

Signal Processing: Accelerator Applications

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Dimtel, Inc., San Jose, CA, 95124, USA

June 15, 2009



Outline

- 1 Organization
- 2 Basic Definitions
- 3 RF Signal Processing and Accelerators
- 4 Some Examples



The Very First Slide

- Welcome to "RF and Digital Signal Processing" class!
- This class will be very much hands-on.
- On-line references:
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 - <http://www.rfcafe.com>
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- All day on Thursday is devoted to the final project.
- Working in teams:
 - Lab work will be done in teams of 4–6 people;
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Search

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Class Schedule

Monday, June 15, 2009

Time	Program
9:00 am - 9:30 am	Lecture: "Signal Processing Accelerator Applications"
9:45 am - 11:00 am	Lecture: "RF Basics"
11:25 am - 12:25 pm	Lecture: "Test and Measurement Equipment"
12:28 pm - 1:00 pm	Lunch
1:30 pm - 6:00 pm	Lab: "Network Analyzer Calibration"
1:30 pm - 6:00 pm	Lab: "Network Analyzer Calibration"
1:30 pm - 6:00 pm	Lab: "Time Domain Reflectometry"
1:30 pm - 6:00 pm	Lab: "Spectrum Analyzer Measurements"
6:00 pm - 7:00 pm	Dinner
7:00 pm - ...	Lab catch-up, discussion, homework

Tuesday, June 16, 2009

Time	Program
9:00 am - 10:30 am	Lecture: "Passive RF Components and RF System Definitions"
10:45 am - 12:15 pm	Lecture: "Digital Signal Processing: An Introduction"
12:15 pm - 1:20 pm	Lunch
1:30 pm - 6:00 pm	Lab: "Filter Characterization"
1:30 pm - 6:00 pm	Lab: "Passive Components"
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1:30 pm - 6:00 pm	Lab: "S21c Handout/Session"

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Start from looking in a dictionary (Merriam-Webster).

Radio Frequency n., abbr. RF

any of the electromagnetic wave frequencies that lie in the range extending from below 3 kilohertz to about 300 gigahertz and that include the frequencies used for communications signals (as for radio and television broadcasting and cell-phone and satellite transmissions) or radar signals.

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Extraction of information from complex signals in the presence of noise.

- Extracted information can be presented to a human ...
 - Diagnostics in accelerators;
 - Test and measurement equipment.
- ... or used in real-time:
 - Feedback control;
 - Wireless communications.



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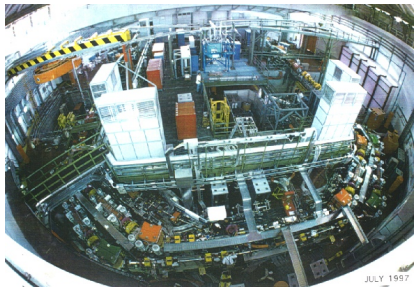
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Signal Processing Applications in Accelerators

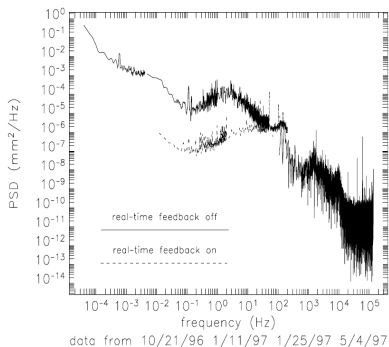


- RF accelerating systems.
- Beam diagnostics.
- Instability feedback.
- Timing and synchronization.



Signal Processing Challenges

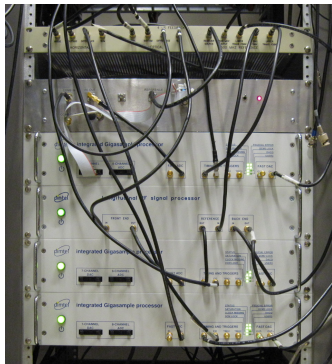
Horizontal Mean PSD at Insertion Device Source Points



- Power spectral density of horizontal motion in the APS.
- 9 decades frequency range!
- 12 orders of magnitude in power ...
- Data from 40 beam position monitors (BPMs).



