Signal Processing: Accelerator Applications

Dmitry Teytelman

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

June 15, 2009



Outline





8 RF Signal Processing and Accelerators





• Welcome to "RF and Digital Signal Processing" class!

- This class will be very much hands-on.
- On-line references:
 - http://www.microwaves101.com
 - http://www.rfcafe.com
 - http://www.dspguide.com
 - http://www.wikipedia.org
- A reminder don't forget to turn on your cell phone after the lectures! That would also be a good time to open your laptop, if needed...



- Welcome to "RF and Digital Signal Processing" class!
- This class will be very much hands-on.
- On-line references:
 - http://www.microwaves101.com
 - http://www.rfcafe.com
 - http://www.dspguide.com
 - http://www.wikipedia.org
- A reminder don't forget to turn on your cell phone after the lectures! That would also be a good time to open your laptop, if needed...



- Welcome to "RF and Digital Signal Processing" class!
- This class will be very much hands-on.

On-line references:

- http://www.microwaves101.com
- http://www.rfcafe.com
- http://www.dspguide.com
- http://www.wikipedia.org
- A reminder don't forget to turn on your cell phone after the lectures! That would also be a good time to open your laptop, if needed...



- Welcome to "RF and Digital Signal Processing" class!
- This class will be very much hands-on.
- On-line references:
 - http://www.microwaves101.com
 - http://www.rfcafe.com
 - http://www.dspguide.com
 - http://www.wikipedia.org
- A reminder don't forget to turn on your cell phone after the lectures! That would also be a good time to open your laptop, if needed...



- Welcome to "RF and Digital Signal Processing" class!
- This class will be very much hands-on.
- On-line references:
 - http://www.microwaves101.com
 - http://www.rfcafe.com
 - http://www.dspguide.com
 - http://www.wikipedia.org
- A reminder don't forget to turn on your cell phone after the lectures! That would also be a good time to open your laptop, if needed...



- Welcome to "RF and Digital Signal Processing" class!
- This class will be very much hands-on.
- On-line references:
 - http://www.microwaves101.com
 - http://www.rfcafe.com
 - http://www.dspguide.com
 - http://www.wikipedia.org
- A reminder don't forget to turn on your cell phone after the lectures! That would also be a good time to open your laptop, if needed...



- Welcome to "RF and Digital Signal Processing" class!
- This class will be very much hands-on.
- On-line references:
 - http://www.microwaves101.com
 - http://www.rfcafe.com
 - http://www.dspguide.com
 - http://www.wikipedia.org
- A reminder don't forget to turn on your cell phone after the lectures! That would also be a good time to open your laptop, if needed...



- Welcome to "RF and Digital Signal Processing" class!
- This class will be very much hands-on.
- On-line references:
 - http://www.microwaves101.com
 - http://www.rfcafe.com
 - http://www.dspguide.com
 - http://www.wikipedia.org
- A reminder don't forget to turn on your cell phone after the lectures! That would also be a good time to open your laptop, if needed...



• Lectures in the morning until lunch.

- Laboratory work after lunch from 1:30 until 6pm.
- No homework assignments.
 - Some labs will have homework-like questions.
 - Unless you are auditing the class you should hand-in lab notes and question responses.
- All day on Thursday is devoted to the final project.
- Working in teams:
 - Lab work will be done in teams of 4-6 people;
 - We will split the class into teams daily before the labs;
 - Each day there are 3–5 labs, teams rotate;
 - Some lab questions are for the group, some individual.



・ロット (雪) (日) (日)

• Lectures in the morning until lunch.

• Laboratory work after lunch from 1:30 until 6pm.

- No homework assignments.
 - Some labs will have homework-like questions.
 - Unless you are auditing the class you should hand-in lab notes and question responses.
- All day on Thursday is devoted to the final project.
- Working in teams:
 - Lab work will be done in teams of 4-6 people;
 - We will split the class into teams daily before the labs;
 - Each day there are 3–5 labs, teams rotate;
 - Some lab questions are for the group, some individual.



- Lectures in the morning until lunch.
- Laboratory work after lunch from 1:30 until 6pm.
- No homework assignments.
 - Some labs will have homework-like questions.
 - Unless you are auditing the class you should hand-in lab notes and question responses.
- All day on Thursday is devoted to the final project.
- Working in teams:
 - Lab work will be done in teams of 4-6 people;
 - We will split the class into teams daily before the labs;
 - Each day there are 3–5 labs, teams rotate;
 - Some lab questions are for the group, some individual.



