Basic Functionality Presentation with Live Demonstration Digital Signal Conditioning

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Multiplexed vs Classic Four Channel Architecture

Multiplexed advantages	Four Channel advantages
Beam Current Dependence (BCD)	Higher speed of data processing
Fill Pattern Dependence (FPD)	Much wider bandwidths possible
Temperature Dependence (TD)	Better Resolution

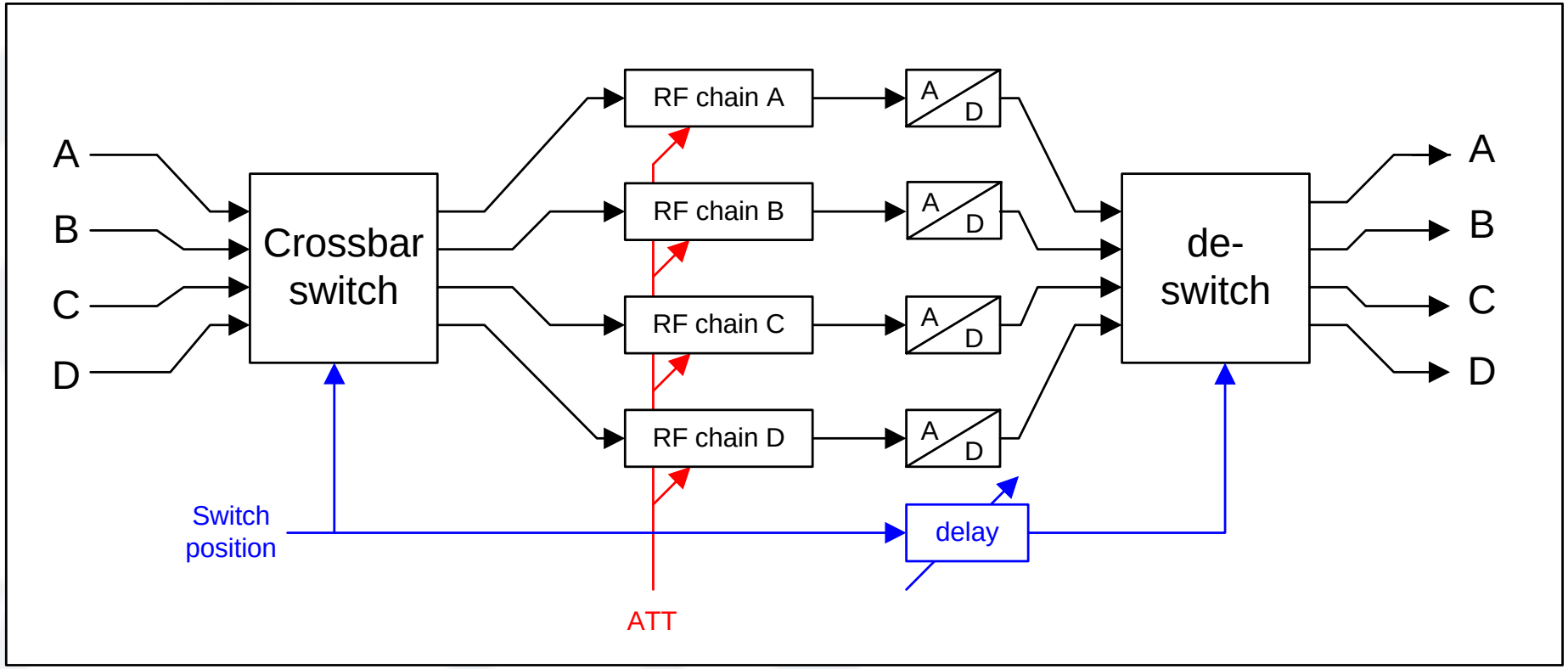
Motivation and Goals for the DSC

- To unite the benefits from both multiplexed and multi channel architectures.
- To not compromise excellent properties of the multi channel system.
- To concentrate on improvement of BCD, FPD and TD on FA and SA data streams.
- Wideband measurements (ADC, TBT) are not affected by BCD, … and therefore should be preferably performed with DSC stopped.

RF Board with Crossbar Switch, 1

- The switch facilitates redirection of any of the four input signals to any of the four RF channels.
- The digital crossbar switch is able to redirect the analog channels back to the original channel.
- Switching significantly improves important Libera parameters, like Beam Current Dependence, Temperature Dependence and Bunch Pattern Dependence.

RF Board with Crossbar Switch, 2



Switching on Libera, Pattern, 1

- It switches through 8 switch positions (out of 16 possible).
- This means that every channel (A, B, C, D) is passed twice by all four input signals (Va, Vb, Vc, Vd).
- This choice was made after lots of testing, taking into account possible switching frequency also.

Switching on Libera, Pattern, 2

	Input			
switch	A	B	C	D
	Analog Channel			
0	D	C	B	A
1	D	B	C	A
2	A	C	B	D
3	A	B	C	D
4	D	C	A	B
5	D	B	A	C
6	A	C	D	B
7	A	B	D	C
8	C	D	B	A
9	B	D	C	A
10	C	A	B	D
11	B	A	C	D
12	C	D	A	B
13	B	D	A	C
14	C	A	D	B
15	B	A	D	C

