Standards:

- **ITU-T G.984**
  - GPON (Gigabit PON) is an evolution of the BPON standard. Uses new native Generic Encapsulation Method (GEM) transport layer that supports multiple “non-native” transport protocol including ATM, Ethernet and TDM

- **IEEE 802.3ah**
  - EPON or GEPON (Ethernet PON) is an IEEE standard – ratified in June 2004. Uses native Ethernet transport protocol.
### Passive Optical Networking - GPON

**GPON (Gigabit PON):**
- Defined in ITU G.984.2
- Logical reach: up to 60 km
- Split ratio up to 1:128
- Security: Advanced Encryption Standard (AES)

**Operating Wavelength Range:**
- 1310 nm (data/voice upstream signal)
- 1490 nm (data/voice downstream signal)
- 1550 nm (video signal)

**CO/HE** - Central Office – Headend
**OLT** - Optical Line Terminal

**ONT** - Optical Network Terminal

1 fiber per subscriber

1 x 64 PLC Splitters

Downstream: 1490 nm
Video signal: 1550 nm

PLC = Planar Lightwave Circuit

### Passive Optical Networking - EPON

**EPON or GEPON (Ethernet PON):**
- Defined in IEEE 802.3ah
- Logical reach: up to 20 km
- Split ratio up to 1:32
- Security: not defined

**Operating Wavelength Range:**
- 1310 nm (data/voice upstream signal)
- 1490 nm (data/voice downstream signal)
- 1550 nm (video signal)

**CO/HE** - Central Office – Headend
**OLT** - Optical Line Terminal

**ONT** - Optical Network Terminal

1 fiber per subscriber

1 x 32 PLC Splitters

Downstream: 1490 nm
Video signal: 1550 nm

PLC = Planar Lightwave Circuit
25.5.2010

PLC Splitter - packaging

Basic parts:
- glass chip
- fiber arrays
- single fibers or ribbon fibers

PLC splitters Manufacturing

Technological base:
1. Wafer cutting, polishing
2. Mask design and Photolithography
3. Chip manufacturing (A-C)
4. Chip cutting and polishing
5. FA manufacturing and chip coupling
6. Splitter testing and packaging
**Example for a waveguide simulation**

**Mask design**

**Technology:**

- **Primitive**
  - straight waveguide
  - Y branch ratio: 5:95 - 50:50
  - bended waveguide segment
  - directional coupler ratio: 50:50

**Layout on 2'' or 3'' wafer**

**V-Grooves & Fiber Arrays - manufacturing**

**Design of fiber arrays:**

- fiber chip interface: special glue
- fiber carrier: glass for optimum thermal expansion matching
- assembling: glue is used to connect V-groove array and fiber carrier

**V-groove array:** precise fiber alignment

**Fiber stress release:** bare fiber is fixed between V-groove and fiber carrier.

**Fiber bending:** Fixation of the coated fiber in the array preserves the bare part of the fiber from damage.
V-Grooves & Fiber Arrays - parameters

**Specification:**

<table>
<thead>
<tr>
<th>V-Grooves &amp; Fiber Arrays:</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rear Arrays Types available:</td>
<td>from Single Channel up to 64 Channels</td>
</tr>
<tr>
<td>Material:</td>
<td>Glass (Quartz, Pyrex or Tempra), Silicon, Ceramic</td>
</tr>
<tr>
<td>Pitch:</td>
<td>127, 250 or Custom µm</td>
</tr>
<tr>
<td>Rear:</td>
<td>SM, MM and special fiber</td>
</tr>
<tr>
<td>Releaved end face:</td>
<td>flat or angled ±0.2 and better or customer specified</td>
</tr>
<tr>
<td>Fiber Core Offset:</td>
<td>&lt; 0.5 µm</td>
</tr>
<tr>
<td>PM version:</td>
<td></td>
</tr>
<tr>
<td>Angle deviation:</td>
<td>± 0.5 (± 0.25)</td>
</tr>
<tr>
<td>Extinction ratio:</td>
<td>≥ 25 dB</td>
</tr>
<tr>
<td>Fiber Core Offset:</td>
<td>&lt; 1.0 µm</td>
</tr>
</tbody>
</table>

**Applications:**

- In Telecom: FTTH, AIN(P) packaging
- In Non Telecom: Medical, Measurement Equipment, Sensors

---

PLC Splitter - characteristics

**Optical characteristics:**

**Splitter models:**
- 1xN, 2xN PLC Splitters
- Asymmetric Splitters
- Multiple Monolithic Splitters
- Customized mask design

Available cut-off wavelengths:
- 480 nm, 630 nm, 850 nm, 980 nm, 1060 nm, 1260 nm

**Application:** FTTx Networks, Analog/Digital Passive Optical Networks, CATV Networks, Medical, Chemistry, Instrumentation sensors, Test equipments, Photonics
Parameters definition:

Splitter models:
- 1xN, 2xN PLC Splitters
- Asymmetric Splitters
- Multiple Monolithic Splitters
- Customised mask design

IL:
- Remember the IL mentioned in the table is max. value valid over full operating wavelengths and temperature range for all states of polarization. The uniformity is defined over the whole wavelength range!!!

