An FPGA-based Turn-by-Turn Beam Position Monitoring System for Studying Multiple Bunch Beams in the ATF Damping Ring

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Motivation for a turn-by-turn BPM system for the ATF2 DR:

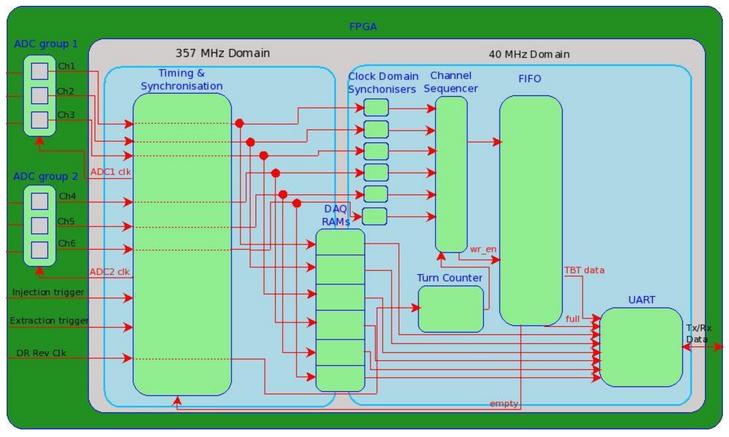
Poor bunch-to-bunch correlations observed for a 3-bunch train in the ATF2 extraction line. Possibly caused by oscillations/instabilities in the ATF damping ring.

FONT5 hardware is suitably fast for the DR BPM system. New firmware is loaded onto the digital board; analogue hardware is unaltered.

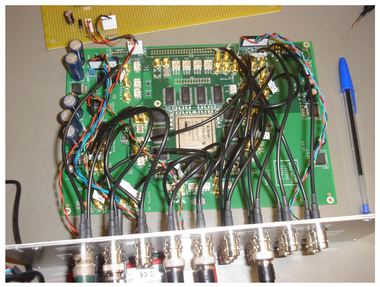
Damping ring beam position monitoring firmware:

DR firmware has been optimised to utilise the maximum amount of RAM on the FONT5 digital board. This allows a total of 131,071 samples to be stored in one acquisition of the DR firmware. The total number of turns in the DR that this corresponds to depends on the number of bunches in the DR and the number of ADC channels being recorded.

In the turn-by-turn mode, the FONT5 board records the peak sample for each bunch in the train. For the last turn of acquisition, 164 samples are taken in steps of 2.8ns. This allows us to observe any features of the bunches and baseline regions.



Digital feedback processor:



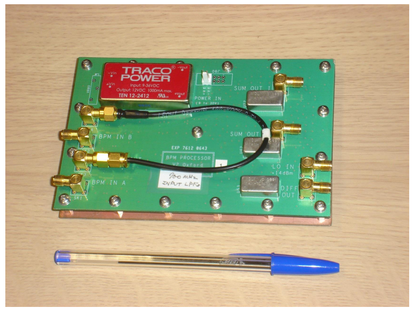
Xilinx Virtex5 FPGA

Clocked at 357 MHz phase-locked to beam

9 ADC input channels (TI ADS5474)

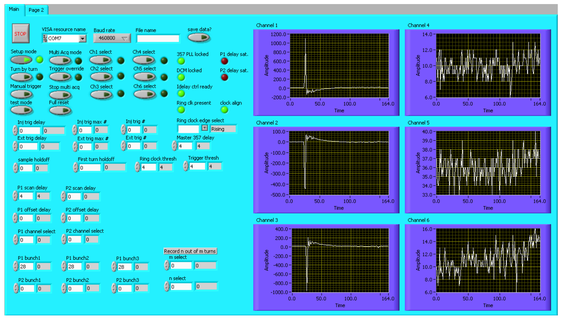
4 DAC output channels (AD9744)

Analogue processors:



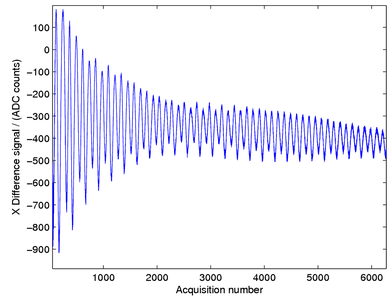
The analogue processors were unmodified for the DR system. DR BPMs not on movers and beam is far from centre of BPM; this saturates the Diff output of the processor. Different value attenuators placed on the two processor inputs. This appears as a position offset, while minimising the effect on the bunch charge.

Damping ring DAQ system:

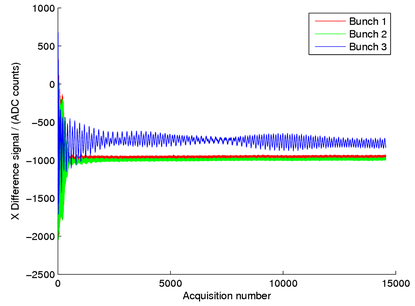


Screenshot of the damping ring DAQ system being used at ATF2, KEK

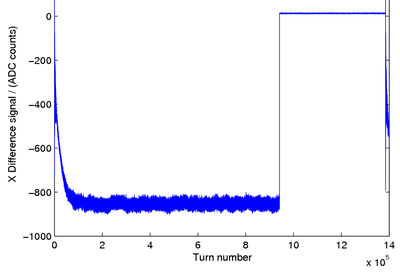
Initial data from ATF2 DR:



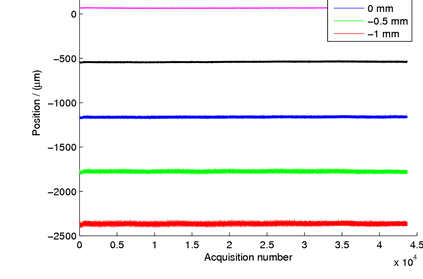
X difference signal for first few thousand turns of single bunch beam. Note injection occurs at turn number 6.



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.