・ロット (雪) (日) (日)

- Lectures in the morning until lunch.
- Laboratory work after lunch from 1:30 until 6pm.
- No homework assignments.
 - Some labs will have homework-like questions.
 - Unless you are auditing the class you should hand-in lab notes and question responses.
- All day on Thursday is devoted to the final project.
- Working in teams:
 - Lab work will be done in teams of 4-6 people;
 - We will split the class into teams daily before the labs;
 - Each day there are 3–5 labs, teams rotate;
 - Some lab questions are for the group, some individual.



・ロット (雪) (日) (日)

- Lectures in the morning until lunch.
- Laboratory work after lunch from 1:30 until 6pm.
- No homework assignments.
 - Some labs will have homework-like questions.
 - Unless you are auditing the class you should hand-in lab notes and question responses.
- All day on Thursday is devoted to the final project.
- Working in teams:
 - Lab work will be done in teams of 4-6 people;
 - We will split the class into teams daily before the labs;
 - Each day there are 3–5 labs, teams rotate;
 - Some lab questions are for the group, some individual.



- Lectures in the morning until lunch.
- Laboratory work after lunch from 1:30 until 6pm.
- No homework assignments.
 - Some labs will have homework-like questions.
 - Unless you are auditing the class you should hand-in lab notes and question responses.
- All day on Thursday is devoted to the final project.
- Working in teams:
 - Lab work will be done in teams of 4-6 people;
 - We will split the class into teams daily before the labs;
 - Each day there are 3–5 labs, teams rotate;
 - Some lab questions are for the group, some individual.



- Lectures in the morning until lunch.
- Laboratory work after lunch from 1:30 until 6pm.
- No homework assignments.
 - Some labs will have homework-like questions.
 - Unless you are auditing the class you should hand-in lab notes and question responses.
- All day on Thursday is devoted to the final project.
- Working in teams:
 - Lab work will be done in teams of 4-6 people;
 - We will split the class into teams daily before the labs;
 - Each day there are 3–5 labs, teams rotate;
 - Some lab questions are for the group, some individual.

Tou are here: Welcomet + MF and Digital Signal I			
,Bearch			
Class home Schedule Lachure notes Lab handouts Device datasheets	Class Schedule Monday, June 15, 2009		Table of Cardenia a -Class Dundan -Phones, Jone 13, 2019 -Phones, Jone 13, 2019 -Phones, Jone 15, 2019 -Phonese, Jone 37, 2019 -Phonese Phonese Phonese -Phonese Phonese -Phonese Phonese -Phonese Phonese -Phonese Phonese -Phonese
Instrument menuals	Time	Program	
	9:00 am - 9:30 am	Lecture: "Signel Processing: Accelerator Applications"	
	0:40 am - 11:10 am	Lecture: 10 'NP masce'	
	11:25 em - 12:25 pm	Lextane: MiTest and Hoesenment Equipment'	
	12.25 pm - 1:30 pm	Lunch	
	1:30 pm - 6:00 pm	Lob: "S"Network Analyzer Colibration"	
	1:30 prs - 6:00 prs	Lab: ""Interverk Analyzer Learning"	
	1:30 pm - 6:00 pm	Lob: "S"Time Domain Reflectametry"	
	1:30 pre - 6:00 pre	Lab: ""Tpectrum Analyzer Measurements"	
	6:00 pm - 7:00 pm	Dimer	
	7100 pera	Lab catch-up, discussion, homework	
	Tuesday, June	16, 2009	
	Time	Program	
	0100 ans - 10130 ans	Lecture: "Passive RF Companents and RF System Definitions"	
	18:45 em - 12:15 pm	Lecture: "Digital Signal Processing: An Introduction"	
	12:13 pm - 1:30 pm	Lunch	
	1:30 pm - 6:00 pm	Lab: "S"When Characterization"	
	1:30 pre - 6:00 pre	Lab: "Passive Components"	
	1:30 pm - 6:00 pm	Lab: "Step Response"	

Web site at http://dimtel.com/uspas

- Schedule
- Lecture notes
- Lab handouts
- Datasheets
- Instrument manuals
- If you think something should be on the web site — let us know!



