Qualification of the CMS Digital Optohybrid

Outline:
- CMS optical digital control links
- DOH components
- DOH history and assembly
- Qualification programme
- Visual inspection
- Optical/Electrical tests
- System tests
- Environmental tests
- Radiation tests
- Pull tests
- Summary
CMS Control Link Digital Optohybrid (DOH)

CMS Tracker Optical Digital Control Links
- Bi-directional
- Extreme environment
  - High radiation levels
  - High magnetic field
  - Restricted access for repair
- Derived from analogue readout links
- Adopted by other CMS sub-detectors

<table>
<thead>
<tr>
<th>CMS Sub-detector</th>
<th>Rings</th>
<th>DOHs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixels</td>
<td>64</td>
<td>128</td>
</tr>
<tr>
<td>Tracker</td>
<td>350</td>
<td>700</td>
</tr>
<tr>
<td>ECAL</td>
<td>368</td>
<td>736</td>
</tr>
<tr>
<td>Preshower</td>
<td>52</td>
<td>104</td>
</tr>
<tr>
<td>RPCs</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>862</strong></td>
<td><strong>1696</strong></td>
</tr>
</tbody>
</table>
DOH Components

- Optical fibres
- MU connectors
- DOH PCB

- 26-way NAIS
  Electrical connector:
  - CK/DA to/from CCUMs
  - Reset to CCUM
  - I^2C to/from CCUM

- LLD ASIC
- Laser diodes
- RX40 ASIC
- Pin photodiodes
- Fibre clamp
DOH Production History

- 2001-3 Preliminary specs/prototypes
- 10/03 Order placed with Kapsch
- 12/03 Specifications frozen
- 03/04 Pre-production batch (40 pcs)
- 04/04 Rejection
- 06/04 Re-qualification batch (37 pcs)
- 07/04 Acceptance
- 08/04 Start of final production
DOH Assembly Sequence

- DOH PCB
  - Production

- SMD components
  - Assembly

- LLD and RX40 ASICs
  - Bump bond

- Pin photodiodes
  - Solder

- Lasers
  - Glue and wire bond

- Fibre clamp and laser cover
  - Glue
Qualification Programme

Quality

Visual inspection

Geometrical measurements

Functionality

Optical and electrical test

Environment and reliability

Thermal cycling test

Irradiation test

Magnetic field test

Fibre pull tests

Mechanical shock and vibration test
Visual Inspection

<table>
<thead>
<tr>
<th>Inspection test</th>
<th># failures</th>
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<tbody>
<tr>
<td>Fibre clamp</td>
<td>10</td>
</tr>
<tr>
<td>Laser cover</td>
<td>20</td>
</tr>
<tr>
<td>QR code</td>
<td>2</td>
</tr>
<tr>
<td>Soldering</td>
<td>12</td>
</tr>
<tr>
<td>Fibre buffer rupture</td>
<td>5</td>
</tr>
</tbody>
</table>
Optical/Electrical Test Setup

Rx Tests:
- Receiver sensitivity
- Receiver saturation
- Output voltage swing
- Reset generation

Tx Tests:
- Optical modulation amplitude (OMA)
- Average launch power (ALP)
- Input impedance
- I²C check
- L-I characteristics

System Tests:
- Power supply
- Eye pattern
- Skew
- Jitter
Optical/Electrical Tests

**Sensitivity**

- Frequency vs. Sensitivity [dBm]
- Specification

**OMA & ALP**

- ALP [dBm]
- OMA [dBm]
- Specification

**LLD and LASERS**

- I2C check and L-I char.
- Default LLD input
- Minimum LLD input

**Reset generation**

- 10 missing '1's
- Data
- Reset

**I2C check and L-I char.**

- Laser Output [µW]
- LLD Bias Setting
- Default I2C = 48

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15th September 2004

Qualification of the CMS Digital Optohybrid

Etam Noah, CERN
System Tests

- Power consumption within 350mW spec.
- Bit Error Rate, $<10^{-12}$
- Skew <1ns
- Jitter well within 250ps rms spec.
Environmental Tests

- Temperature cycling (CERN)
- B-field (CERN)
  - 2 DOHs, 3 orientations, 2.4 T
- Shock test (Kapsch)
  - 6 DOHs, 20G
- Vibration test (Kapsch)
  - 6 DOHs, 10Hz-500Hz
- All DOHs were functional after above tests
Radiation Tests

- Irradiation (6 DOHs)
  - 100kGy Co-60 gamma
  - Up to 9.4x10^{14}n/cm^2 (UCL ~20MeV)
- Expected laser and photodiode damage
- Final system laser threshold shift should be less:
  - ~6mA (LLD bias shift =13)

**LASERS**

**PHOTODIODES**

<table>
<thead>
<tr>
<th></th>
<th>Clock</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prerad avg. [µW]</td>
<td>8.7</td>
<td>9.1</td>
</tr>
<tr>
<td>Prerad-gamma [%]</td>
<td>-5</td>
<td>-1</td>
</tr>
<tr>
<td>Prerad-neutron [%]</td>
<td>-29</td>
<td>-32</td>
</tr>
</tbody>
</table>
Pull Tests

Non-destructive pull tests:
• Attach 700g to fibre
• 3/40 fibres failed (all lasers)

Destructive pull tests:
• Pull fibre until it fails
• 2/36 fibres below spec (all lasers 5.5N & 6.7N)

In Summary
• Fibre strength reasonably good
• Revise DOH pull strength specification
Summary

- DOH has undergone an extensive series of tests
  - Good functionality
  - Quality of assembly
    - 1\textsuperscript{st} Pre-production failed visual inspection
    - 2\textsuperscript{nd} Pre-production much better:
      - Redesigned fibre clamp
      - Redesigned assembly jig

- Remaining issues
  - Buffer ruptures on fibres
  - Soldering of photodiodes onto DOH pcb

- Production phase
  - 100 DOHs in August 04
  - Expect to reach production rate of ~200 DOHs/month