Digit500 Tests on SXFEL

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SSRF

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Recent status on SSRF

- Synchrotron radiation facility: upgrade in progress (beam lines construction)
- Soft X-FEL Test Facility: completed in this June. User Facility: will start in August
- SHINE: tunnel construction in progress, and key-technologies research stage
BPM processors for SHINE

- Signal processing for Cold Button, Stripline, Cavity BPMs
- Standalone structure based on Xilinx SOC FPGA, 1U’ height
- FPGA mother board, FMC ADC and timing mezzanine cards
- $\geq 500\text{MSPS}, \geq 14\text{bits}$, also can be used as bunch by bunch processor on synchrotron facility
- 1MHz repetition rate
- Digit500 is applied as a test platform to check the design.
Pre-research with Digit 500

Libera Digit 500 - overview

- 4 input channels – 50Ohm
- ADC: 500MHz – 14bit
- Sampling clock: free running or externally locked with HW PLL
- 32 dB of variable gain (channel independent)
- 3x LVTTL trigger lines

DC~250MHz BW
Cavity BPM test

- Cavity BPM reference IF signal @700pC was split to 2 ways and fed into Digit500 2 channels
- External 476MHz sampling clock
- Off-line data evaluation: noise level and resolution

![Diagram of Cavity BPM test setup]

- RF front-end
- 1-2 splitter
- Digit500
- Clock
- 4.7GHz RF
- 30MHz IF
- Trigger
Noise level

- No input signal: Mean[std(noise)] = 3.3
- With signal: Mean[std(noise)] = 4.2
**Amplitude and phase resolution**

- **Relative amplitude resolution** \(0.034\%\)
- **Relative phase resolution** \(12.5\text{fs}\)

**Graphs:**

- **Amplitude vs. Time:**
  - Amplitude / a.u.
  - Time / us

- **Relative Resolution:**
  - Linear fitting
  - Relative resolution = 0.034%
  - Total samples = 980 / 1000

- **BFT Resolution:**
  - BFT / fs
  - Counts
  - BFT resolution = 12.5 fs
  - Gaussian fitting

- **Phase vs. Counts:**
  - Phase / deg
  - Counts
  - Trigger jitter?
Beam charge measurement

1-2 splitter

Digit500 /OSC.

ICT

Trigger

Data from oscilloscope

Data from Digit500

DSO9064A
600MHz BW
10GSa/S
Current calculation directly

- The Digit500 relative resolution is 0.76% compared to 0.6% of oscilloscope.

Digit 500

Oscilloscope
Charge measurement--PCA

- After applying PCA, the Digit500 relative resolution is improved to 0.25% compared to 0.32% of oscilloscope.
Conclusions

- Digit500 hardware shows good performance, can be used for cavity BPM signal acquisition. Also stripline BPM can be used.

- SXFEL is using oscilloscope for ICT charge measurement. Digit500 shows comparable performance, could be used for charge measurement after calibration.
Question: How to resolve the clock and trigger jitter?

One possible explanation:
- Trigger signal arrives on the edge of clock.
- Trigger signal may be captured 1 clock delayed.
- Phase result will be different after one sample point.

How to resolve this problem?