Tou are here: Welcomet a MP and Digital Signal I			
_Bearch			
Class home Schedule Lacture notes Lab handouts Device datacheets	Class Schedule Monday, June 15, 2009		Table of Cantonia A
			-Casii Scholae -Nocley, June 15, 2019 -Sander, June 15, 2019 -Rodmolder, June 35, 2019 -Rodmolder, June 35, 2019 -Rodmolder, June 35, 2019
Instrument menuals	Time	Program	
	9:00 am - 9:30 am	Lexture: "Signel Processing: Accelerator Applications"	
	0:40 am - 11:10 am	Lecture: 1 10 marcs"	
	11:25 em - 12:25 pr	m Lectare: 🌒 'Test and Hoesenement Equipment'	
	12:25 pm - 1130 pm	Lunch	
	1:30 pm - 6:00 pm	Lob: "S"Network Analyzer Collbration"	
	1:30 prv - 6:00 prv	Lake 🐩 "Network Analyzer Learning"	
	1:30 pm - 6:00 pm	Leb: "S"Time Comain Reflectametry"	
	1:30 prv - 6:00 prv	Laki 🐩 "Spectrum Analyzer Measuremends"	
	6:00 pm - 7:00 pm	Dinner	
	7100 pris	Lab catch-up, discussion, homework	
	Tuesday, Jun	e 16, 2009	
	Time	Program	
	0:00 ars - 10:30 ars	Lecture: "Passive RF Companents and RF System Definitions"	
	18:45 em - 12:15 pr	m Lecture: "Digital Signal Processing: An Introduction"	
	12:13 pm - 1:30 pm	Lunch	
	1:30 pm - 6:00 pm	Lab: ""Wher Characterization"	
	1:30 pre - 6:00 pre	Lab: "Passive Components"	
	1:30 pm - 6:00 pm	Lab: "Step Response"	

Web site at http://dimtel.com/uspas

- Schedule
- Lecture notes
- Lab handouts
- Datasheets
- Instrument manuals
- If you think something should be on the web site — let us know!



Tou are here: Welcomet + MF and Digital Signal I			
Jeans .			
	Class Schedule		Table of Contents A
Schedule Lacture notes Lab handouts Deuto Affantieuty	Monday, June 15, 2009		-Case Schooles -Norder, Scie 13, 2019 -Norder, June 13, 2019 -Reader, June 15, 2019 -Reader, June 25, 2019 -Parader, June 25, 2019
Instrument menuals	Title	Program	CONTRACTOR OF THE
	9:00 am - 9:30 am	Lecture: "Signel Processing: Accelerator Applications"	
	0:40 am - 11:10 am	Lecture: () "RF Basics"	
	11:25 em - 12:25 pm	Lecture: STest and Hoesenement Equipment'	
	12:25 pm - 1:30 pm	Lunch	
	1:30 pm - 6:00 pm	Leb: "S"Network Analyzer Collbration"	
	1:30 pm - 6:00 pm	Lak: ""Tertwork Analyzer Learning"	
	1:30 pm - 6:00 pm	Leb: 15"Time Comain Reflectametry"	
	1:30 pm - 6:00 pm	Lab: "Inpectrum Analyzer Measurements"	
	6:00 pm - 7:00 pm	Dimer	
	7100 pm	Lab catch-up, discussion, homework	
	Tuesday, Jun	e 16, 2009	
	11246	Program	
	Martine - Date and	London Visited Completence and Property of States	
	1212.00 - 112.00	Local - Copie Signe Fraction g. He in Council	
	1.20 per - 1.20 per	Labor Characterization?	
	1.30 pm - 0.00 pm	Lab. "Testas Concentration	
	1:30 pm - 6:00 pm	Lab: "Stan Bannana"	

- Web site at http://dimtel.com/uspas
 - Schedule
 - Lecture notes
 - Lab handouts
 - Datasheets
 - Instrument manuals
- If you think something should be on the web site — let us know!



Tou are here: Welcomet + MF and Digital Signal I	horming Case + Case Schedule		
_beach			
Class Nome Schedule	Class Schedule Monday, June 15, 2009		Table of Contents A
Lacture rotes Lab handouts			-Bencher, June 15, 2019 -Funder, June 15, 2019 -Bencher, June 15, 2019 -Burndry, June 15, 2019
Instrument menuals	Time	Program	- HER, SHE LE LIND
	9:00 am - 9:30 am	Lectare: "Signel Processing: Accelerator Applications"	
	0:40 am - 11:10 am	Lecture: 11/107 Basics"	
	11:25 em - 12:25 pm	Lextene: I Test and Neesenement Equipment'	
	12:25 pm - 1:30 pm	Lunch	
	1:30 pm - 6:00 pm	Lob: "S"Network Analyzer Colibration"	
	1:30 pm - 6:00 pm	Lab: Mintecek Analyzer Learning"	
	1:30 pm - 6:00 pm	Lob: "S"Time Domain Reflectametry"	
	1:30 pm - 6:00 pm	Lab: ""Tpectrum Analyzer Measurements"	
	6:00 pm - 7:00 pm	Dimer	
	7:00 pm	Lab catch-up, discussion, homework	
	Tuesday, Juni	16, 2009	
	Time	Program	
	9100 Ars - 10130 Ars	Lecture: "Reserve RF Companients and RF System Definitions"	
	18:45 em - 12:15 pm	Lecture: "Digital Signal Processing: An Introduction"	
	12:13 pm - 1:30 pm	Lunch	
	1:30 pm - 6:00 pm	Lab: ""Titler Cheracterization"	
	1:30 pre - 6:00 pre	Lak: "Passive Components"	
	1:30 pm - 6:00 pm	Lab: "Step Response"	

