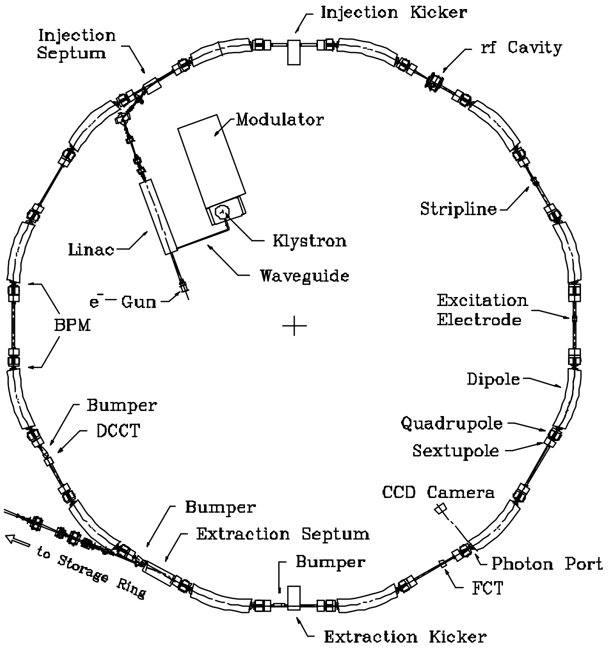

Fig. 1. Brief Layout of SRRC Booster Synchrotron

In order to improve the beam diagnostic capability, an easy and convenient method for studying the behavior of the electron beam closed orbit during ramping was installed in our present beam diagnostic system. The cabling and electronics of the multiplexer system were modified such that the BPM signals can be acquired with an IBM/PC automatically. The block diagram of hardware setup is shown in Fig. 2.

The acquisition time for each pair took about 5 μsec, thus, each BPM 10 μsec. The cables from the BPM to the first stage multiplexer were calibrated and trimmed in order to have the same response at the input of the first stage multiplexer. The trigger signal for the acquisition was coming from the 10 Hz signal of the fast timing system, which was used to monitor and synchronize the magnet families of the synchrotron and also to generate the injection and extraction enable signal for the fast time system. After the timing and trigger circuit receiving the trigger signal, it would also activate the multiplexer system. The acquired signal from the button would pass through the 3-stage multiplexer system to the receiver in the control electronics unit continuously during ramping. After digitizing, the signal was stored in a 16 KW FIFO. This FIFO allowed us to acquire signals for about 80 msec. It covered more than a full ramping cycle, which took about 50 msec. After the FIFO was full, the data was transferred to an IBM/PC to convert it into the beam position for further processing.

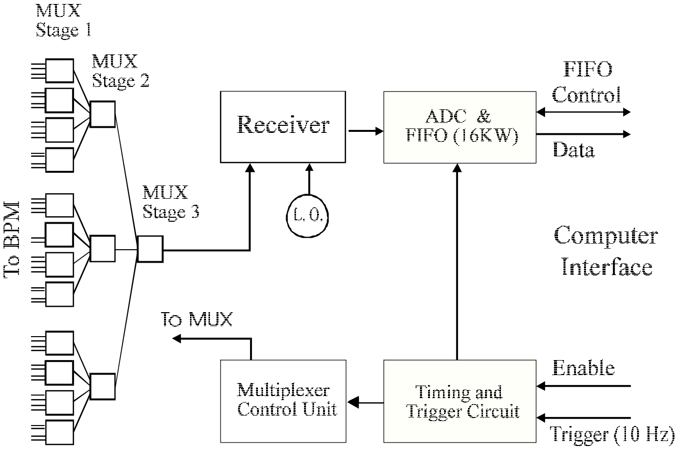

Fig. 2 Block diagram of hardware

III. THE RESULT AND DISCUSSION

With the new beam position acquisition system, we have a first look at the closed orbit of the SRRC synchrotron during ramping. The measurement accuracy is estimated about 250 microns. At present we have measured the horizontal closed orbit with the machine parameters used during routine operation. The closed orbit distortion of electron beam during ramping at some specific time is shown in Fig. 3. During this measurement, the extraction bumpers and kicker were not turned on. From this figure, we suspected that two or three BPMs did not act as expected. But, in general, the bars representing the beam positions give us about 4 periods, which is consistent with our previous measured tune, around 4.15 [2]. At the beginning of ramping, the beam position changed rapidly with time. After ramping for 15 msec these bar charts are shown to have the same shape, which indicates that the beam positions become stable until the next ramping cycle begin. This can also be seen in Fig. 4, where the 3 extraction bumpers were turned on about 47 msec after the ramping cycle began. Thus, it indicates that the horizontal tune and orbit had no significant change after 15 msec from the injection.