Insertion Loss (IL): Max/Min IL(WR)

Uniformity: \( U_{\text{max}} = \text{IL}_{\text{max}} - \text{IL}_{\text{min}} \)

Temperature dependent Loss (TDL):
\( \Delta \text{IL}(T) = -40^\circ C - 85^\circ C \)

Polarisation dep. Loss (PDL):
\( \text{PDL} = \text{IL}_{\text{max}}(\text{POL}) - \text{IL}_{\text{min}}(\text{POL}) \)

POL: All states of polarization

Wavelength Ranges (WR):
- 1260 nm - 1650 nm

Insertion Loss (IL):

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>IL (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1300</td>
<td>8.5</td>
</tr>
<tr>
<td>1350</td>
<td>9.0</td>
</tr>
<tr>
<td>1400</td>
<td>9.5</td>
</tr>
<tr>
<td>1450</td>
<td>10.0</td>
</tr>
<tr>
<td>1500</td>
<td>10.5</td>
</tr>
<tr>
<td>1550</td>
<td>11.0</td>
</tr>
<tr>
<td>1600</td>
<td>11.5</td>
</tr>
<tr>
<td>1650</td>
<td>12.0</td>
</tr>
</tbody>
</table>

Optical Specification 1xN:
- Configurations: 1x2, 1x4, 1x8, 1x14, 1x16, 1x18, 1x24, 1x32
- Insertion Loss max.: 3.5 dB
- Insertion Loss typ.: 3.0 dB
- Uniformity typ.: 0.5 dB
- Rel. Dependent Loss: 0.15 dB

Optical Specification 2xN:
- Configurations: 2x2, 2x4, 2x8, 2x16, 2x32
- Insertion Loss max.: 5.0 dB
- Insertion Loss typ.: 4.5 dB
- Uniformity typ.: 1.2 dB
- Rel. Dependent Loss: 0.2 dB
- Return Loss: 55 dB
- Isol. typ.: 45 dB

Wavelength range: 1360 - 1650 nm

*Note: All values are valid over operating wavelength and temperature range! **All values are max. values! **
### Mechanical Specification

<table>
<thead>
<tr>
<th>Fiber type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM/50/1250 B1.65</td>
<td>m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard length of fiber</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>68x10x6.5 / 67x19.5x7 / 64,5x31.5x6</td>
<td>mm</td>
</tr>
<tr>
<td>53x7x4 / 50x15x6 / 44x4x4</td>
<td>mm</td>
</tr>
</tbody>
</table>

**Housing material & dimension:**
- Nickel plated brass: 44x4x4 mm
- Plastic (black): 50x15x6 mm
- Plastic (blue): 69x10x5.6 mm
- Aluminium: 64,5x31,5x6 mm
- Aluminium: 67x19,5x7 mm

<table>
<thead>
<tr>
<th>Environmental Specification</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature</td>
<td>°C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>°C</td>
</tr>
</tbody>
</table>

### Environmental Tests

**Humidity:** 85% RH
**Duration:** 2000 hrs
**Wavelength:** 1310 nm + 1550 nm
**Specified maximum IL:** +0.50 dB

**Operating temperature:** -40°C to +85°C
**Storage temperature:** -40°C to +85°C

**Based on Telcordia 1209 and 1221:**

### Performance and Reliability Testing

**Damp Heat Test 2000 hrs**

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Humidity</th>
<th>Duration</th>
<th>IL</th>
<th>Wavelength</th>
<th>Specified maximum IL</th>
</tr>
</thead>
<tbody>
<tr>
<td>+85°C</td>
<td>85% RH</td>
<td>2000 hrs</td>
<td>±0.50 dB</td>
<td>1310 nm + 1550 nm</td>
<td></td>
</tr>
</tbody>
</table>

**Mechanical Test (Vibration, Twist, Pull)**

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>Amplitude</th>
<th>Sweep time</th>
<th>Number of sweeps</th>
<th>Direction</th>
<th>IL</th>
<th>Wavelength</th>
<th>Specified maximum IL</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Hz - 2000 Hz</td>
<td>1.52 mm</td>
<td>10 Hz - 2000 Hz - 10 Hz in 20 min</td>
<td>12 per axis</td>
<td>3 perpendicular axes</td>
<td>±0.50 dB</td>
<td>1310 nm + 1550 nm</td>
<td>±0.50 dB</td>
</tr>
</tbody>
</table>
Performance and Reliability Testing