- Web site at http://dimtel.com/uspas
 - Schedule
 - Lecture notes
 - Lab handouts
 - Datasheets
 - Instrument manuals
- If you think something should be on the web site — let us know!



Tou are here: Welcome! + MF and Digital Signal	Processing Gase + Gase Schedule		
, Branch			
Class home Schedule Lachme notes Lab handouts Device datalheets	Class Schedule Monday, June 15, 2009		Table of Cantonia a -Class Scholare -Class Scholare -Charter Scholare -Charter Scholare -Charter Scholare Scholare -Charter Scholare Scholare -Charter Scholare Scholare
Instrument menuals	Time	Program	
	9:00 am - 9:30 am	Lecture: "Signel Processing: Accelerator Applications"	
	6:40 am - 11:10 am	Lecture: 10 'NP masce'	
	11:25 em - 12:25 pm	Lextere: STest and Hoesenment Equipment'	
	12:25 pm - 1:30 pm	Lunch	
	1:30 pm - 6:00 pm	Lob: "S"Network Analyzer Colibration"	
	1:30 pm - 6:00 pm	Lab: 📆 "Network Analyzer Learning"	
	1:30 pm - 6:00 pm	Lob: "S"Time Contain Reflectametry"	
	1:30 pm - 6:00 pm	Lak: 🐩 "Epectrum Analyzer Measurements"	
	6:00 pm - 7:00 pm	Dimer	
	7:00 prv	Lab catch-up, discussion, howevork	
	Tuesday, Jun	16, 2009	
	11916	Program	
	www.ars - 10:00 ars	tenary. Passive or Comparent's and RP System Definitions"	
	18:45 6m - 12:15 pm	receive: - coloral ordinal subcassing: we maconection	
	12114 pm - 1130 pm	Lunc	
	1:30 pm - 6:00 pm	Las: S river Characteristicat	
	a no pre - 6: DO pre	Les: Passer Lampanes	
	1:30 pm - 6:80 pm	ree: perb werboure	

- Web site at http://dimtel.com/uspas
 - Schedule
 - Lecture notes
 - Lab handouts
 - Datasheets
 - Instrument manuals
- If you think something should be on the web site — let us know!



Tou are here: Welcomet + MF and Digital Signal I	horming Case + Case Schedule		
_beach			
Class Nome Schedule	Class Schedule Monday, June 15, 2009		Table of Contents A
Lacture rotes Lab handouts			-Bencher, June 15, 2019 -Funder, June 15, 2019 -Bencher, June 15, 2019 -Burndry, June 15, 2019
Instrument menuals	Time	Program	- HER, SHE LE LIND
	9:00 am - 9:30 am	Lectare: "Signel Processing: Accelerator Applications"	
	0:40 am - 11:10 am	Lecture: 11/107 Basics"	
	11:25 em - 12:25 pm	Lextene: I Test and Neesenement Equipment'	
	12:25 pm - 1:30 pm	Lunch	
	1:30 pm - 6:00 pm	Lob: "S"Network Analyzer Colibration"	
	1:30 pm - 6:00 pm	Lab: Mintecek Analyzer Learning"	
	1:30 pm - 6:00 pm	Lob: "S"Time Domain Reflectametry"	
	1:30 pm - 6:00 pm	Lab: ""Tpectrum Analyzer Measurements"	
	6:00 pm - 7:00 pm	Dimer	
	7:00 pm	Lab catch-up, discussion, homework	
	Tuesday, Juni	16, 2009	
	Time	Program	
	9100 Ars - 10130 Ars	Lecture: "Reserve RF Companients and RF System Definitions"	
	18:45 em - 12:15 pm	Lecture: "Digital Signal Processing: An Introduction"	
	12:13 pm - 1:30 pm	Lunch	
	1:30 pm - 6:00 pm	Lab: ""Titler Cheracterization"	
	1:30 pre - 6:00 pre	Lak: "Passive Components"	
	1:30 pm - 6:00 pm	Lab: "Step Response"	

- Web site at http://dimtel.com/uspas
 - Schedule
 - Lecture notes
 - Lab handouts
 - Datasheets
 - Instrument manuals
- If you think something should be on the web site
 — let us know!



