1G - 10Gig PON Systems
Standards, Platforms and Applications

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March 2020
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Basic PON Architectures
GPON Reference Architecture

- OLT at the TA5K
- Fiber / Splitter
- ONT at the customer premises

Central Office

Total Access 5000

Interconnected devices:
- Internet
- IPTV Head END
- IP Core
- Voice Switch
- Phone
- Internet
- Set-Top Box
- HDTV
Basic PON construction

OLT
• Source of the PON network Signal
• Housed in the central office

Can Be
• GPON
• XGSPON
• NGPON2

Splitter
• Splits the Light coming from the OLT
• Housed in the central office or deployed in the field

Splitters Can Be
• 1x32
• 1x16
• 1x8
• 1x4
• 1x2
• Many shapes and sizes

ONT
• Terminates the GPON signal
• Found at the Customer Premise

Can Be
• Indoor
• Outdoor
• Many shapes and sizes

ONT
• Terminates the GPON signal
• Found at the Customer Premise

Can Be
• Indoor
• Outdoor
• Many shapes and sizes
Splitters and Layouts
Splitters

ISO Top View

1 x 32 Splitter

1 x 16 Splitter

Package Style F, M

Package Style G, N, K

Rack Mount Splitter Chassis
Splitters
PLC or Fused Biconic Taper

- Higher Cost
- Fibers Spliced on a chip
- Always Equal Output
- Lower Loss
- 1260 to 1650 (Wider Range)

- Lower Cost – basic MFG and Material
- Custom Power Outputs
- 850, 1310, 1550 (Limited Range)
- Higher Loss
PON Distances

OLT

1x4

1x32

1x32

ONT

ONT

ONT

20KM Standard

30KM to 37KM Extended

62KM Extreme

General Business
Centralized Splits

CO / DC
OLT
OLT
OLT
OLT
OLT

Splitter
Splitter
Splitter
Splitter
Splitter

ONT
ONT
ONT
ONT
ONT

HomeRun Fiber to each location
Cascade or Distributed Splits

CO / DC
OLT
OLT
OLT
OLT

OLT
OLT
OLT
OLT

1 x 2
1 x 4
1 x 4
1 x 4
1 x 32

Splitter
Splitter
Splitter
Splitter

1 x 4
1 x 4
1 x 4

ULTIMATE
Split Ratio

1 x 32

OLT
OLT
OLT
OLT

ONT
ONT
ONT
ONT

General Business
## Typical Loss Values

<table>
<thead>
<tr>
<th>Split Ratio</th>
<th>Loss (dB)</th>
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<tbody>
<tr>
<td>1x4</td>
<td>7.0</td>
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<tr>
<td>1x8</td>
<td>10.5</td>
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<tr>
<td>1x16</td>
<td>14.0</td>
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<tr>
<td>1x32</td>
<td>17.5</td>
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<tr>
<td>1x64</td>
<td>21.0</td>
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Angle Polish or Ultra Polish Connectors
PON Economics
The Cost Advantage
P2P Deployment Fiber counts

- Transport Fiber 1:1
- 32 strands to feed 32 CPE

- At install the raw fiber cost is a push
- Splicing Adds up
- Existing fiber = Huge Expense
P2P Deployment

- Optics – 1:1 Ratio
- 64 optics for 32 DPUs

- Large investment in Optics
- Standard Ethernet optics can be cheaper
Passive Optical Networks

- Transport Fiber = 1
- Distribution Fiber = 32

- Added Splitter Cost = $200 to $1000
- Less Splicing
- Less raw fiber
- Efficient for existing fiber deployment
Passive Optical Networks

- Optics – 1:8 Ratio
- 33 optics for 32 CPE

- Major cost advantage
- PON Optics are price competitive with P2P Optics
Splice Points – Lowest Cost

128 Total

1 2 3 2 3 32

Passive Splice

Ethernet Switching

32

PON OLT

1 2 3 32

Field Splitter

1 2 3 32

66 Total

DPU

1 2 3 32

DPU
PON Cost Factors

• Installed Fiber cost is generally a push
  • Fiber counts are lowered to meet very aggressive business cases
  • Generally strand counts are maximized in relation to the budget
  • Labor costs generally drive installing excess fibers