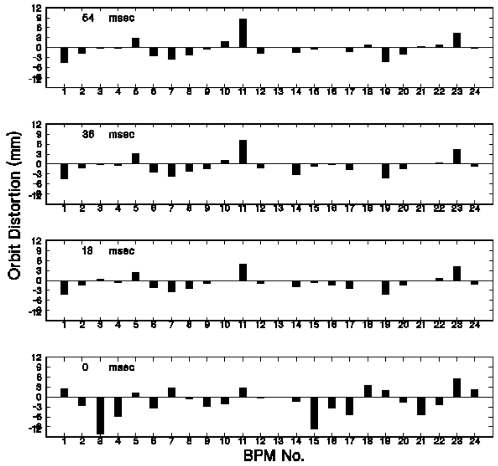

Fig. 3 Closed orbit distortion measured at some specific time during ramping, where the BPM No. 1 is located in the section before the injection septum and the BPM No. 13 is not used.

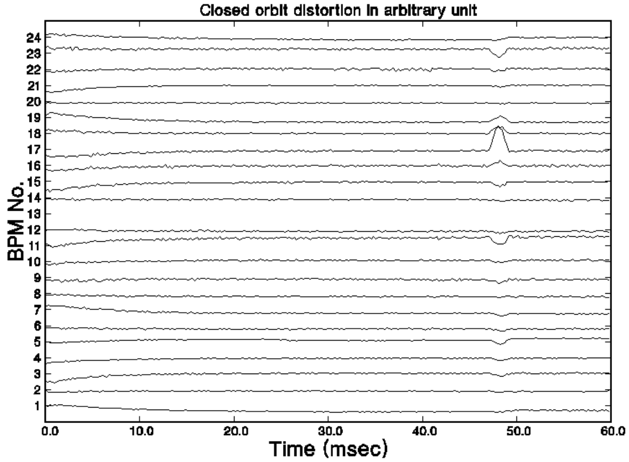

Fig. 4 Closed orbit when all 3 extraction bumpers were on. The tick mark on both sides also marks the center of the orbit of the corresponding BPM. Also, the distance between two ticks is 15 mm.

In Fig. 4, the effect of the 3-bumper magnet system used to move the beam close to the entrance of the extraction septum for extraction is shown, where the beam positions measured by all 23 BPMs from the beginning of ramping until 60 msec are presented. One sees that after the extraction bumpers were turned on, the closed orbit was changed by these 3 bumpers. In the figure, it is clear that a bump was created locally between the first bumper and the third bumper, from BPM 16 to BPM 19. And it does give a very large orbit distortion before the extraction septum, BPM 17. But, it is also seen that there were other bumps measured by the BPMs, which do not show up when the 3-bumper system were turned off. Thus, these bumps were obviously created by the 3 extraction bumpers. In other words, these 3 bumper magnets did not create a simple local bump as originally designed.

We have also varied the parameters of some of the steering correctors and single extraction bumper magnet in order to see how the beam reacts to these changes. We found that the correctors affected the electron beam only at low energy as expected, since only small currents used in the correctors. The beam positions obtained by the BPMs were also qualitatively consistent with the theoretical prediction. As for the bumper, most of the beam positions obtained also agreed qualitatively with the calculation, but some did show an unexpected reaction. It still needs further study.

IV. CONCLUSION

From this measurement we have found that the closed orbit of SRRC's booster synchrotron was somewhat different from what we expected. From the information obtained in this measurement we have considered several improvement in the future. Since the beam position at the beginning of the ramping cycle showed varying with time and different from that at 15 msec after the ramping begin, a best combination of the strength of steering correctors should be found to correct the orbit during this period. This will reduce the beam loss during ramping. At the same time, the parameters, such as phase variation between bumpers and the strength of each bumpers should be optimized in order to create a true local bump in the section between the first and the last bumper magnet. If the beam closed orbit of SRRC synchrotron can be optimized and fully controlled, many benefits can be obtained. The most important one is that the Twiss parameters at the exit of the extraction septum can be controlled easily. Thus, the initial condition of the electron beam at the transport line will be known, which will in turn let us tune the electron beam in the transport line much easier and also lead to a better injection efficiency to the storage ring. Meanwhile, a controllable beam closed orbit means we can manipulate the conditions of electron beam. It will provide us more opportunity in studying the beam dynamic behavior.

V. ACKNOWLEDGMENT

The authors would like to show their appreciation to all of the personnel of the injection group of SRRC for their help in setting up the acquisition system and operating the booster synchrotron during the measurement.

VI. REFERENCES

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[2] K. K. Lin et al., "Performance of SRRC 1.3 GeV electron booster synchrotron", To be published in Nuclear Instruments and Methods in Physics Research, Section A (1995).