Possible Switch Combinations

Sequence	Switch positions
1	3
2	7
3	15
4	11
5	0
6	4
7	12
8	8

Chosen Pattern

Switching on Libera, Frequency

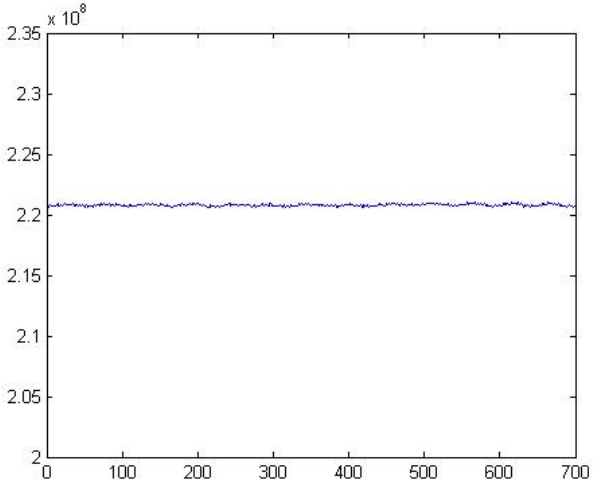
- The frequency of 13kHz (accelerator dependent was chosen).
- Reasons:
  - It still gains enough information from the uninterrupted signal between two switchings (typically ~80 TBT samples).
  - Lowest harmonic is at 1.7kHz (~13kHz/8). This leaves enough undisturbed data, FA bandwidth being 2kHz.

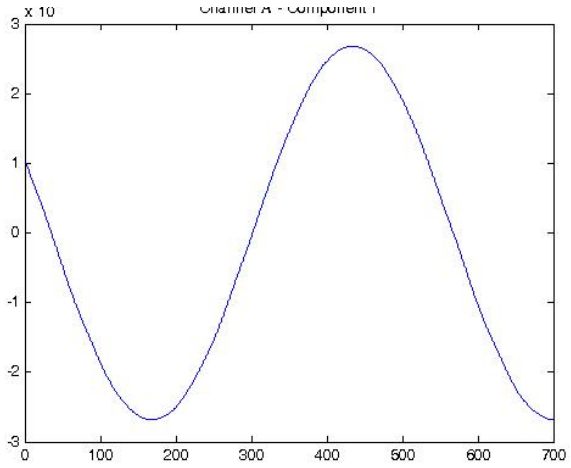
Switching on Libera, Unwanted Side Effect

- The side effect is only one: The glitches on acquired data due to switching.
- Consequences:
  - ADC rate buffer is practically unusable.
  - TBT data has noticeably higher RMS.
  - RMS is higher on FA and SA data, too.

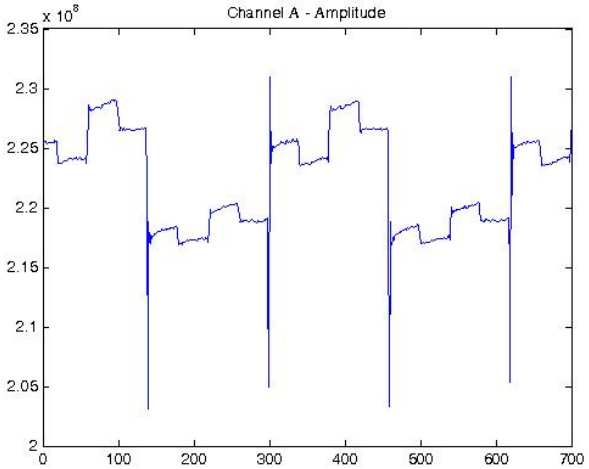
Switching, TBT Data

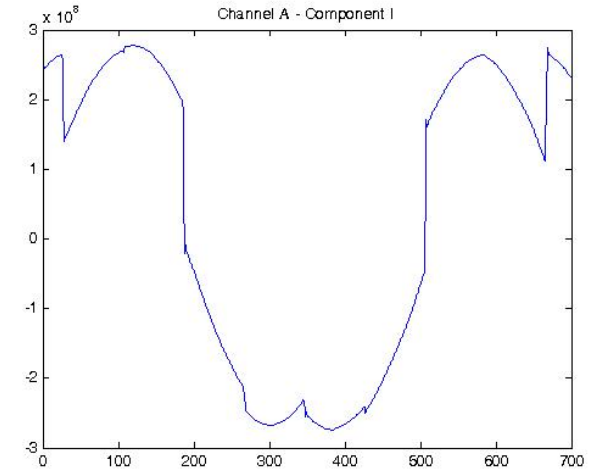
No Switching





Switching On





DSC Modules

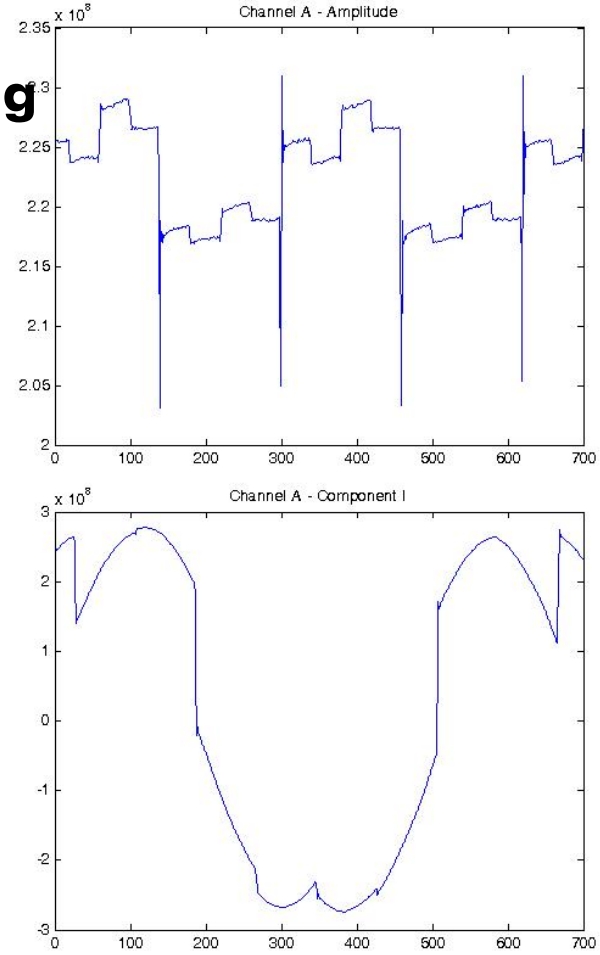
- Minimize unwanted side effects and improve the quality of data.
  - Amplitude compensation
  - Phase compensation
  - Dedicated filtering from TBT to FA rate, with two notch filters
  - Additional improvement in BCD by optimized gain scheme
- Amplitude and phase compensation coefficients are together with AGC coefficients applied in cycles of 12s.