_beach			
Class home Schedule Lacture notes Lab handouts Device datastrants	Class Schedule Monday, June 15, 2009		Table of Cantonits A
			-Class Scholae -Noroka, Save LS, 2009 -Fastorik, June LS, 2009 -Resolut, June LS, 2009 -Resolut, June LS, 2009 -Resolut, June LS, 2009
Instrument menuals	Time	Program	
	9:00 am - 9:30 am	Lecture: "Signel Processing: Accelerator Applications"	
	9140 am - 1110 am	Lecture: 1 "RF Balack"	
	11:25 em - 12:25 pr	n Lextane: 🌒 "Test and Hoesenment Equipment"	
	12:25 pm - 1:30 pm	Lunch	
	1:30 pm - 6:00 pm	Lob: "S"Network Analyzer Colibration"	
	1:30 pm - 6:00 pm	Labo #2"Network Analyzer Learning"	
	1:30 pm - 6:00 pm	Leb: 15"Time Comoin Reflectometry"	
	1:30 pre - 6:00 pre	Laki 🐩 "Spectrum Analyzer Measurements"	
	6:00 pm - 7:00 pm	Dimer	
	7100 p/n	Lab catch-up, discussion, homework	
	Tuesday, Jun	e 16, 2009	
	Time	Program	
	0:00 ars - 10:30 ars	Lecture: "Passive RP Companents and RP System Definitions"	
	18:45 em - 12:15 pr	n Lecture: "Digital Signal Processing: An Introduction"	
	12:15 pm - 1:30 pm	Lunch	
	1:30 pm - 6:00 pm	Lab: "S"Wher Characterization"	
	1:30 prv - 6:00 prv	Lab: "Passive Components"	
	1:30 pm - 6:00 pm	Leb: "Step Response"	
	A DECISION OF A DECISIONO OF A DEC	A CALL AND AN	

- Web site at http://dimtel.com/uspas
 - Schedule
 - Lecture notes
 - Lab handouts
 - Datasheets
 - Instrument manuals
- If you think something should be on the web site
 let us know!

(日)

dimite

Schedule for Today

9:00am	9:30am	"Signal Processing: Accelerator Applications"
9:40am	11:10am	"RF Basics"
11:25am	12:25pm	"Test and Measurement Equipment"
12:25pm	1:30pm	Lunch
1:30pm	6:00pm	"Network Analyzer Calibration"
		"Network Analyzer Learning"
		"Time Domain Reflectometry"
		"Spectrum Analyzer Measurements"
6:00pm	7:00pm	Dinner
7:00pm		Lab catch-up, discussion, homework



・ロト ・回ト ・ヨト ・ヨ

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.

We'll narrow down the range somewhat for our discussion. For accelerator applications 1 MHz to 10 GHz should mostly cover it.



・ロット (雪) (日) (日)

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.

We'll narrow down the range somewhat for our discussion. For accelerator applications 1 MHz to 10 GHz should mostly cover it.



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.

We'll narrow down the range somewhat for our discussion. For accelerator applications 1 MHz to 10 GHz should mostly cover it.



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.

We'll narrow down the range somewhat for our discussion. For accelerator applications 1 MHz to 10 GHz should mostly cover it.



What is Signal Processing

Signal Processing

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.



What is Signal Processing

Signal Processing

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.



What is Signal Processing

Signal Processing

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.



Signal Processing Applications in Accelerators



• RF accelerating systems.

- Beam diagnostics.
- Instability feedback.
- Timing and synchronization.



Signal Processing Challenges



- 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).

ヘロマ ヘヨマ ヘヨマ ヘ





- 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.





- 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.





- 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.



- 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.

BPM Receiver: Swiss Light Source



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

ヘロマ ヘヨマ ヘヨマ ヘ



Some Examples

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.

ヘロマ ヘヨマ ヘヨマ ヘ



Summary

Many signal processing challenges in accelerators.

- An opportunity to push the state-of-the-art.
- Now let's get to the interesting stuff.



Summary

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



Summary

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