• Splicing can be minimized in specific designs
  • This is not always the case

• Splitters are not expensive enough to drive up the cost of PON

• PON wins as Optics are minimized
  • This main drive for the PON cost advantage
Evolving Standards
Ride the Wave
PON Evolution

ITU and IEEE
PON Capacity

- **GPON**
  - 1.25/2.5 Dn/Up

- **XGSPON**
  - 10G Dn/Up
  - Fixed

- **EPON**
  - 1/1 and 2/1 Dn/Up
  - 10/1 or 10/10 Dn/Up

- **NGPON2**
  - 10G Dn/Up
  - 4 or 8 Wavelengths
  - Tuneable
PON Wavelengths

- **GPON**
  - 1310up
  - 1490dn

- **XGSPON**
  - 1270up
  - 1577dn

- **EPON**
  - 1270up
  - 1577dn

- **NGPON2**
  - 1524 to 1544up
  - 1596 to 1602dn
Emerging PON Standards

- **IEEE**
  - 50GEPON (802.3ca)
    - Formerly 100GEPON, now 50GEPON (2x25G/λ)
    - O-band (~1300nm) for low dispersion (unlike NGPON2)
    - No tunability (unlike NGPON2)
    - Wavelength bonding
    - Fragmentation (like ITU)
    - Flow ID (like ITU)
  - 2 bandplans:
    - 50G: coexist w/ 10GEPON & XGS-PON
    - 25G: coexist w/ GPON
  - Expect complete Aug 2020

- **ITU**
  - XGS-PON (G.9807.1)
    - Started by ADTRAN; based on NGPON2 TC layer; compatible with 10GEPON optics
  - NG-PON2 (G.989.x)
    - ADTRAN+ optimized optics std to make realizable
    - ONU: ER, OOC; OLT: N2
    - TC changes: based on ADTRAN+ interop
  - HSP (G.HSP.x)
    - 50G single channel (2021)
    - 200G (4x50) TWDM (2022)
    - Common TC layer
  - Super-PON (G.9807.3)
    - Google hybrid power-split / low-loss λ-routed ODN
    - Currently positioned as NGPON2 reach extender
PON Overlay

OLTs

GPON OLT w/ Standard Optics

GPON

PON Splitter
PON Overlay

- **XGSPON 10G**
  - Fixed wavelength
  - Available Today

- **NGPON2**
  - 4 Waves today
  - 8 Waves defined

- **XGS on GPON**
  - Leverages GPON Wavelengths
  - Replaces GPON long term
Adding P2P Wavelengths

OLTs

Wavelength Mux

WM2

CPRI, P2P 10G, etc.

XGSPON

XGSPON OLT w/ Fixed Optics

NGPON2 OLT w/ TWDM Optics

RF Video

10G PON w/ Class “G” Optics

WM1

Co-existence element

PON Splitter

CE1 or CE2

Dropping Individual Waves from External OLTs and Devices

General Business
Coexistence Module

- Half Height Module
- Same ONE Footprint
- UPC and APC Connectors
- OTDR Port for Testing
- Temp Range -40F to +140F

### Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>Min Pass Band Upstream</th>
<th>Max Pass Band Downstream</th>
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<tbody>
<tr>
<td>Operating Wavelength</td>
<td>nm</td>
<td>1260</td>
<td>1660</td>
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<tr>
<td></td>
<td></td>
<td>1524-1544</td>
<td>1596-1625</td>
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<tr>
<td></td>
<td></td>
<td>1260-1280</td>
<td>1575-1581</td>
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<td>1290-1330</td>
<td>1480-1500</td>
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<tr>
<td></td>
<td></td>
<td>1640-1660</td>
<td>1640-1660</td>
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<tr>
<td></td>
<td></td>
<td>1550-1580</td>
<td></td>
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### Insertion Loss