Amplitude Compensation Module

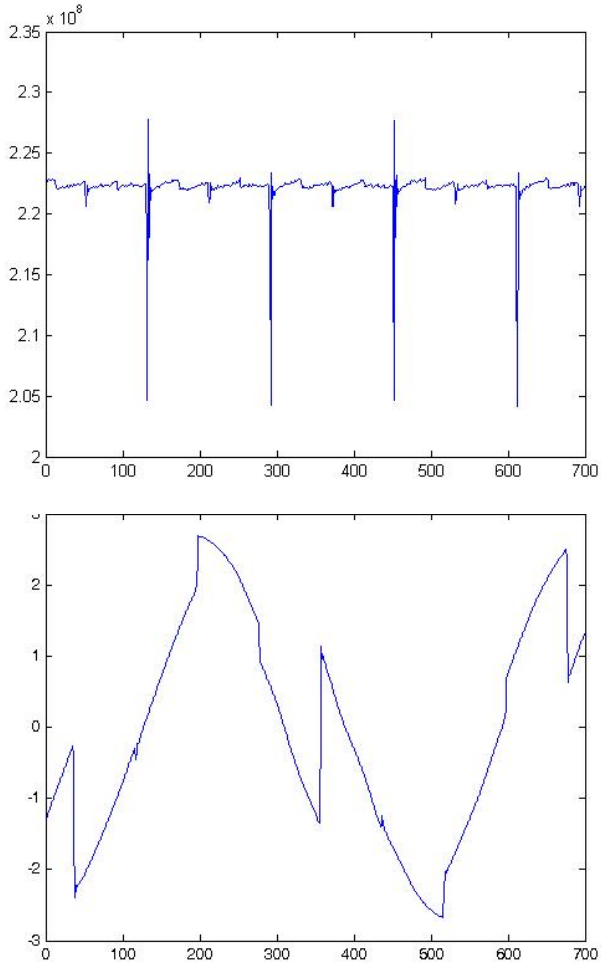
- Measures single channel amplitudes at each switch positions.
- Calculates average amplitudes for each input signal and calculates the correcting coefficients.
- Resulting matrix of 8*4 coefficients is applied to the signal at ADC output.

Switching + Amplitude Compensation

Switching



Switching + Ampl. Comp.

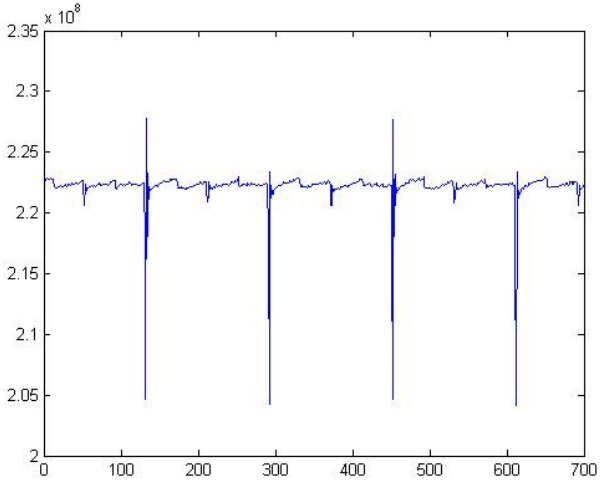


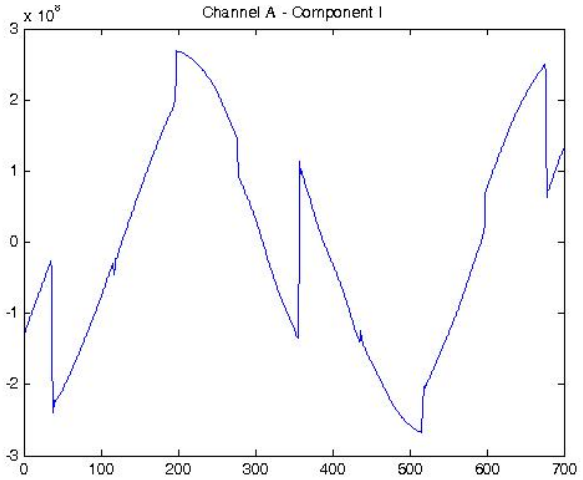
Phase Compensation Module

- Measures single channel phases at each switch position.
- Compares phase of the signal in one (predetermined) switch position with the phase in other 7 positions and calculates the correcting coefficients.
- Resulting matrix of 8*4 coefficients is applied to the signal at ADC output.

