New Low Cost X-band Cavity BPM Receiver[1]

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SLAC is developing a new X-band Cavity BPM receiver for use in the LCLS-II for use in the LCLS_II. The Linac Coherent Light Source II (LCLS-II) will be a free electron laser (FEL) at SLAC producing coherent 0.5-77 Angstroms hard and soft x-rays. To achieve this level of performance precise, stable alignment of the electron beam in the undulator is required. The LCLS-II cavity BPM system will provide single shot resolution better than 50 nm resolution at 200 pC. The Cavity BPM heterodyne receiver is located in the tunnel close to the cavity BPM. The receiver will processes the TM010 monopole reference cavity signal and a TM110 dipole cavity signal at approximately 11 GHz using a heterodyne technique. The heterodyne receiver will be capable of detecting a multibunch beam with a 50ns fill pattern. A new LAN communication daughter board will allow the receiver to talk to an input-output-controller (IOC) over 100 meters to set gains, control the programmable dielectric resonator oscillator, enable self-test, and monitor the status of the receiver. We will describe the design methodology including noise analysis, distortion analysis.

BPM Specifications

- Differences

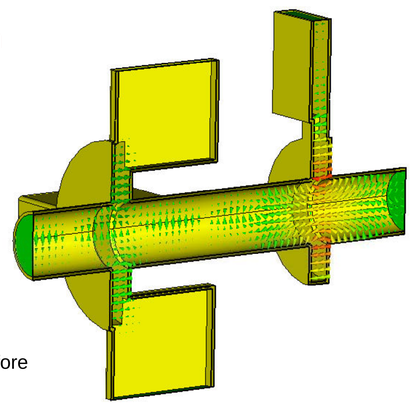
	LCLS-I	LCLS-II	Comments
Frequency	11.384 GHz	11.424 GHz	multibunch
Output	Waveguide	coax	More flexible
Tuning	12 tuning stubs	<= 4 tuners	Lower cost
Receiver	14dB I.L. with 28 dB Gain step	<= 3dB I.L. 1 dB step	Improved noise figure and dynamic range
Digitizer	SLAC/VME	uTCA	Lower cost
Ref. cavity	Single output	2 couplers	Improved mode centering

Parameter	Requirement	Conditions
Resolution	< 1 micron	200 pC < Q < 1 nC Over ± 1 mm range
Offset Stability	< ±1 micron	1 hour ± 1 mm range, 20 C ± 0.56 C
	< ±3 microns	24 hour ± 1 mm range, 20 C ± 0.56 C
Gain Stability	± 10 %	± 1 mm range 20 C ± 0.56 C
Aperture	10 mm	

Design

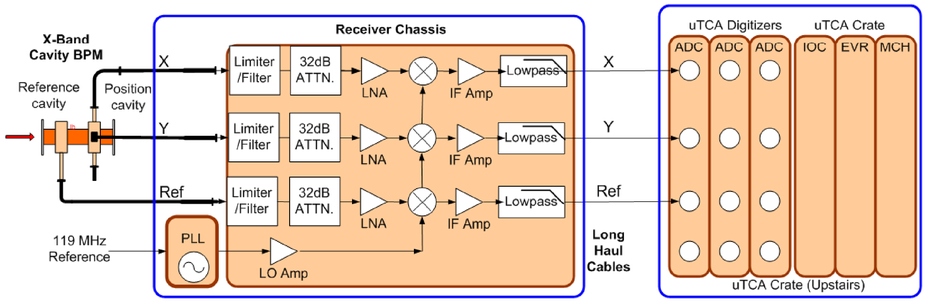
Concepts:

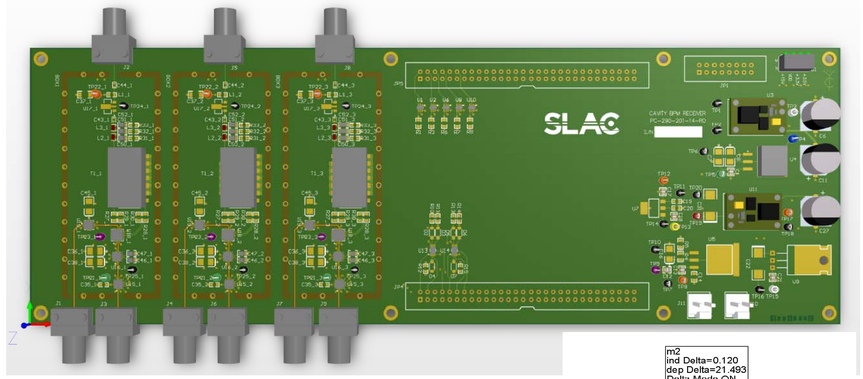
- Avoid monopole mode in position cavity
- Cavity-waveguide coupler rejects monopole mode by symmetry
- Predecessor at KEK's ATF
  - 16 nm resolution in test
- Choices
  - Single, degenerate X&Y cavity
  - Reference cavity per BPM



