

Design and Initial Results of a Turn-by-Turn Beam Position Monitoring System for Multiple Bunch Operation of the ATF Damping Ring

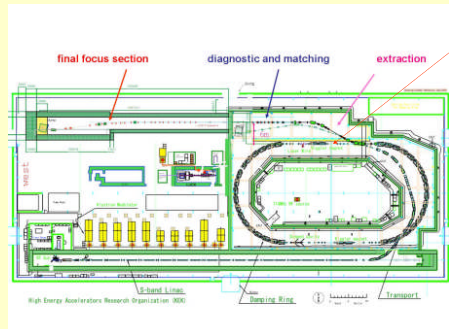


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Abstract

An FPGA-based monitoring system has been developed to study multi-bunch beam instabilities in the damping ring (DR) of the KEK Accelerator Test Facility (ATF), utilising a stripline beam position monitor (BPM) and existing BPM processor hardware. The system is designed to record the horizontal and/or vertical positions of up to three bunches in the DR in single-bunch multi-train mode or the head bunch of up to three trains in multi-bunch mode, with a bunch spacing of 5.6 ns. The FPGA firmware and data acquisition software were modified to record turn-by-turn data for up to six channels and 1-3 bunches in the DR. An overview of the system and initial results will be presented.



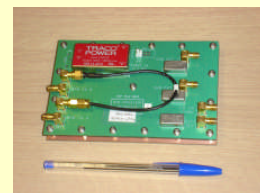
Two stripline BPMs in DR

Properties of ATF DR

- Energy: 1.3 GeV
- Circumference: 138 m
- Revolution frequency: 2.16 MHz
- Machine repetition rate: 1.56 Hz
- Up to 3 trains injected per cycle
- Up to 10 bunches per train @5.6 ns bunch spacing
- Store time per cycle: $\sim 10^6$ turns

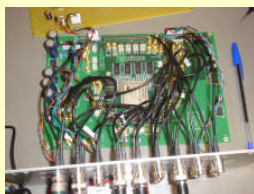
System Design & Hardware

FONT5 digital processor board
 Unmodified from extraction line feedback system – differential attenuation added to measure large position offsets in DR

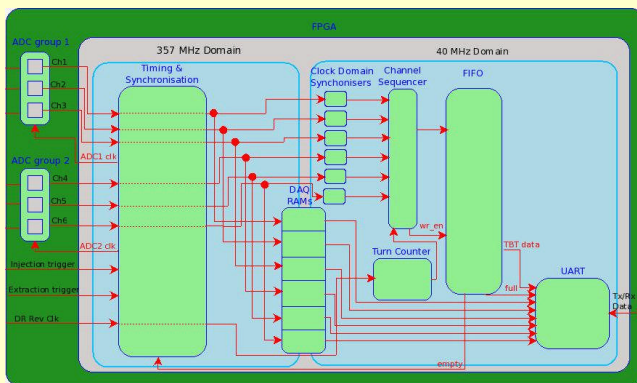


Key Design Features:

- Re-uses existing hardware with modified firmware/DAQ software
- Records turn-by-turn data for up to three bunches per turn
- Record data from up to 6 channels (2 BPMs – horizontal and vertical difference, & sum)
- Single large FIFO memory stores 131071 samples (Maximum of $\sim 15\%$ of store time for consecutive turns single bunch, single channel)
- Can vary time window and time resolution to record every n turns in m .
- Data returned in $\sim 4s$ – can record data from every 1 in 3 machine cycles in multi-train mode.

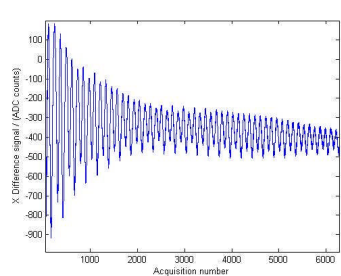


FONT5 FPGA-based digital processor
 Used for DAQ for DR monitoring system. FPGA firmware and DAQ software modified for turn-by-turn operation

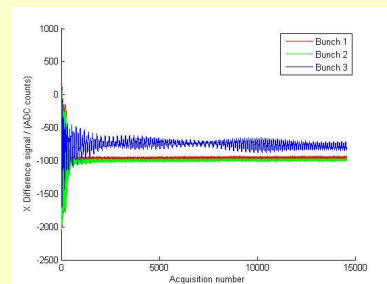


Schematic overview of the FPGA firmware for turn-by-turn monitoring

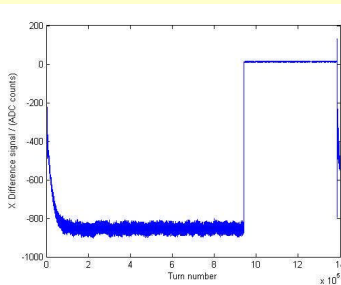
Initial Results



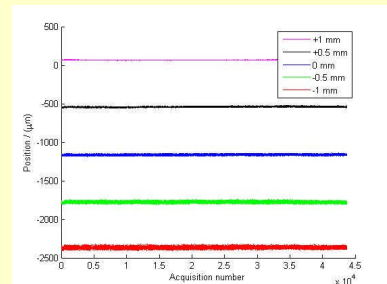
X difference signal for first few thousand turns of single bunch beam. Note injection occurs at turn number 6.



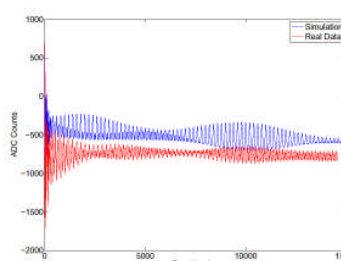
X difference signals for first few thousand turns of multi-train beam.



X difference signals for every 1 turn in 32 of single bunch beam. Note that injection occurs at turn 0 and extraction around turn number 940000. On the far right of the figure a subsequent injection can be seen, at a time of 0.65 s after the first, corresponding to the next machine cycle.



Vertical position for c. 45000 turns of single bunch beam, for five different vertical orbit bump settings.



Simulation

A comparison between the simulated and real difference signals in the damping ring. The high frequency betatron oscillation can be seen in the first few turns, while the lower frequency synchrotron oscillation and its various harmonics can be seen to last for much longer timescales. The very low frequency beating is believed to be due to a harmonic of the 50Hz mains AC voltage.

References

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- [4] R. Apsimon et al, Proceedings IPAC10, Kyoto, Japan, p. 2788.
- [5] M. Ross, B. Mellor, ATF Report, ATF-04-06,
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