Signal Processing Challenges (Continued)

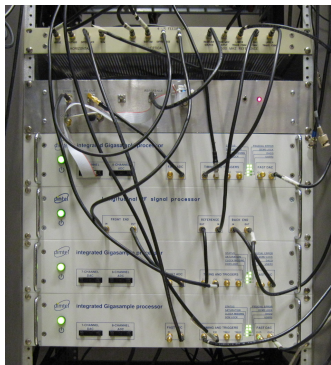


- Bunch-by-bunch feedback in a storage ring.
- Processing at 500 MHz, detection at 1.5 GHz, back-end at 1.1 GHz.
- Residual longitudinal beam motion in 100s of femtoseconds.
- Requirements for wideband operation with high dynamic range are common.
- Cutting-edge technology that must operate 24/7 for many years.



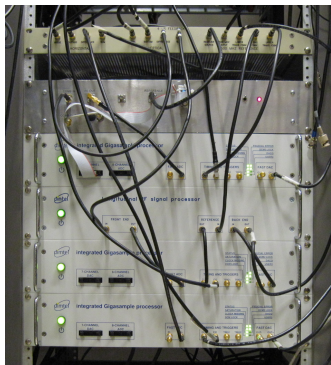
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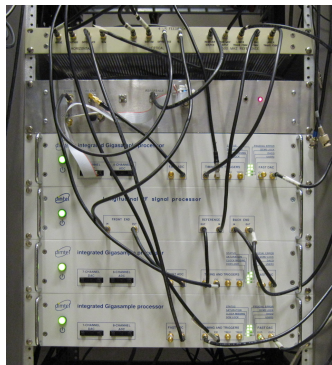


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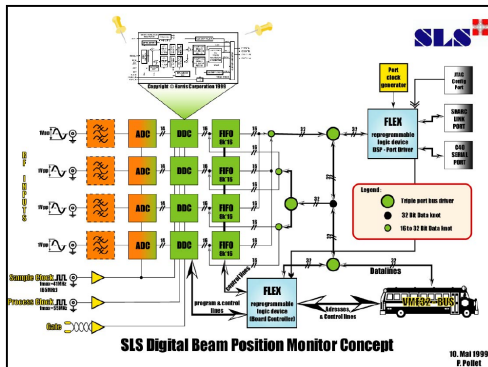
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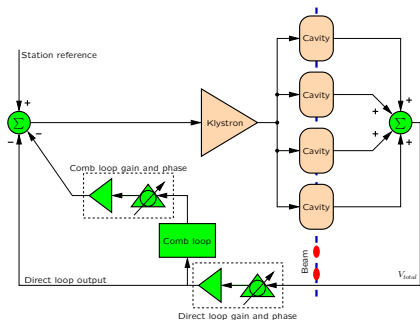


BPM Receiver: Swiss Light Source



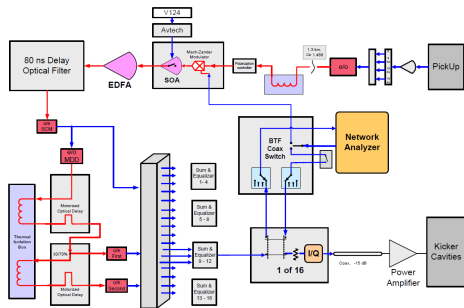
- Four independent channels.
- RF pilot tone for gain calibration.
- Sampling, digital downconversion.

Low-level RF System: PEP-II



- 476 MHz RF system.
- Mixed analog/digital implementation.
- 1 MW klystrons — that's average power, not peak!
- Multiple independent RF stations.
- Distortion in a 120 W preamplifier was limiting system performance.

Stochastic Cooling: RHIC



- Feedback for bunched ion beams.
- Bandwidth: 5–8 GHz.
- 1.3 km 10 GHz wide fiber-optic link across the ring.
- Kicker "synthesized" from 16 narrowband resonant cavities.



Summary

- Many signal processing challenges in accelerators.
- An opportunity to push the state-of-the-art.
- Now let's get to the interesting stuff.



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