- BPMs tuned and cold tested before brazing
- Tuned by micro-machining end-caps
- Good correlation between cold test data before and after braze
- Position and reference cavities machined in common block
- Closed with endcaps

Block Diagram





Three-channel Receiver

- Downconverts 11.4 GHz RF to 40 MHz IF
- 3 Channels: X & Y positions, reference
- DRO lockable to RF
- mounted underneath the undulator
- Coax input and coax outputs
- LAN communication
- Wide frequency Range (8-13GHz)

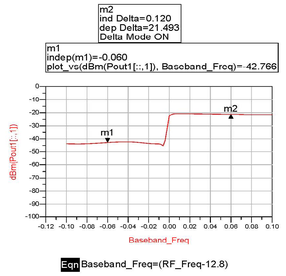


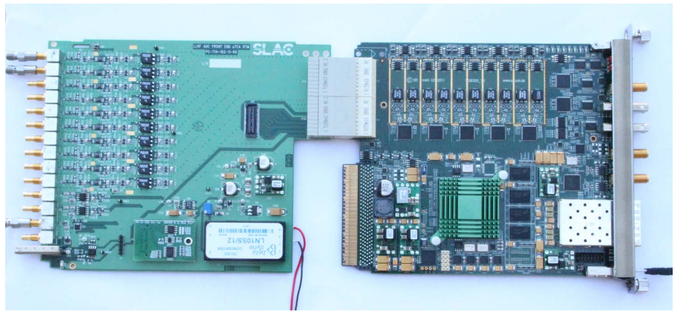
Image Rejection Ratio 21dB

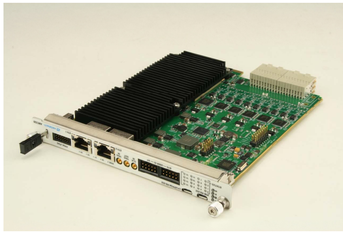
µTCA Platform

- High density plug connectors up to 5 GHz available (µTCA) – interface on rear adapters
- High Availability standard architectures (µTCA)
- Hot swap modules demonstrated (µTCA)
- Gigabit communications w/ embedded processor chips, high speed 12-16 bit sampler ADC-DAC commodity products, more to come…..
- IPMI interfaces let you know staus of temperatures, power, cooling, module present.

Cannot afford to NOT explore latest technologies.

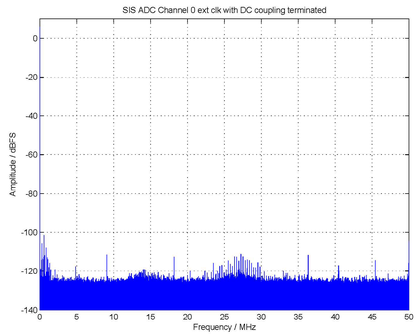
µTCA SLAC RTM and SIS 119 MHz Digitizer





This figure shows the Vadatech Version of a 10-Channel 119MSa/s ADC

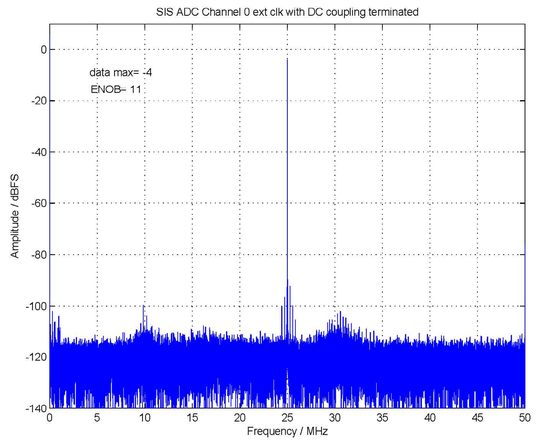
This figure shows the frequency response of the ADC with all inputs terminated.



ADC:

- 10-Channel in µTCA Package Designed by SIS
- 10 Channel RTM designed by SLAC
- digitizes IF at 119MSa/s
- 16-bit (11 effective see figure)
- Xilinx Virtex-5 FPGA
- Block reads
- Can perform digital downconversion

The Figure is a plot of the frequency spectrum of a 25MHz tone being digitized at 100MHz. ENOB was calculated using Matlab by fitting the data to a sine wave.



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