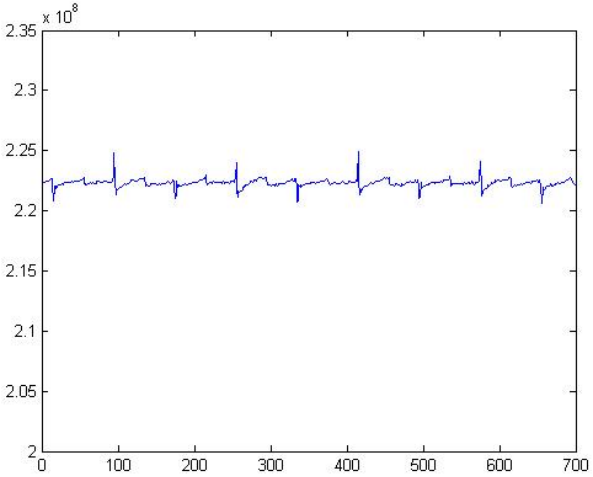
Switching + Amplitude + Phase Compensation

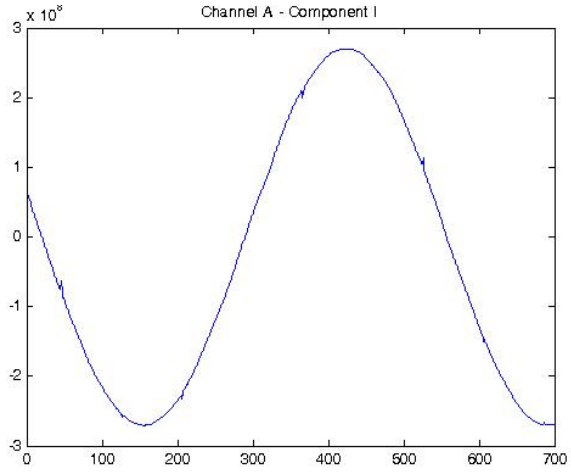
Switching + Ampl. Comp.





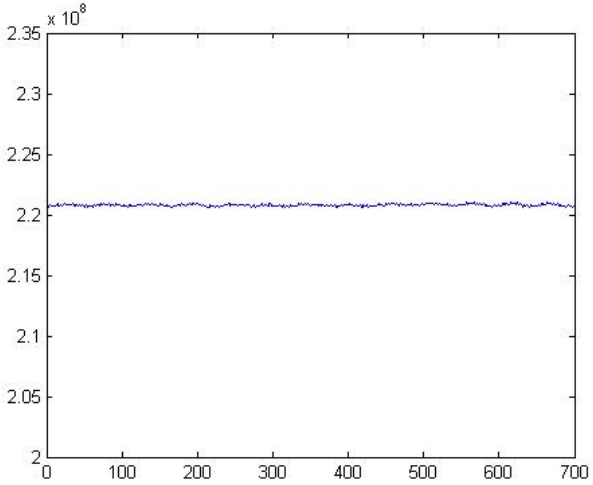
Switching + Ampl. + Phase Comp.



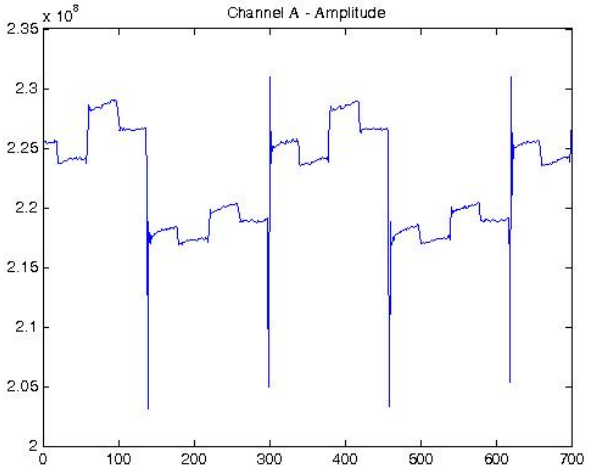


Amplitude Comparison

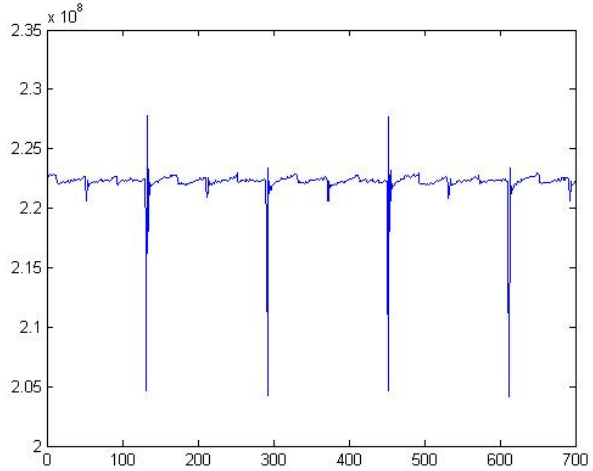
No Switching



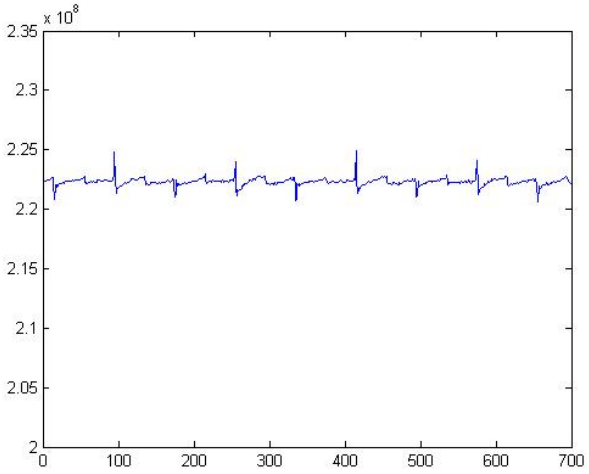
Switching On



Switching + Ampl. Comp.

