Serial 10G EPON Downstream Considerations

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Agenda

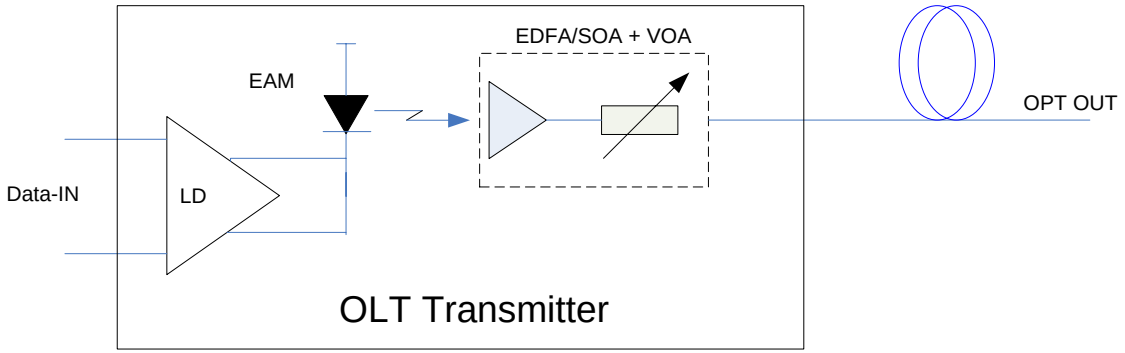
- Overview of optical system for Serial 10G EPON
- Laser modulation
- Amplifiers
- Fibers

Motivation

- An economic and robust solution for FTTH Multi services application topology (Triple play)
- Wide optical budget
- High split ratio >=128
- Long distance >=10Km
- Use of installed base standard single mode fiber (G.652)

System overview

- Assumption:
  - ***No Overlay channel for Analog Video***
- Low power Serial 10Gbps EAM Laser at the OLT
- Connected to an active optical device (EDFA or SOA + VOA)
- The OLT MAC controls the VOA by digital interface
- VOA is needed to support wide range of optical budget
- APD at the ONU Transceiver



System benefits

- Use of low power EAM Laser enabled by Optical Amplifier
  - Less than 0dBm
- Support wide range of Optical budget, from Saturation to Sensitivity, enabled by VOA
  - 0dB to 35db
- Can support the required numbers of ONUs and distances
  - 1:16 to 1:128
  - Up to 20Km

The most cost effective 10G system

Why 1550nm Downstream?

- Most common in Digital link and WDM systems
- Lowest attenuation
- EDFA, SOA and VOA – off the shelf
- Low cost standard fiber
- High speed Modulators and Detectors – off the shelf
- Other optical components – off the shelf
- Most industrial support in the future

Optical Modulation

	Direct	External
Type	FP, DFB, VCSEL	EML, EAM, MZ
Bit rate	<= 2.5Gbps	>= 2.5Gbps
Bias	Use Bias	Zero Bias
	Chirp	Minor Chirp
Extinction Ratio*	Limited	Large
	High cost	Higher cost

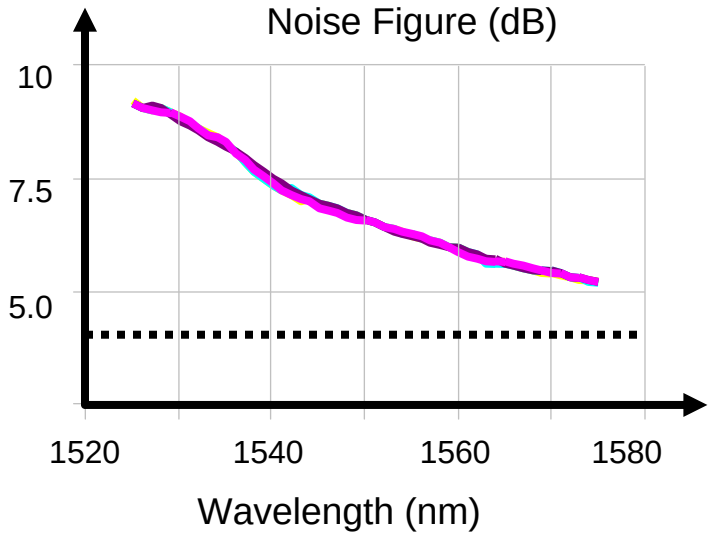
* BER directly effected by Extinction Ratio

EDFA

- EDFA
  - All optical and fiber compatible
  - Wide bandwidth, 20~70 nm
  - High gain, 20~40 dB
  - High output power
  - Bit rate, modulation format, power and wavelength insensitive
  - Low distortion and low noise (NF<5dB)

Noise Figure (NF)

- Input signal dependent
  - In a saturated EDFA, the NF depends mostly on the wavelength of the signal
  - Physical limit: 3.0 dB



SOA

Advantages

- Is the right size to be integrated with waveguide photonic devices (short path length requirement)
- Uses same technology as diode lasers
- Gain relatively independent of wavelength
- Is pumped with current, not another laser

Disadvantages:

- Polarization dependence
- Self-phase modulation leading to chirp
- Cross-phase modulation
- Four-wave mixing and crosstalk

Optical Amplifier Comparison

	SOA	EDFA
Gain [dB]	>30	>40
Wavelength [nm]	1280-1650	1530-1560
Bandwidth [nm]	60	30-60
$P_{(saturation)}$ [dBm]	15	20
Polarization [dB]	<0.5	0
Noise Figure [dB]	8	5

Fiber Optic cable types

There are 3 types of fiber optic cables:

- Non-Dispersion Shifted Fiber (NDSF) → G.652
- Dispersion Shifted Fiber (DSF) → G.653
- Non-Zero-Dispersion Shifted Fiber (NZ-DSF) → G.655

Installed Single Mode Fiber Types

Name	ITU-T	IEC Reference	Optimized Dispersion Range [nm]	Referred to use in 802.3ae Specification?
Non-Dispersion Shifted Fiber	G.652	IEC 60793-2 (B1, B1.3)	1300 – 1324	YES
Dispersion Shifted Fiber	G.653	IEC 60793-2 (B2)	1500 – 1600	NO
Cutoff Shifted Fiber	G.654	IEC 60793-2 (B1.2)	1550 – 1625	NO
Non-Zero Dispersion Shifted Fiber	G.655	IEC 60793-2 (B4)	1530 – 1565 (C-Band) 1565 – 1625 (L-Band)	YES

Limitations at 10Gbps

- Expensive electronic components
- Transmitter chirp
- Chromatic Dispersion
- Polarization Mode Dispersion (PMD) increase BER

Some networks already are running 10GbE, but only on selected fibers

G.652 vs. G.655

	Units	G.655	G.652
Attenuation @1550nm	dB/km	<0.25	<0.25
Chromatic Dispersion	ps/nm/km	1-14	14-23
Dispersion Slope	ps/km/nm²	<0.07	<0.09
Effective area	µm²	55	80
PMD	ps/km½	<0.2	<0.5
Bit Rate	Gbps	>10	2.5

Next Steps

- Invite contributions from study group members on the optical system
- Simulation by OptSim or other software tools
- Lab proof of concept

Conclusions

- High split ratio Serial 10G EPON is technically feasible
- Significant penalties when using existing fiber optics – need further study
- Economic model for 10G – need further study

Achieving a 10x data throughput on legacy fiber optic cables obviously is attractive

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