MTCA for the Optical Synchronization Systems at XFEL and FLASH

for Beam Diagnostics, Laser Synchronization, Reference Distribution

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for the LbSyn Team
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Overview

> Introduction
  - Optical Synchronization System
  - Fiber Link Stabilization
  - Principle System Layout

> MTCA Setups
  - Link Control: Building Blocks
  - Crate Topology
  - Laser Synchronization

> Conclusion
Provide a global reference for the synchronization of timing-critical (fs-level) subsystems of the accelerator
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> Bunch arrival time measurements (BAM)

- These monitors are used by the beam-based feedback to synchronize (= stabilize) the arrival time of individual bunches to the optical reference
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- Laser synchronization (L2RF & L2L)
  - Injector-, Seed-, and Pump-Probe lasers (their repetition rate and phase of the pulse train) are synchronized to the optical reference.
Introduction – Optical Synchronization System

Provide a global reference for the synchronization of timing-critical (fs-level) subsystems of the accelerator

> Bunch arrival time measurements (BAM)
  - These monitors are used by the beam-based feedback to synchronize (= stabilize) the arrival time of individual bunches to the optical reference

> Laser synchronization (L2RF & L2L)
  - Injector-, Seed-, and Pump-Probe lasers (their repetition rate and phase of the pulse train) are synchronized to the optical reference.

> RF synchronization for LLRF-reference (L2RF)
  - The 1.3 GHz reference input for from the main drive line is synchronized to the optical reference in the REFMs
Introduction – Fiber Link Stabilization

- Long- and short-term phase-stable optical pulse train has to be distributed along ≤ 3.4 km
- Active fiber link length stabilization

Courtesy S. Schulz

MTCA
The reference timing information is encoded in the precise repetition rate of an optical pulse train.
Introduction – Principle System Layout

The reference timing information is encoded in the precise repetition rate of an optical pulse train

RF Master Oscillator

Laser Synch.

Master Laser Oscillator

Laser source locked to machine reference

Distribution and active length stabilization in Link Stabilization Units

Fiber links ≤ 3.4 km

Application

End-Station

Injector Laser

L2RF

Diagnostic

L2RF

Diagnostic

L2RF

Laser Synch.

Seed Laser

PP-Laser

GUN / Injector

LINAC

Undulator

Pump-Probe Exp.
**Introduction - Optical Links at the European XFEL**

**Synch Hutch**
- 2 Laser Synchs
- 24 LSUs

**Sub-Synch Hutch**
- 2 Laser Synchs
- 8 (20) LSUs

**Summary:**
- Two synch hutches (Accelerator + Experiments)
- 7 BAMs planned (could be 10)
- Up to 6 Pump-Probe Lasers
- 12 LLRF stations

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Matthias Felber | MTCA for Optical Synchronization Systems at XFEL and FLASH | 12th December, 2013 | Page 10
MTCA integrates many components in a compact form factor

Now: Electronic Infrastructure for Opt. Synch @ FLASH (2 MLOs, 16 LSUs)

- 4 x 42 HE Racks
- 5 x VME Crates (ADCs, DSPs, DACs, BAM-Readout, LDDs)
- 6 x PLC (Beckhoff Step-Motors, GPIO, Temperature, Monitoring)
- 18 x Piezo-Driver
- 6 x Vector Modulators

Future

- 1 x 42 HE Racks
- 3 x MTCA Crates
One Channel requires \(\frac{1}{4}\) of a set of 2 boards / 2 slots

4 Link stabilizations with 2 slots

(option: 8 Links on one ADC/Controller, but 2 Actuator cards)
One Channel requires ¼ of a set of 2 boards / 2 slots

4 Link stabilizations with 2 slots

(option: 8 Links on one ADC/Controller, but 2 Actuator cards)
Digitizer-RTM

DRTM-AD84

- 8 x ADC:
  - 16 bit
  - 10 MSPS
  - 50 Ω or 1 kΩ
  - 90 MHz (2 MHz)
  - ±1 V

- 4 x DAC
  - 16 bit
  - 1 (16) MSPS
  - ±1 V / ±3 V @ 50 Ω

- Zone 3: D1.0 / D1.1

Developed by Robert Wedel, Desy
One Channel requires ¼ of a set of 2 boards / 2 slots

4 Link stabilizations with 2 slots

(option: 8 Links on one ADC/Controller, but 2 Actuator cards)
Controller-AMC

DAMC-FMC25

- Processing:
  - Virtex 5
- Communication:
  - Spartan 6
  - 2 x FMC (HPC)
- Zone 3: D1.1 / D1.2 / D1.3