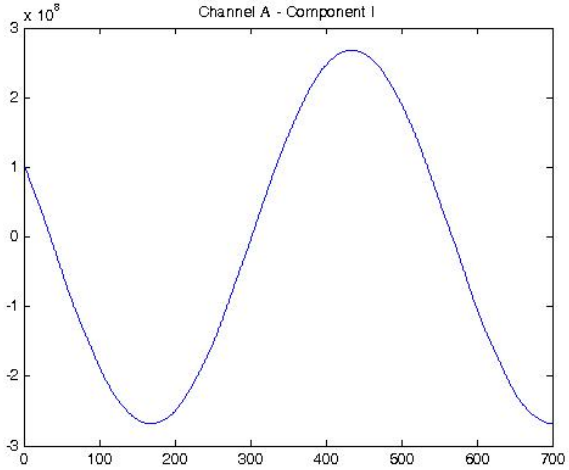


Switching + Ampl. + Phase Comp.

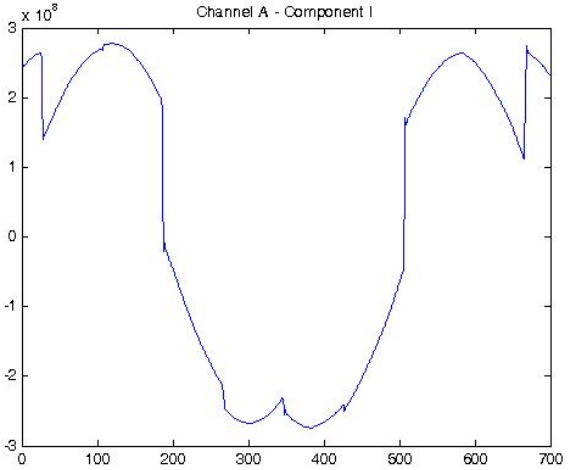


I Component Comparison

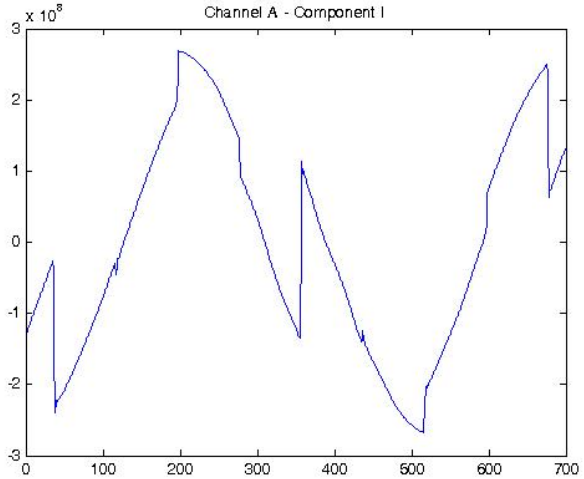
No Switching



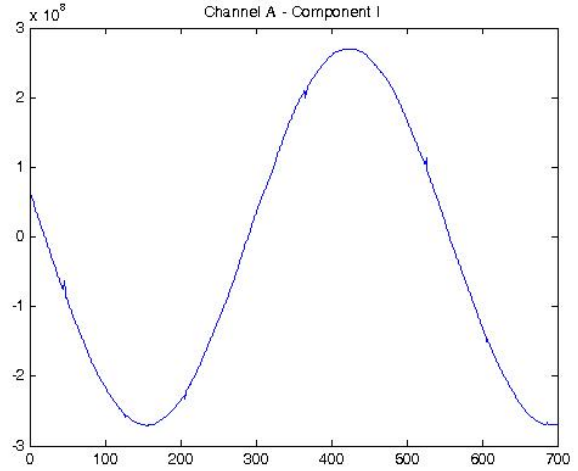
Switching On



Switching + Ampl. Comp.



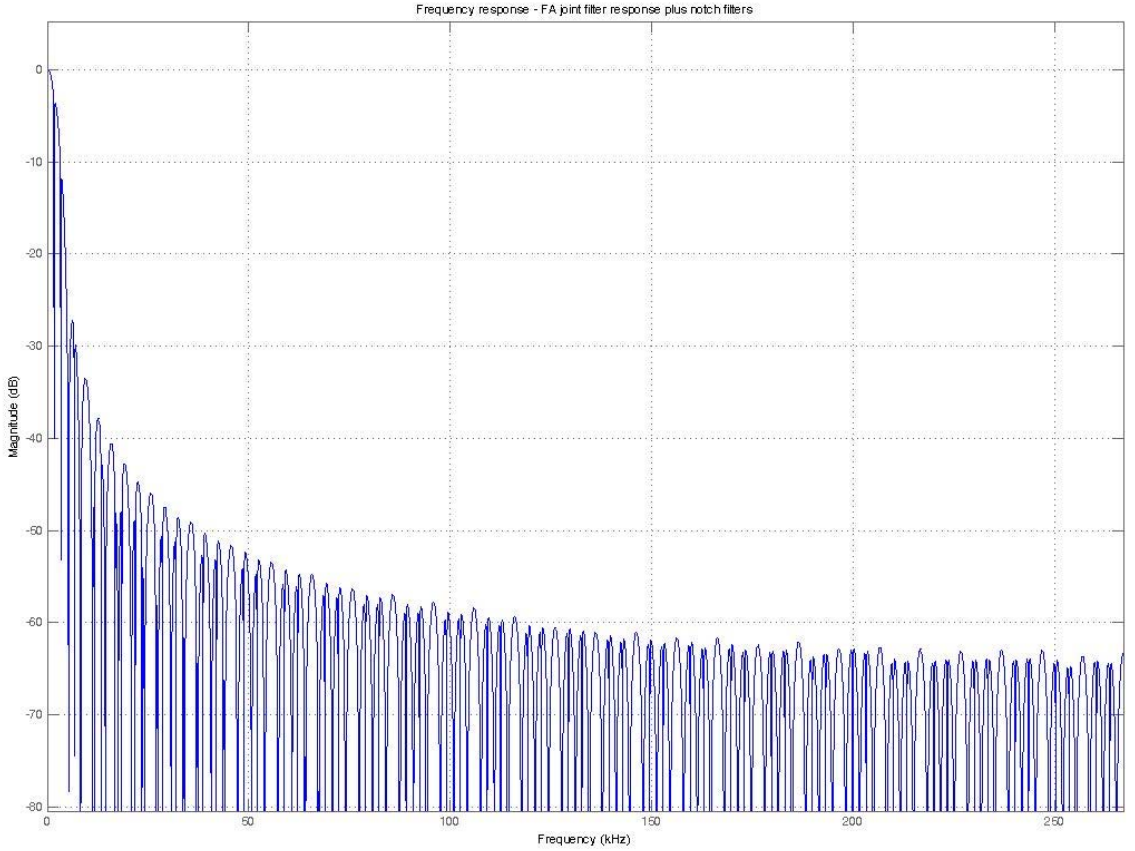
Switching + Ampl. + Phase Comp.



