Survey of LLRF Development for the ILC

Julien Branlard, FNAL
Brian Chase, FNAL
Shin Michizono, KEK
Stefan Simrock, DESY

And also

E Pluribus Unum

- TTF/A0 Photo Injector collaboration
  - Started in the mid 1990’s
  - H. Edwards, S. Simrock
  - Exchange of knowledge and expertise
- ILC is the International Linear Collider
  - Need for a global collaboration
  - Across the globe video conferencing and LLRF workshops are now routine
  - This talk: DESY, KEK, and FNAL for the 3 ILC regions
Future Projects Goals (ILCTA, XFEL, STF, ILC)

Require the next generation RF Control System

- Global 0.1% RMS beam energy regulation
- Multi-cavity regulation per klystron system (e.g. 26 for ILC, 48 for HINS)
- Active piezo-electric tuner feedback system
- Phase reference distribution over kilometers
- Automation to fit the ILC machine scale (~16,000 cavities)
- High reliability, modularity, and cost effective
Survey of LLRF Development for the ILC

MO (1300 MHz ref)

LLRF Scheme

RECEIVER

down conversion

CONTROL

digital signal processing

TRANSMITTER

vector modulator

RF 1300 MHz

Klystron

Cavity

Cavity2

Cavity1

RF

RF2

RF1

RF

ADC

ADC

DAC

DAC

I

Q

X 26

X 26

X 26

06/29/2007

Julien Branlard
New generations of FPGA controllers

SIMCON boards (DESY, Lodz, Warsaw)
Survey of LLRF Development for the ILC

DESY – Hardware R&D

- **SIMCON DSP:**
  - Xilinx Virtex II
  - TigerShark DSP
  - 10 ADCs
  - 8 DACs
  - 2 opto gigalinks
  - VME interface

- **DSP**
  - pulse to pulse algorithms

- **FPGA**
  - fast corrections during pulse
Survey of LLRF Development for the ILC

DESY – Hardware R&D

- For 24 cavities
  - 3 SIMCON controllers
    (for cavity probes only)

- SIMCON4.0 (concentrator board)
  - Xilinx Virtex II Pro
  - 8 opto gigalinks

06/29/2007

Courtesy S. Simrock
Survey of LLRF Development for the ILC

Receiver Prototype

- IF down converters (WEPN011)
  - Digital mother board for testing analog multi channel down converter daughter boards

Other hardware R&D include
- Master Oscillator (MOPAN019)
  - Investigate a laser based reference distribution

06/29/2007 Julien Branlard

Courtesy S. Simrock
Use of hardware

• Cross lab applications for SIMCON
  – DESY
    • RF gun controller at FLASH
    • ACC1 controller at FLASH
    • Desy Module Test Stand controller
  – FNAL
    • SC Capture Cavity I at A0 (~ 16 MV/m)
    • SC Capture Cavity II at Meson (~ 32 MV/m)
    • Horizontal Test Stand at Meson

• Hardware / Firmware exchange
• Knowledge / Expertise transfer
Survey of LLRF Development for the ILC

STF for the ILC

<table>
<thead>
<tr>
<th>Phase</th>
<th>STF-0.5</th>
<th>2 cavities</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase</td>
<td>STF-1</td>
<td>8 cavities + gun</td>
<td>2008</td>
</tr>
<tr>
<td></td>
<td>STF-2</td>
<td>26 cavities + gun</td>
<td>2010</td>
</tr>
</tbody>
</table>

Phase 1

- AR-east cryogenic system
- new UV Laser (ILC struc.)
- 200kV DC gun of ERL develop
- new 5m Cryomodule (35MV/m 4 cavity)
- new 5m Cryomodule (45MV/m 4 cavity)

Phase 2

- STF-1
- STF-2
- TESLA+ Ichiro

Courtesy S. Michizono
Multichannel FPGA controller

- 10x 16 bit ADCs
- Virtex II Pro
- 2 DACs
- Commercial DSP board
- low-profile coaxial multiple contact connector
- EPICS GUI interface
Summing IFs

- Reduce ADC channel count
- Freq. multiplexing and summing before ADC
- Demultiplexing in FPGA

Preliminary stability results:
  amplitude: ±0.2%
  phase: ±0.2°

06/29/2007

Courtesy S. Michizono
ILCTA at FNAL for the ILC

- Adopted the DESY Simcon system
- Contributed by implementing higher IF and firmware development
- Fermilab has produced a new version Simcon card
- Develop a Multi-Channel Field Control Module (MFC)
  - 32 ADC channels, FPGA, DSP, 4 DAC channels
  - High density, low cost, low power
- Develop the analog RF sections
  - 96 channel receivers
  - Transmitter
  - Master Oscillator
**Survey of LLRF Development for the ILC**

**LLRF Rack Overview**

- **Cav. Probe**
- **P_{FWD}**
- **P_{REF}**
- **Modularity**
  - cost effective

06/29/2007
8 channel module
IF down converter

- 13 MHz IF downconverter (8 channel module)
- 96 channel crate (12 modules)

(WEPMN102)
Multi Field Controller (MFC)
32 channel cavity field controller

(WEPMN112)
Multi Field Controller (MFC)
32 channel cavity field controller

- Altera Cyclone II FPGA
- Sharc DSP
- 4x octal 12 bit ADCs (65 MSPS) → 32 ch.
- 1x 14 bit ADC (105 MSPS)
- 2x dual DACs
- 5x compact 8 channel connectors
- 1 external CLK input → on board clk dist
- only linear regulators for power supply
CONCLUSION: Exciting Times

• Many projects ahead worldwide
  – FLASH, XFEL (DESY)
  – STF (KEK)
  – ILCTA, HTS, HINS (FNAL)
  – Etc…
  – Gain experience with tools and techniques
    ➔ make value-based judgments/decisions for the ILC

• On going cross lab collaborations
  – RDR completed this year
  – EDR developed over the next 3 years
Thank you for your attention!