Developed by Jaroslaw Szewinski, NCBJ

Talk Session 5, 11:15
One Channel requires ¼ of a set of 2 boards / 2 slots
→ 4 Link stabilizations with 2 slots
(option: 8 Links on one ADC/Controller, but 2 Actuator cards)
DAMC-FMC20

- Processing:
  - Spartan 6 (LX150)
- Communication:
  - Spartan 6 (LX45)
  - 2 x FMC (HPC/LPC)
- Zone 3: D1.0
- Licensed to EicSys

Developed by Hans-Thomas Duhme, Desy
MTCA Setups – LSU Control: Building Blocks

- One Channel requires ¼ of a set of 2 boards / 2 slots
- 4 Link stabilizations with 2 slots
  (option: 8 Links on one ADC/Controller, but 2 Actuator cards)
Piezo Driver-RTM

DRTM-PZT4

- 4 x Channel
- On-board ±85 V PS
- On-board DACs
- Metal-cover
- Zone 3: D1.0 / D1.1 D1.2

Talk Session 6, 13:15

Developed by Konrad Przygoda, DMCS
MTCA Setups – LSU Control: Building Blocks

- One Channel requires ¼ of a set of 2 boards / 2 slots
- 4 Link stabilizations with 2 slots
  (option: 8 Links on one ADC/Controller, but 2 Actuator cards)
Motor Driver-FMC

DFMC-MD22

- Stepper Motors
- 2 x Channel
- End switch readout
- Encoder readout

Developed by Robert Wedel, Desy
MTCA Setups – LSU Control: Building Blocks

- One Channel requires ¼ of a set of 2 boards / 2 slots
- 4 Link stabilizations with 2 slots
  (option: 8 Links on one ADC/Controller, but 2 Actuator cards)
Monitor ADC-FMC

**DFMC-AD16**

- 16 (2x8) x ADC
  - 18 bit
  - 200 kSPS
  - 1 MΩ
  - 23 kHz / 15 kHz
  - ±10 V / ±5 V

Developed by Robert Wedel, Desy
LSU Control: Crate Configuration (max. 32 Links)

Data Flow:
- Analog ADC
- Zone 3 FMC
- LLLL Hub (SFP Fiber)
- FMC20 FMC/SPI Zone3/LLL
- MD22 PZT4

ADCs
Controllers
Motor Actuators
Piezo Actuators
MTCA Setups - Laser Synchronization

Mode Locked Laser

- Balanced Detector
- OXC or MZI
- Baseband
- Photo Diode
- RF, Higher Harmonic
- RF, Repetition Rate
- 2x Piezo voltage <80kHz, ±80 V

RTM LO-DWC-Laser
- Reference or Clock & LO

RTM PiezoDriver uPZT4
- 2/4

AMC SIS8300
- Zone 3
- Baseband
- IF
- Rep. Rate
- Backplane 10 MBit/s

AMC FMC20
- DFMC-LASIO
- DFMC-MD22

Stepper Motor
- or TTL coarse tuning

Talk Uros Mavric
Session 4, 09:15
New RTM, specifically for laser synchronization

- 4 DWC cells - only two with mixer, others for bucket detection (direct sampling)
- External LO/Clk input or internal generation from Reference
- Baseband inputs for balanced detector
- DAC for external feed of PZT4 or other analog driver
- Laser signal:
  - RF input (ext. diode)
  - Optical input (int. diode)
    - PS for ext. Diode
MTAC Setups - Laser Synchronization

New RTM, specially for laser synchronization
- 4 DWC cells - only two with mixer, others for bucket detection (direct sampling)
- External LO/Clk input or internal generation from Reference
- Baseband inputs for balanced detector
- DAC for external feed of PZT4 or other analog driver
- Laser signal:
  - RF input (ext. diode)
  - Optical input (int. diode)
    - PS for ext. Diode

New FMC, specially for laser control
- 25 TTL GPIO pins, jumper activation/deactivation
- RS232 interface
- Shutter driver

Talk Uros Mavric
Session 4, 09:15
See talk from Jaroslaw Szewinski at 11:15

MTCA Setups - BAM Electronics

DFMC-DSBAM
- 3 x On-Board PDs
- 4 x ADC (216 MSPS)
- Clk generation/management

Courtesy M. K. Czwalinna
Conclusion

- MTCA will replace most of the existing hardware solutions (VME, Beckhoff, Piezo Driver, …)

- AMC: FMC20, FMC25, SIS8300L, CAN, x2Timer

- RTM: AD84, PZT4, DWC10 (→ “LO-DWC-LAS”)

- FMCs: MD22, AD16, LASIO, DSBAM

- Laboratory Test-Setups available

- First implementation (‘System Ready’) in 3 month!
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Thank You!