Applications of Emerging Parallel Optical Link Technology to High Energy Physics Experiments

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For the Versatile Link Common Project
Outline

Overview of Components and Trends

Review of Test Hardware and Components

A Look at Emerging Optical Engines

Some Test Results

Future Directions and Acknowledgments
Versatile Link: CERN-organized common project for ATLAS and CMS
Goal: “Development of a general purpose optical link which can cover all envisioned transmission applications: a versatile link” @ data transfer rates of up to 5 Gbps.

**Versatile Link Common Project**

**On-Detector**
Custom Electronics & Packaging
Radiation Hard

**Off-Detector**
Commercial Off-The-Shelf (COTS)
Custom Protocol

**Work Package 1.1** (Southern Methodist University)
Point to Point Architecture and System Engineering

**Work Package 2.1** (CERN)
Front End Components (Versatile Transceiver)

**Work Package 2.2** (Fermilab)
Back End Components (COTS, Off Detector Components)

**Work Package 2.3** (Oxford University)
Passive Components

Source: “Versatile Link Status Report”
Jan Troska
CMS Tracker Upgrade Meeting
April 24, 2009

*See TIPP 2011 Presentation Dr. Annie Xiang, “A Versatile Link for high speed radiation, resistant optical transmission in LHC upgrades”*
Versatile Link Common Project

Versatile Transmitters (Custom Development)

Front End

12 Channel Parallel Receivers (Commercially Available)

Back End
Parallel Optics – Technology Evolution

Optical Transceivers

Transceiver Package or Form Factor
- Relative Sizes

Image Courtesy of Avago Technologies
Parallel Optics – Device Comparision

- Emerging Standards (100 GbE) Driven by Telecom and Storage
- Off the shelf and prototype devices evaluated
- High speed, parallel communications in multiple footprints
- For HEP: High Channel Count, Easier Cable Management
  Reduced Board Area (including connectors)

- CXP Transceiver
  (12 channels TRx, 10 Gbps/channel)

- SNAP12 Transmitter
  (12 channels, 2.7 Gbps/channel)

- Parallel Optical Engine Transceiver
  (4 channels, 6.25 Gbps/channel)
  (Efficient PCB Applications, Lower Electromagnetic Noise)

- SFP+ Single Channel Transceiver
  (10 Gbps)
Parallel Optics – Optical Engine Evaluation Hardware

Vendor Supplied Evaluation Board

Fermilab Designed Evaluation Board

Vendor Supplied Evaluation Board

Fiber Ribbon Breakout Cable

MTP Connector
Parallel Optics – Emerging OE Products

Parallel Optical Engine Tx/Rx (12 channels, 10 Gbps/channel)

Parallel Optical Engine Tx/Rx (12 channels, 10.3 Gbps/channel)

Parallel Optical Engine TRx (12 channels, 10 Gbps/channel)
Parallel Optics – Optical Engine Mezzanine

- FPGA Mezzanine Card (FMC) Connector
- Control Signal Level Translation
- Optical Engine
Optical Test and Measurement

Digital Signal Analyzer (Eye Patterns, Jitter)

Labview VIs (Histogram Analysis)

Variable Optical Attenuators (Receiver Sensitivity)

FPGA Signal Integrity Kit (BERT, PRBS Generation)
Optical Test and Measurement

Eye Pattern Measurements
Optical Modulation Amplitude

Target Value

**Transmitter Measurements**

- Optical Modulation Amplitude (OMA): 3.2 dBm*
- Transmit Eye Extinction Ratio: 3.0 dB
- Transmit Eye Opening: 60% of OMA
- Transmitter Rise Time: 52 ps
- Transmitter Fall Time: 52 ps
- Transmitter Total Jitter: 0.25 of UI
- Transmitter Deterministic Jitter: 0.12 of UI

**Receiver Measurements**

- Receiver Sensitivity: -11.1 dBm
- Receiver Total Jitter: 0.34 of UI
- Receiver Deterministic Jitter: 0.14 of UI

TIPP 2011 June 11, 2011
Optical Transceiver Test Measurements

Industry Standard Measurements and Apparatus

Eye Diagram Measurements:
- Optical Modulation Amplitude
- Extinction Ratio
- Rise/Fall Times

Jitter Analysis:
- Deterministic Jitter (including decomposition)
- Random Jitter (Gaussian, unbounded)
- Eye Opening @ 10^{-12} BER
Parallel Optics Device Measurements

Transmitter Measurement

(each point is a different channel; each line is a different device)

Data Collected at: 5 Gbps

Channel No.

OMA (uW)
Parallel Optics Device Measurements

Data Collected at: 10 Gbps

- OMA: -3.2 dBm
- Rx Sensitivity: -11.1 dBm
- Ext. Ratio: 3.0 dB
- Tx. Eye Opening: 60% of OMA
- Tx Rise Time: 52 ps
- Tx Fall Time: 52 ps
- Tx Total Jitter: 0.25 of UI
- Tx Deterministic Jitter: 0.12 of UI
- Rx Total Jitter: 0.34 of UI
- Rx Deterministic Jitter: 0.14 of UI

* Calorimeter Grade Version
Future Directions

Continue to work with vendors on the testing of emerging products

Provide our Versatile Link collaborators with prototype test platforms

Develop per channel specifications for parallel devices for Versatile Link

Document test results and provide engineering support from lessons learned

Identify and recommend suitable multi-channel receiver modules for the Versatile Link
Acknowledgments

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