This is a 1987 state of the art 600Mbps “transceiver”

Patrik von Matern
PLM Optical Devices
Smartoptics

“Transceivers beyond 100G”
100G standards and MSA’s for Grey optics

- **4 lanes** 25Gbps CWDM, LANWDM
- **1 lane** 50GBaud CWDM, 1311nm

**LR4**
- CWDM4
- 4WDM10

**ER4**
- 4WDM20

**SR4**
- 4WDM20

**ZR4**
- SWDM4

**FR**
- LR

**DR**
100G standards and MSA’s for Grey optics

1 lane
50GBaud

CWDM
1311nm
400G standards and MSA’s for Grey optics

400G transceiver for fiber-pair configurations

400G transceiver for ribbon cable

4 lanes
50GBaud

CWDM

PAM4 ASIC
8x 25Gbd↔4x 50Gbd
4x PIN ARRAY

400G-FR4
400G-LR4
400G-DR4

2km Fiber-pair
10km Fiber-pair
500m Ribbon-fiber

smartoptics
Step up in form-factor

Things that matter:

Size and Power!

QSFP-DD
- is longer than a QSFP28
- is backwards compatible with QSFP28
- has a higher power class capability than QSFP28

<table>
<thead>
<tr>
<th>Power Class</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5W</td>
</tr>
<tr>
<td>2</td>
<td>2.0W</td>
</tr>
<tr>
<td>3</td>
<td>2.5W</td>
</tr>
<tr>
<td>4</td>
<td>3.5W</td>
</tr>
<tr>
<td>5</td>
<td>4.0W</td>
</tr>
<tr>
<td>6</td>
<td>4.5W</td>
</tr>
<tr>
<td>7</td>
<td>5.0W</td>
</tr>
<tr>
<td>8</td>
<td>10W</td>
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</tbody>
</table>

QSFP28

<table>
<thead>
<tr>
<th>Power Class</th>
<th>Max</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>1.5W</td>
</tr>
<tr>
<td>2</td>
<td>3.5W</td>
</tr>
<tr>
<td>3</td>
<td>7.0W</td>
</tr>
<tr>
<td>4</td>
<td>8.0W</td>
</tr>
<tr>
<td>5</td>
<td>10.0W</td>
</tr>
<tr>
<td>6</td>
<td>12.0W</td>
</tr>
<tr>
<td>7</td>
<td>14.0W</td>
</tr>
<tr>
<td>8</td>
<td>&gt;14.0W</td>
</tr>
</tbody>
</table>

A typical 400G grey transceiver consumes ~ 10W
Coherent 400G

Electrical interface: 8 lanes PAM4 25Gbd / 50Gbps (400GAUI-8) for ZR and also 4x100GAUI-2 for ZR+.
Internal conversion to 1 lane DP-16QAM, ~60Gbd / 400Gbps.

DP-16QAM (DP = Dual Polarization)
4 bits per symbol (x2)

AUI = Attachment Unit Interface
400GAUI-8 where 8 is number of lanes

DSP: Digital Signaling Processor
SOSA: Silicon Optical Sub-Assembly
### 400G Industry Standards

There are three principal initiatives to provide standardized 400G solutions.

<table>
<thead>
<tr>
<th>Target application</th>
<th>Edge DCI/Campus</th>
<th>Metro/Regional DCI</th>
<th>Metro/Regional DCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reach</td>
<td>80 – 120km / 11dB</td>
<td>&gt;120km</td>
<td>&gt;120km</td>
</tr>
<tr>
<td>Line capacity</td>
<td>400G</td>
<td>100G/200G/300G/400G</td>
<td>200G/300G/400G</td>
</tr>
<tr>
<td>Client formats</td>
<td>400GE</td>
<td>100GE/200GE/400GE</td>
<td>100GE-400GE + OTN</td>
</tr>
<tr>
<td>FEC</td>
<td>CFEC</td>
<td>oFEC</td>
<td>oFEC</td>
</tr>
<tr>
<td>Line modulation</td>
<td>16QAM</td>
<td>QPSK/8QAM/16QAM</td>
<td>QPSK/8QAM/16QAM</td>
</tr>
</tbody>
</table>

**In short:**

- 400G Ethernet Mid span meet
- 100/400G Ethernet Performance Competition
- Ethernet + OTN Performance ROADM network mgmt
Tx power challenges

400G ZR is challenging to mix with 10G to 100G channels due to low Tx power (-10dBm) and OSNR performance (26dB).