Test Report
QM – 017/06

Table of Contents
1 Device under Test .................................................. 2
2 Test Equipment ..................................................... 2
  2.1 Testing laboratory .............................................. 2
  3 Test Specification and Results .................................. 3
  3.1 High Power Test ................................................ 3

2 Test Equipment

<table>
<thead>
<tr>
<th>Device</th>
<th>Type</th>
<th>Manufacturer</th>
<th>Inventory No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical multimeter</td>
<td>HP 8510A</td>
<td>Hewlett-Packard</td>
<td>SN 284000125853</td>
</tr>
<tr>
<td>Power meter</td>
<td>Microwave PM5</td>
<td>Microlab</td>
<td>1601276 01</td>
</tr>
<tr>
<td>Power meter</td>
<td>RT-130 CHD</td>
<td>Laser Precision Corp</td>
<td>SN: 0822466</td>
</tr>
<tr>
<td>EDFA</td>
<td>CAF 055</td>
<td>JDSU</td>
<td>SN 125E0047</td>
</tr>
</tbody>
</table>

3 Test Specification and Results

3.1 High Power Test

Test Conditions:
- Saturated output power [P] 25.2 dBm
- Operating wavelength 1550.12 nm
- Power monitoring period 1 hour
- Duration 2000 ms

Test Results:
FTTx Components

PLC Splitter Modules

for centralized splitting of fiber in Passive Optical Network (PON) FTTx architectures

LGX compatible

Cable Profile (MxE2000)

Optical Patch Panel (NxE2000) (1)

Optical Patch Panel (NxE2000) (2)

Optical Patch Panel (NxE2000) (M)

Passive Splitter Modules

max. ports: 768

Passive Splitter Modules

max. ports: 96

ONT’s

ONT’s

ONT’s

OLT

Fan-out Module

MP O/
• Regular housing, I/O ribbon fiber 250um

PLC Splitters 1 x 8

- housing material
  nickel plated brass
  44 x 4 x 4 mm

• Regular housing, I/O de-ribbonized Leads 250um
• Regular housing, Input fiber 900um

• Regular housing, FOB interface (900um fiber / 2.0mm Cable)
• Splice Tray cassette storage, I/O Ribbon 250um

• Splice tray storage, Input & Output buffered fiber 900um
• Splice Tray storage, Output cable fiber 2.0mm

• Special housing, I/O buffered fiber 900um
• Special housing, I/O cable 2.0mm

• LGX cassette design, I/O buffered fiber 900um
• LGX Cassette design, I/O cable 2,0mm

• LGX Cassette design, Optical connector interface
• LGX Cassette design, MPO optical interface

• Special Cassette design, XX connector interface
• Special Cassette design, XX connector interface

• 19" modules with optical connector interface
- 19" Modules with optical connector interface

### US FED STD 209E cleanroom standards

#### ISO 14644-1
- FED STD 209E
- Cleanroom Standards

<table>
<thead>
<tr>
<th>Class</th>
<th>maximum particles/m³</th>
<th>FED STD 209E equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 1</td>
<td>10  2</td>
<td></td>
</tr>
<tr>
<td>ISO 2</td>
<td>100 24 1000 10000</td>
<td>Class 1</td>
</tr>
<tr>
<td>ISO 4</td>
<td>10000 20000 100000</td>
<td>Class 10</td>
</tr>
<tr>
<td>ISO 5</td>
<td>1,000,000 20000000</td>
<td>Class 100</td>
</tr>
<tr>
<td>ISO 6</td>
<td>1,000,000 20000000</td>
<td>Class 1000</td>
</tr>
<tr>
<td>ISO 7</td>
<td>352000 832000 293000</td>
<td>Class 10,000</td>
</tr>
<tr>
<td>ISO 8</td>
<td>3,520,000 832000 293000</td>
<td>Class 100,000</td>
</tr>
<tr>
<td>ISO 9</td>
<td>35,200,000 8,320,000 293000</td>
<td>Room air</td>
</tr>
</tbody>
</table>
SQS Photo gallery

SQS Photo gallery
Conclusion:
PLC splitters made by SQS Vlaknova optika a.s.

- Integrated splitter modules (cassettes, connectors)
- Clearly defined parameters (ILmax, uniformity)
- Ideal location in the Centre of Europe (Czech Republic)
- High level of technical support
- Complete in house testing solution (Spectrometers, temperature chambers, FA geometry measuring devices, etc.)
- Reasonable price