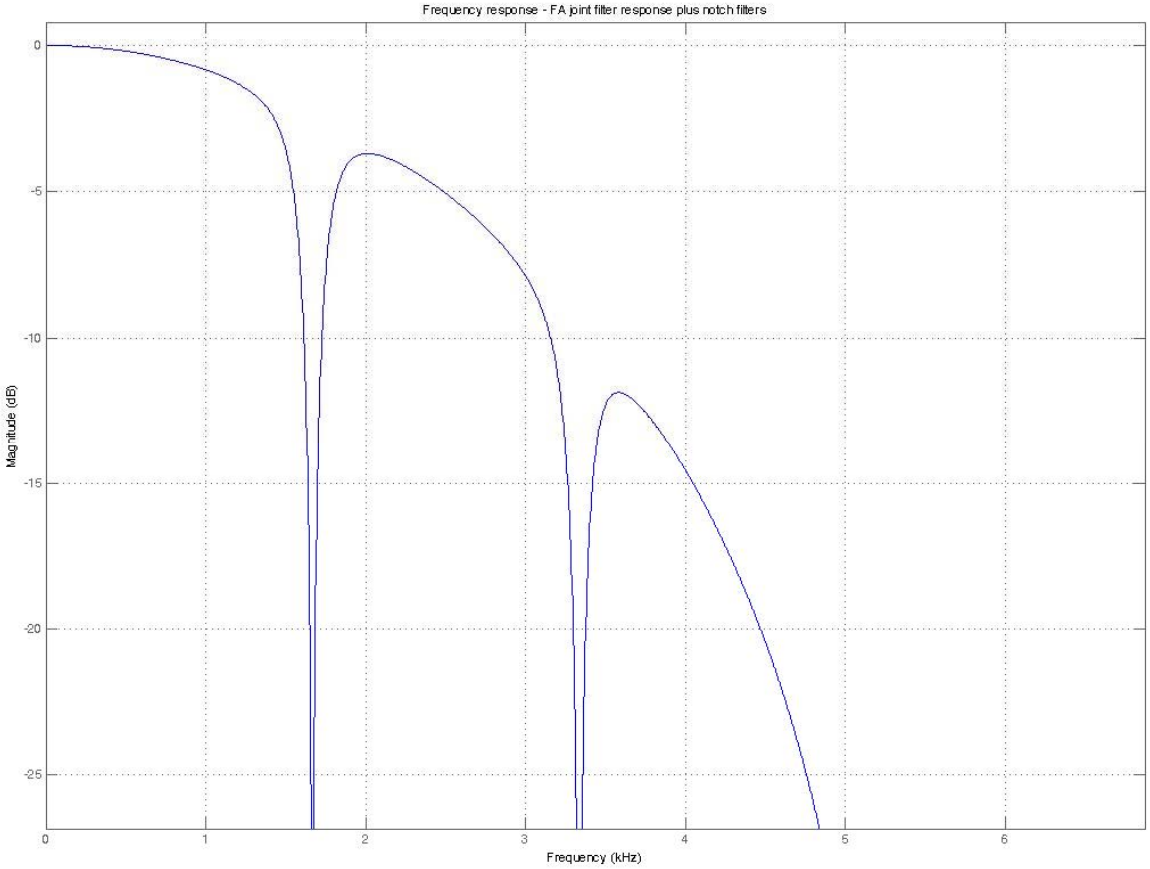
FA Filter, 1

- Optimized for speed and performance
- It consists of:
  - Polyphase FIR Filter with 3dB bandwidth of 2kHz.
  - Two Notch filters, placed at two lower harmonics of the switching (at ~1.7kHz and 3.4kHz).
  - It very effectively removes the remaining glitches (after the DSC) due to switching.
  - Simple CIC filter is added in the front if the FA decimation is over 64.