The Smartoptics DCP-M Flexible Open Line Systems are designed to manage these signals.

TECHNICAL DATA

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>DWDMD QSFP-DD type 2</td>
</tr>
<tr>
<td>Transmission media</td>
<td>SM (2x LC)</td>
</tr>
<tr>
<td>Typical reach</td>
<td>120km</td>
</tr>
<tr>
<td>Nominal wavelengths</td>
<td>192.00 - 196.00 THz</td>
</tr>
<tr>
<td>Interface standards</td>
<td>400GBASE-ZR</td>
</tr>
<tr>
<td>Protocol support</td>
<td>4GBASE-N</td>
</tr>
<tr>
<td>Power consumption</td>
<td>&lt; 17 W (Class 8)</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>0°C to +70°C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>-40°C to +65°C</td>
</tr>
</tbody>
</table>

1) Receiver sensitivity at unamplified configurations
2) Signal power of the channel at the OSNR performance value
3) Input power needed to achieve post-FEC BER
4) At CFE threshold
5) OSNR tolerance penalty over OSNR Tolerance due to reflections and dispersion
6) Tolerance to PMD with +0.5 dB penalty to OSNR sensitivity.

Safety/Regulatory compliance:
- TUV/UL/CETL (contact Smartoptics for latest certification information)
- RoHS compliance

Parameter | Value
---|---
Transmitter data: |  
Output power | Min. -10.0dBm Max. -6.0dBm
Transmit wavelengths | 192.00 - 196.00 THz in 100 (75) GHz steps (0.694 ±)
Receiver data: |  
Minimum input power | -20.0dBm
Input sensitivity | -12.0dBm
Overhead (max power) | 0 dBm
OSNR tolerance | Max. 26dB/0.1nm
CD Tolerance | Min. 2400ps/nm
Optical path OSNR penalty tolerance | Max. 0.5dB
PMD tolerance | Min. 10 ps
DOM | Yes
MSA compliance | QSFP-DD MSA

QSFP-DD type 2a
Revision 3.0 was released in Aug 2018. A 3.0.1 update in Jan, 2019.
Revision 4.0 was released in May 2019.
Revision 5.0 was released in May 2021

Different system vendors have implemented different versions!
CMIS3.0 is not compatible with CMIS4.0 or CMIS5.0 and vice verse.
CMIS5.0 contains additions and bug fixes.

Imperative to check what version that the host equipment supports and select a transceiver having the corresponding CMIS version.

Used by both grey and coherent 400G transceivers!
Coherent 400G capable filters

Signal spectrum for different rates and modulation formats.
400G Capable filters

400G 16QAM

400G 16QAM can be multiplexed @ 100GHz grid, but requires a wider channel passband than lower rates!

<table>
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<tr>
<th>16 Levels</th>
<th>Q uadrature</th>
<th>A mplitude</th>
<th>M odulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>1001</td>
<td>1011</td>
<td>1010</td>
</tr>
<tr>
<td>1100</td>
<td>1101</td>
<td>0111</td>
<td>0110</td>
</tr>
<tr>
<td>0000</td>
<td>0001</td>
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Must be > 75GHz
800G Technology
800G Grey optics

How is 800G achieved?

By doubling 400G technology!

Challenge!

Double number of optical connections!
Size and power consumption of electronics and optics.
800G Grey optics

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Form-factors for 800G

Form-factor options:

New QSFP-DD MSA spec with multiple connector options!
Coherent 800G

“interoperable 800G coherent line specifications for campus and DCI applications”.

Scope:

• Define single-lambda 800G coherent line interfaces for two applications:
  - Amplified, single span, DWDM links up to 80-120km
  - Unamplified, fixed wavelength links of 2-10km

• Support Ethernet client(s) (minimum 100GE) up to 800G aggregate bandwidth

First availability in second half of 2023.

Same modulation format as 400G, but with a higher baud rate.

Will require even wider channel filter passband than 400G.

Power consumption between 24-27W
Summary

- 400G Coherent DSP
- 8x 25Gbd, 2x 60Gbd
- FEC, Frame, DAC

4 lanes, 50GBaud, CWDM

16 Levels
Q uadrature
A mplitude
M odulation

Pulse
Amplitude
Modulation
4 Levels

01 00 10 11

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<th>OpenZR+</th>
<th>OpenROADM</th>
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THOU SHALL NOT PASS

smartoptics
Thank you!

please visit smartoptics.com