ISBN: 978-3-95450-214-1 ISSN: 2673-5490 doi:10.18429/JACoW-IPAC2021-MOPAB124

APS BOOSTER INJECTION HORIZONTAL TRAJECTORY CONTROL UPGRADE*

C. Y. Yao#, H. Shang, A. Pietryla, G. Fystro, J. Calvey
Argonne National Laboratory, 9700 S. Cass Ave, IL60439, U.S.

Abstract

The APS booster is a 7-GeV electron synchrotron with a 0.5-second cycle. The booster runs a set of injection control programs that correct the beam trajectory in the horizontal and longitudinal planes, and the betatron tunes. Recently we developed a single-turn BPM controllaw program for horizontal trajectory control to replace the previous FFT based horizontal controllaw program. We present the system configuration and results.

INTRODUCTION

The APS Booster synchrotron runs a set of feedforward injection control programs: longitudinal, horizontal and tune control, to maintain injection efficiency. These are all based on FFT-processed real and imaginary components of two BPMs [1]. Recently we upgraded the Booster BPMs to BSP-100 system [2], which has both average and single-turn acquisition modes. We implemented a new horizontal injection controllaw process that monitors a set of single-turn BPMs. The new process allow to steering the trajectory of first turn beam instead of simply minimize betatron oscillation.

HORIZONTAL INJECTION CONTROL CONFIGURATION

Figure 1 shows lattice of the first quadrant of the Booster synchrotron lattice. The horizontal injection controllaw monitors the BPMs from injection point B4C8P2 through B1C9P2. The variables are injection septum (BIS) and kicker (BIK).

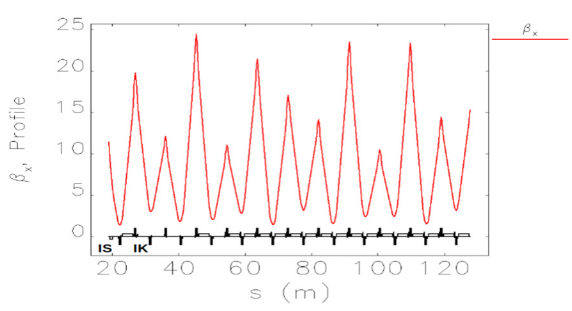

Figure 1: Booster injection to first quadrant lattice.

BOOSTER SINGLE-TURN BPM SETUP

The Booster BPM system is triggered by an event system of the APS control system [3]. The event system has a time resolution of 100 ns.

Figure 2 shows a timing diagram of the BPM single-turn acquisition. For single-turn injection applications we use Booster injection event. The injection event marks a start of an injection cycle of 0.5 s. Due to the cable length differences of the BPMs, each BPM needs a different delay from the event in order to align its sample time with arrive time of injected beam. The adjustment resolution of the delays is 0.1 µs. The Booster revolution clock, with a period of 1.227 µs, provides final synchronization with the injected beam.

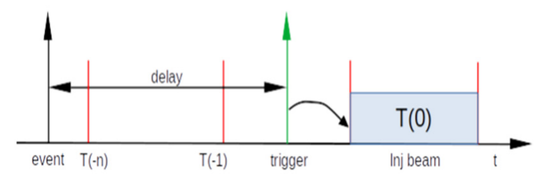

Figure 2: Timing diagram of the Booster BPM singleTurn trigger. T(0)-T(-n) are booster turn marks. Trigger delays are set so all BPMs sample only at firs turn.

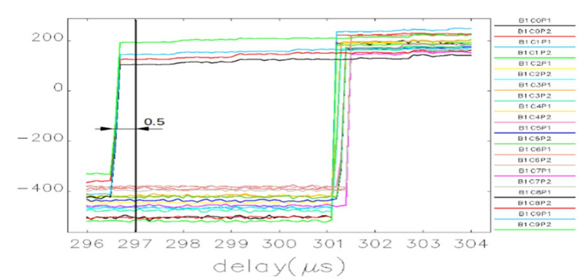

Figure 3: Timing scan of BPM sum signal. Trigger delay is set at 0.5 µs after rise time of sum signals. The vertical line shows delays for B1C0 and B1C1 BPMs.

A timing scan program scans the delays and monitors the sum signal of the BPMs and determines the best delay value for the BPMs. Figure 3 shows a plot of the scan results.