FA Filter, Frequency Response



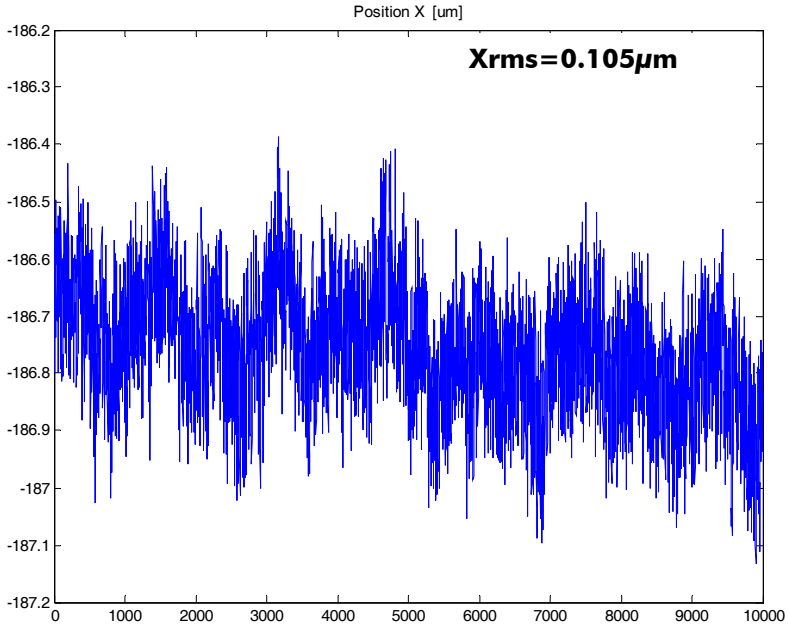
FA Filter Zoomed



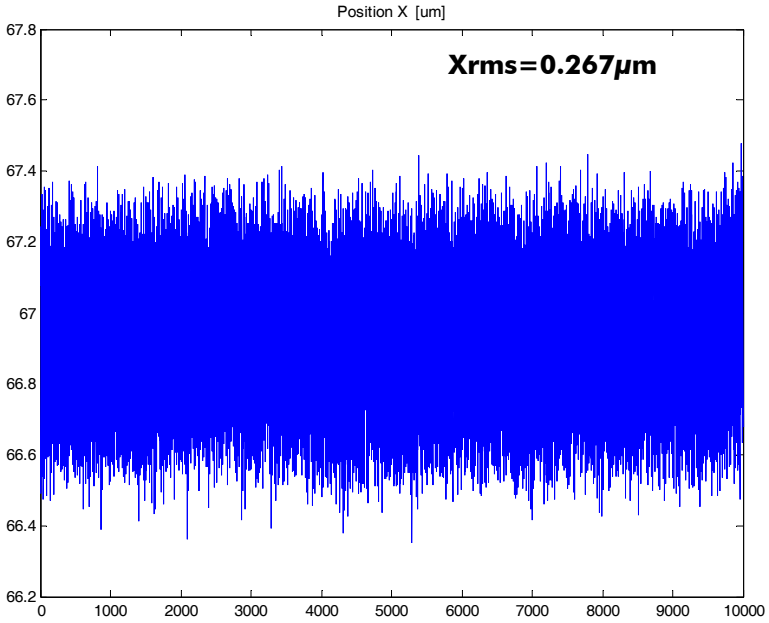
DSC Results, 1

- Main consequence of the three modules (amplitude, phase compensation and customized FA filter) is low RMS on FA data at 10kHz rate and 2kHz bw.
- Overall processing latency is kept at approx. 350*μs*.
- Both points above are the prerequisites for the Fast Feedback building.
- Slow Acquisition data has excellent RMS and very good BCD, FPD and TD, which makes it an ideal input for eventual slow feedback application.

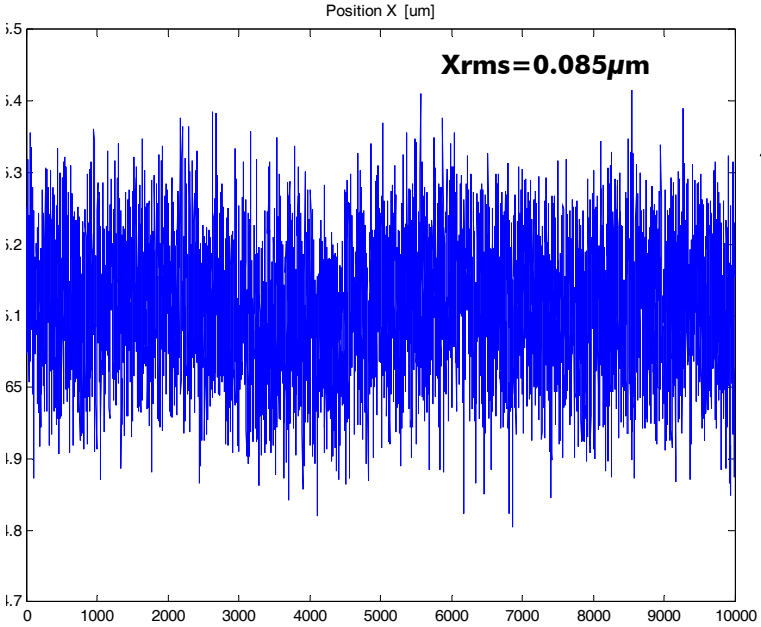
FA Data (10kHz)



Switching Off



Switching On



Switching + Ampl. + Phase Comp.

DSC Results, 2

TBT	Xrms	Yrms	position_X	position_X
no_switching	1.3747	1.5392	50.9028	-63.3279
amp_comp	17.6176	21.4091	68.8495	-114.6193
amp+phase_comp	8.3343	6.3281	69.2099	-115.0281

