DEVELOPMENT OF HIGH PRECISION BEAM POSITION MONITOR READOUT SYSTEM WITH NARROW BANDPASS FILTERS FOR THE KEKB INJECTOR LINAC TOWARDS THE SUPERKEKB

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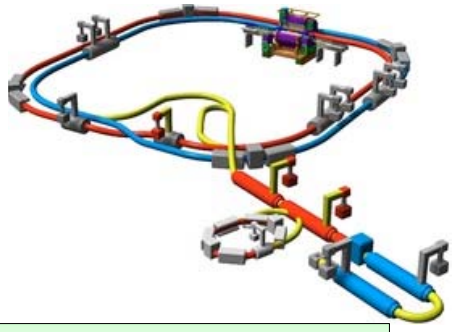
SuperKEKB accelerator complex

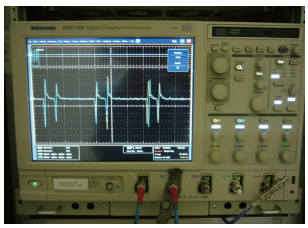


SuperKEKB specifications

- World highest luminosity: L=8x10^{35} /cm^2/s
  - 40 times brighter than KEKB
- Positron dumping ring
- 8-GeV injector linac, *in each 20ms (50Hz)*, injects e$^-$ and e$^+$ into
  - KEKB high-energy ring (HER): **7 GeV, 5 nC, 20 mm mrad e$^-$**
    - at KEKB, 8GeV, 1nC, 100 mm mrad e$^-$
  - KEKB low-energy ring (LER): **4 GeV, 4 nC, 10 mm mrad e$^+$**
    - Positron primary: **4 GeV, 10 nC e$^-$**
    - at KEKB, 3.5GeV, 1nC, 2100 mm mrad e$^+$
  - Photon Factory (PF): **2.5 GeV, 0.1nC e$^-$**
  - PF-AR (single bunch mode PF): **3.0GeV, 0.1nC e$^-$**
- Accelerator structures have to align within ±0.1 mm accuracy.
  - BPM are required to have *one magnitude better position resolution*:
    - <10 μm position resolution.

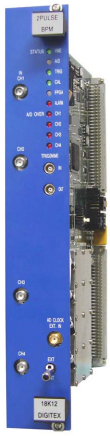
Existing system (oscilloscope)

- 100 BPMs are read out by ~20 readout system.
- 10 Gsa/s oscilloscope as a waveform digitizer.
- Two scope's channels with different attenuation are used for wide dynamic range input.
- ~50 μm position resolution.
- EPICS IOC is running on scope's WinXP.



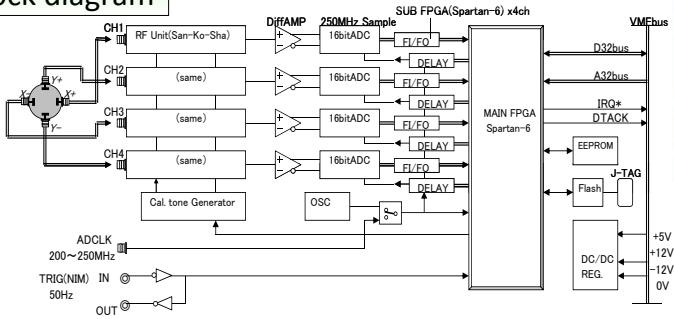
Tektronix DPO7104 (10 Gsa/s 4 ch, 8 bit, 50 Hz trigger operation)

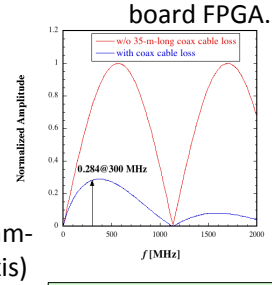
New system

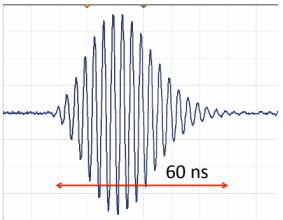


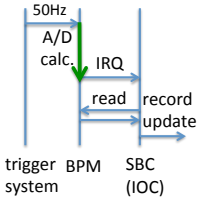
- VME-based system
  - 1 board for 1 BPM
- Narrow bandpass filter (BPF) under sampling type.
  - 16-bit 250MSa/s ADC
  - Fc=300 MHz (3rd Nyquist Zone: 250-375MHz)
    - Two Bessel filters with helical-coils.
- Accepts 96 ns interval two bunches.
- Two electrical attenuators for high dynamic range input.
- Measured position drifts are compensated by on-board calibration.
  - Between the beam cycle, calibration tones are output to the BPM electrodes to determine the inter-channel gain imbalance.
- Position/Charge calculations are performed with on-board FPGA.

Block diagram

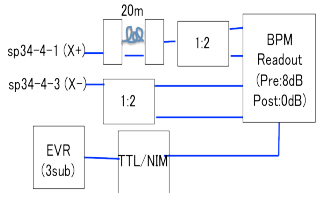




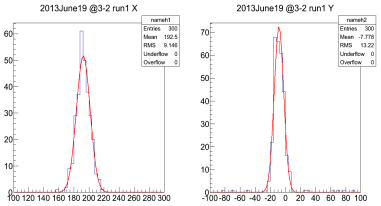




Beam Test



- Using beam signal, ideal (no beam-jitter) two-bunch beam (for X-axis) is emulated.
- 100 events (at 0.45 nC /bunch) taken.



Position Resolution	1st	2nd
ch1, 2(X)	5.7 μm	8.2 μm
ch3, 4(Y)	5.1 μm	

(preliminary)

Summary and future plan

- Achieved target position resolution (<10 μm) and design refining for final prototype is underway.
- New readout system will be installed at 2014 summer shutdown.
- EPICS IOC, timing system implementation.