* work supported by the U.S. Department of Energy, Office of Science, under Contract No. DE-AC02-06CH11357.
# cyao@anl.gov

12th Int. Particle Acc. Conf. IPAC2021, Campinas, SP, Brazil JACoW Publishing
ISBN: 978-3-95450-214-1 ISSN: 2673-5490 doi:10.18429/JACoW-IPAC2021-MOPAB124

RESPONSE MATRIX

BPM response matrix is simulated with elegant and measured with beam. Figure 4 shows the simulated and measured system response.

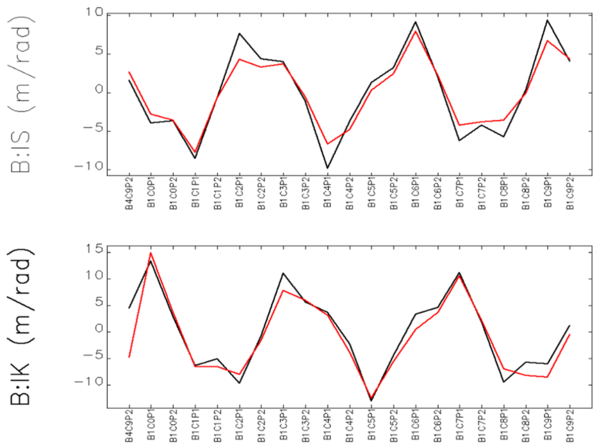

Figure 4: Simulated (Black) and Measured response matrix (Red).

SYSTEM STABILITY TEST

We performed system stability test with a large change of the BIS and BIK. Figure 5 shows the results. Both variables return to the normal values after an exponential decay process. And there is little coupling between the IS and IK, which is an improvement from previous FFT-based injection control.

We monitored the changes in BIS and BIK during normal operations. Figure 6 shows the data over a five-day period. The injection control process maintained the BIK and BIS setpoints within ±0.04 kV and ±0.2 V, respectively.

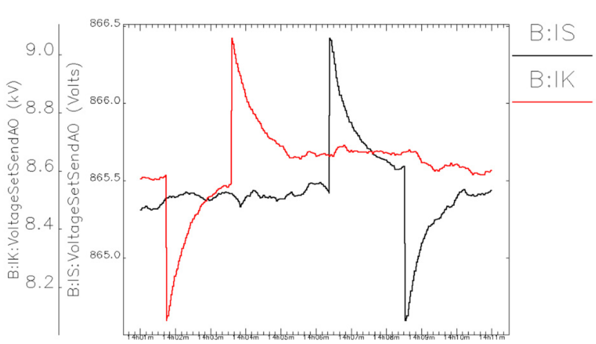

Figure 5: IS and IK response after a large step changes.

The APS Booster syschrotron runs with a momentum offset of -0.063% due to circumference changes of APS storage ring. For machine studies we sometimes need to ramp the rf frequency. With the new horizontal injection control process we can maintain the Booster injection efficiency by running the injection control process and updating the trajectory setpoint in steps along the ramp process.

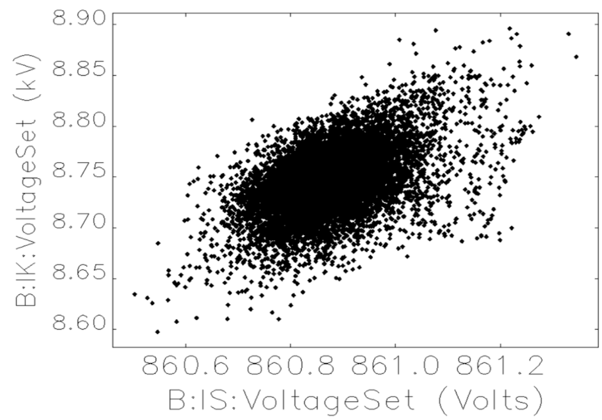

Figure 6: Logged IS and IK setpoint during normal operations.

CONCLUSIONS

A new single-turn BPM injection control is implemented for the APS Booster to replace the original FFT based control. Beam test showed the system is effective in maintaining injection trajectory for both normal operations and machine studies.

ACKNOWLEDGMENTS

We thank APS operators for their assistance during studies and operations.

REFERENCES

[1] N. Sereno, *et al.*, "Feedback correction of injection errors using digital signal-processing techniques", *Phys. Rev. ST Accel. Beams*, vol. 10, no. 1, p. 012803, Jan. 2007. doi:10.1103/physrevstab.10.012803

[2] H. Shang, *et al.*, "Application software for the BSP-100 beam position monitor at the APS", in *Proc. ICALEPCS'09*, Kobe, Japan, Oct. 2009, paper TUP036, pp. 167-169.

[3] F. Lenkszus, "APS injection timing", APS ICMS document aps_1284690.pdf