<table>
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<th>Insertion Loss*</th>
<th>Unit</th>
<th>Initial</th>
<th>EoL Max</th>
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<tbody>
<tr>
<td>NGPON2–ODN</td>
<td>dB</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>XGPON–ODN</td>
<td>dB</td>
<td>2.0</td>
<td>2.5</td>
</tr>
<tr>
<td>GPON–ODN</td>
<td>dB</td>
<td>2.0</td>
<td>2.5</td>
</tr>
<tr>
<td>OTDR–ODN</td>
<td>dB</td>
<td>2.0</td>
<td>2.5</td>
</tr>
<tr>
<td>RF Video–ODN</td>
<td>dB</td>
<td>2.0</td>
<td>2.5</td>
</tr>
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</table>

### Uniformity* (BoL Max)

<table>
<thead>
<tr>
<th>Uniformity* (BoL Max)</th>
<th>dB</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>0.5</td>
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4x ODN CE Module

- Add GPON and XGS-PON to the Same ODN
- Supports up to 4 x ODN / Splitters
- ONE Mux Form Factor
- Deploy in Chassis with Carrier Module
- Deploy in External Panel
- Same Price as standard CE1 Module
CEx4 Migration Overview

20KM Distance
Cloud based PON Redundancy
Geographic Diversity

GPON Chassis “A”

1 x 32 Splitter

GPON Chassis “B”

Ont

Rolling out Now

Redundancy App Needed
Cloud based PON Redundancy
Geographic Diversity

GPON Chassis “A”

GPON Chassis “B”

1 x 32 Splitter

Rolling out Now

Redundancy App Needed
Summary

• Multiple flavors of PON on the same ODN
• P2P Wavelengths to be added in the future
• Significant expansion of capability
  • Multiple services across a common infrastructure
• Drives the long term effectiveness of the installed ODN
OTLs and ONTs
The many faces of FTTx Hardware
OLT platforms
GPON

- 4 and 8 Port OLTs
- 20 Gigs per slot
- 1:32, 1:64 and 1:128 (F2 Part) Way Split Ratios
  - Enabling new CapEx models
- Enhancing Range
  - 20km, 30km, 37km and 62.5km (F2 Part)
  - Creating Deployment Flexibility
- ADVANCED DBA
  - Enabling High Quality Gigabit Services
  - Defining High Value Services Per Customer
    - Flexibly Committed Information Rates
4 Port 10Gig OLT

- 4-Port XGS-PON Optical Line Terminal
  - ADTRAN FPGA based architecture
    - ADVANCE DBA
      - Flexibly Committed Information Rates
    - Type B Redundancy
  - 4 X 10/10 XFP ports
    - XGS-PON 1577nm / 1270nm
    - Class “G” 2nd Fixed 10/10 option
    - NGPON2
XGS-PON Evolution

**XGSPON-8**

TA-5000 OLT
- 8 Ports
- XGSPON
- GPON
- COMBO PON – Dual Rate
- 168 10G Pon per Chassis

8 Port Release Q2-2020

**Dual Rate PON**

Dual Rate Port

GPON T/X

XGSPON T/X

Requires Dual Rate Optics
1:32 Split Supported

Splitter

GPON ONT

XGSPON ONT
Aggregation/ToR Switches
(32x100G each)

200G Links to ToR Switches
TOR and Aggregation

- **SDX-8310-32**
  - 32 x 100Gig
  - QSFP28
  - 100, 40 or 4 x 10Gig breakout
- **SDN Capable**
  - OpenFlow
  - NetCONF / YANG
  - Mosaic Cloud Platform
- **Spine and Leaf**

- **SDX-8210-54CE**
  - 48 x 10Gig SFP+
  - 4 x 100 / 40Gig QSFP20
- **SDN Capable**
  - OpenFlow
  - NetCONF / YANG
- **Mosaic Cloud Platform**
- **Spine and Leaf**

**SDN Capable**
- Mosaic Cloud Platform
- VoLTHA / SEBA
- OpenFlow
- NetCONF / YANG
Virtual OLTs

- **SDX-6310-16**
  - 16 Ports
    - GPON / XGSPON / NGPON2 / 10Gig EPON

- **SDX-6010-16**
  - 16 Ports – Extended temp range -40 to +65

- **SDX-6020-48**
  - 48 Ports
    - GPON, XGS-PON or Active Ethernet

- **SDN Capable**
  - Mosaic Cloud Platform
  - VoLTHA / SEBA
  - OpenFlow
  - NetCONF / YANG
ONT Variants
GPON ONTs: A Closer Look