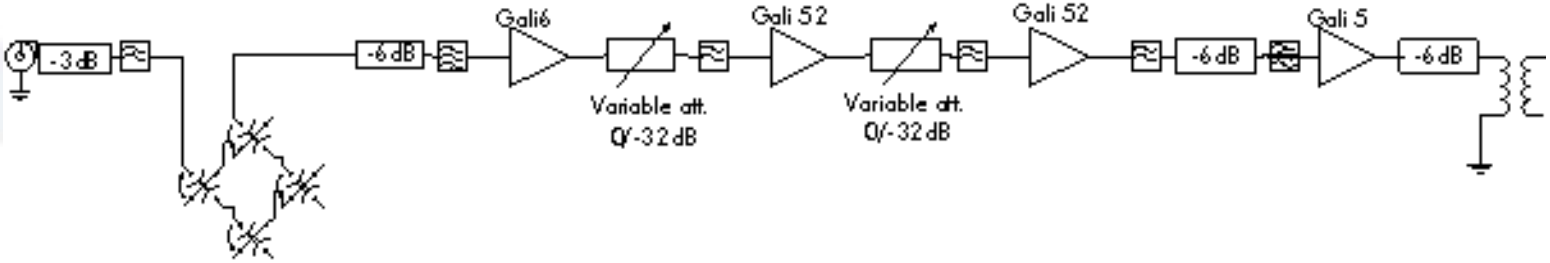
FA	Xrms	Yrms	position_X	position_X
no_switching	0.2474	0.3295	50.0450	-62.2022
amp_comp	0.3527	0.5218	68.7996	-114.4007
Measurement 01	0.3627	0.4953	69.1852	-115.0281

SA	Xrms	Yrms	position_X	position_X
no_switching	0.7152	0.3347	50.9539	-62.4946
amp_comp	0.1867	0.2601	68.8116	-114.5585
Measurement 01	0.2189	0.2286	69.1801	-115.0026

Automatic Gain Control

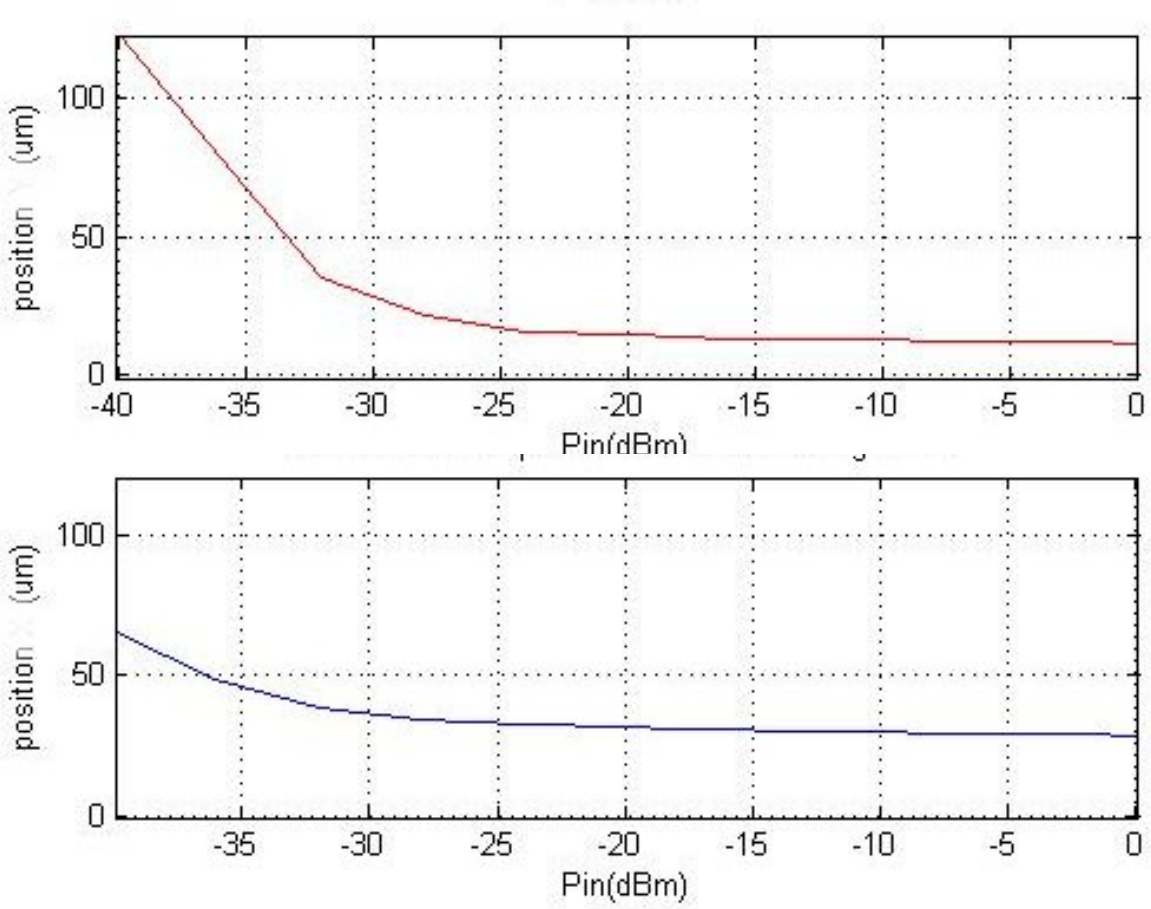
- The gain control of the analog board is possible in manual and automated manner.
- Two attenuators are placed in each analog channel, both are 5bits and the attenuation can be set between 0 and 31dB.
- The AGC is intended to cover slow fluctuations of input power; the update rate is typically in order of 10s.
- The input to AGC is the ADC rate data.
- AGC sets both attenuators according to measured amplitude and to predefined gain scheme.

Optimization of the Gain Control Scheme



- Two variable attenuators in the RF chain.
- Huge effort and lots of testing on finding ideal gain scheme. Signal levels kept under control throughout RF chain.
- Optimized gain scheme is ready, additional adjustments to special customer needs are possible.

Optimization of the Gain Control Scheme



Default

Optimized

Conclusion

- Libera full functionality is reached with the 1.40 Release (December 2006). Final performances are met.
- Libera benefited a lot from the accelerator people, especially from our two launch customers Soleil and Diamond, but not only.
- Libera is setting standards for the BPM electronics.
- Gained experience will be used in the future.