**TA350/450 Outdoor**
- 2 to 4 Gig
- 2 to 4 FXS
- Outdoor Rated
- Autosensing

**TA400 Micro**
- 1 Gig
- 1 FXS
- Indoor
- Autosensing

**TA372 Small Biz**
- 2 Gig
- 8 FXS
- 4 x DS1 PWE
- Outdoor Rated
- GPON
- AE (P2P)

**Multi-Unit Housings**
- Up to 4 x ONTs
- Power MGMT
- Fiber MGMT
10G ONTs: A Closer Look

SDX 602X
10G Small Business Unit ONT
- Carrier Ethernet Feature Set
- SFP+ Network Interface
- SFP+ UNI

SDX 621
10G Small Family Unit ONT
- Optional POTS Support
- Optional 1G UNI

SDX 621X
10G Small Family Unit ONT
- SFP+ Network Interface
- IP Video Support

SDX 624v
10G Multiport ONT
- Optional POTS Support
- Optional 1G UNI

SDX 622vh
10G Outdoor ONT
- 10G Outdoor ONT
- Outdoor Temp Rating (-40 to 65C)
- Corning Housing
Optical Network Terminal (outdoor)

- Technician Access
  - Internal and external
  - Basic troubleshooting
  - POTS
  - ETH
  - LEDs
  - Optional Home owner access

Can-wrench security screw
Flat head
Padlock point

LEDs
RJ-45 Eth
POTS
Applications
Market Leader

- 1,000+ Gigabit communities
- 60,000+ nodes deployed worldwide
- Highest density platform (60,000+ subscribers/rack)
- Available in high-density, medium-density or compact chassis
TA-5000 ERPS

100G ERPS (SM200)
ETOS-10
Transport and Service Delivery

• TA-5000 based 10 Gig Ethernet Switch
  • Non-Blocking L2 Switch
  • 8 x 10GE and 2x1/2.5GE ports on single-wide module
  • Deploy in any TA5000 chassis – fully redundant
  • LAG/LACP and ERPS Rings

• MEF 2.0 Business Service Delivery
  • SLA
  • E-LINE, E-LAN Services
Substation Services

Site P

10Gig ERPS

Local Ethernet

Substation Boundary

GPON - Broadband

FWA Backhaul

General Business
Reclosure Coordination

Improving Grid reliability
Grid Isolation - Past

- Substation Breaker
- Manual Switches
- Fuses
Grid Isolation - Yesterday

Substation Breaker

Automated Device

[Diagram showing a substation breaker and an automated device activating due to a potential issue]
Grid Isolation - Today

Substation Breaker

Auto-Transfer Scheme

SCADA Device
Grid Isolation - Future

1) Fault Isolation (Peer to Peer Communication)
2) System Restoration (Communication with a central hub)
Key Needs

Point to Multi-Point Communication

High Speed, Low Latency

High Reliability

Proven Technology
Right of Way - Assets

- Existing ROW Assets
- Hold Reclosures
- Path to BB Customers
Pole Line Access
Pole Line Hardware
Isolate Services

Combined XGS and GPON

20KM Distance
Isolate Services

**SDX-6312-4**
- Pole Line OLT
- Combo
- GPON
- XGSPON

**Dual Rate PON**
- Dual Rate Port
- Requires Dual Rate Optics
- 1:32 Split Supported

- **GPON T/X**
- **XGSPON T/X**

RC

Splitter
Summary – What can be connected

- LINC Towers & AMI Meter Collectors
- Recloser Deployment
- Support engineering coordination strategies
- High Density Coordination
- More Auto Devices = Better FISR
- Phasor Measurement Units
- Substation Connectivity & Security
- Business / Engineering Office Connectivity

APC Crews being Trained on Fiber
BRINGING THE WORLD TOGETHER

Thank You