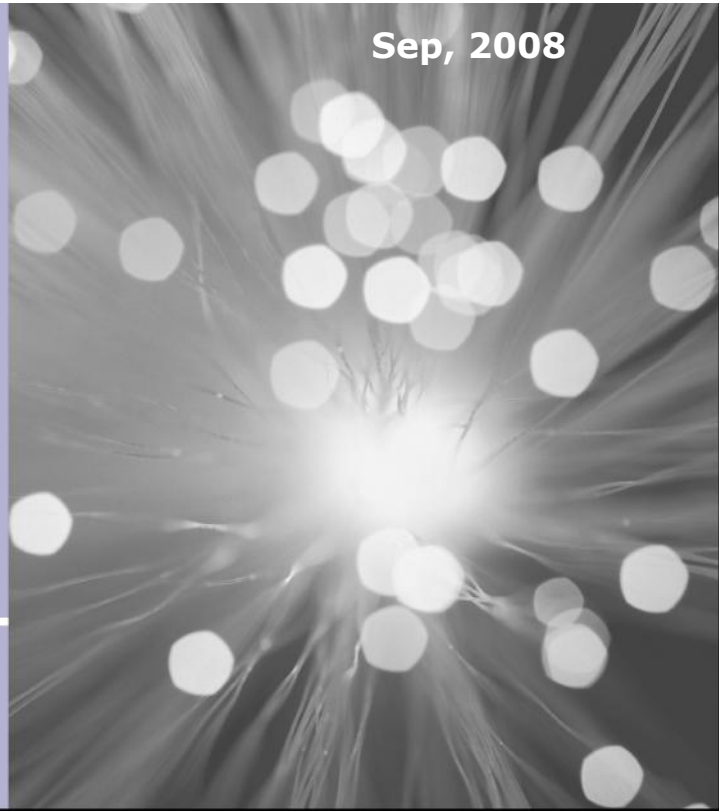
CORECESS

WDM-PON Introduction



CORECESS **Inc.**

http://www.corecess.com

WDM-PON

1.FTTH

2.PON

3.RSOA (Reflective Semiconductor Optical Amplifier)

FTTH

Background

- ✓ “Ubiquitous” the era of voice and data integration, fixed and mobile integration, communication and broadcasting integration, Home networking make a big change in communication services environment. So the fact is that service paradigm is rapidly changed into mass multimedia service such as high quality- high speed internet, Video Phone, Video conferencing, high - definition VOD, IPTV, Satellite TV and cable TV, etc.

- ✓ But now, due to the insufficient bandwidth, distance limitation of the ADSL, VDSL, HFC which are used widespread in access network area, it is impossible to reserve high bandwidth(over 70Mbps) and QoS guarantee required for mass multimedia services such as real-time high - definition IPTV service.

- ✓ Accordingly, “FTTH”, the next generation of high speed internet which enable the real time data sending with 100Mbps for mass multimedia service become noticeable and evaluated as the best solution for building the next generation access network.

Footprint of Fiber optic access network

- ✓ TPON : Telephony PON,1980s’
- ✓ B-PON : Broadband PON, 155Mbps
- ✓ APON : ATM PON, 622Mbps
- ✓ GPON : Gigabit PON, 2.5Gbps
- ✓ EPON : Ethernet PON, 1.25Gbps, EFM(Ethernet in the First Mile)

PON

- **A point to multipoint network architecture in which unpowered optical splitters are used to enable a single optical fiber to serve multiple premises.**
- **Two forms of technology, TDM-PON and WDM-PON due to multiplexing difference.**

TDM-PON

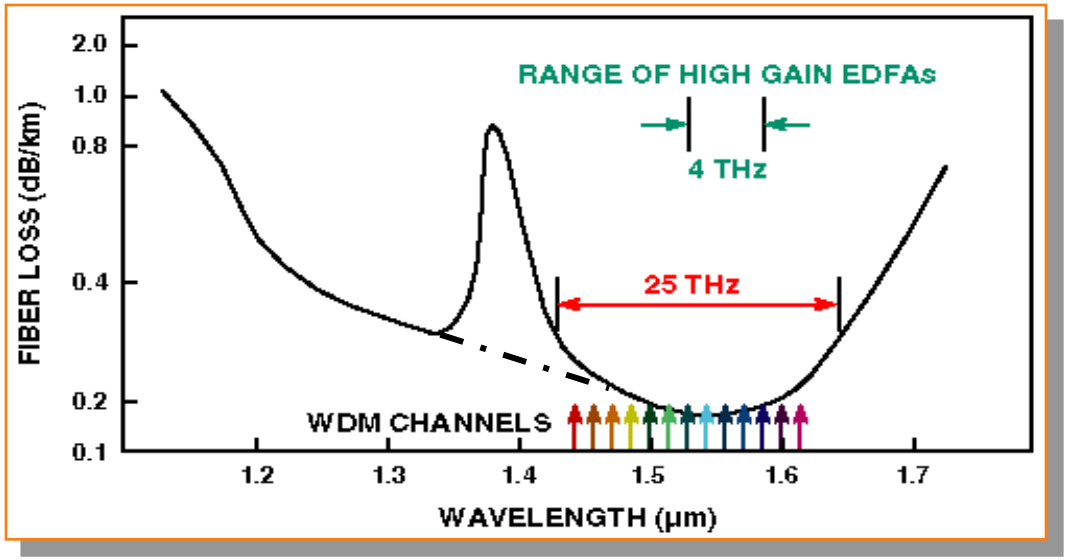
- Broadcasting toward downstream, bandwidth allocation with TDMA toward upstream for collision prevention.
- ATM protocol based A-PON/B-PON/G-PON and Ethenet protocol based E-PON(GE-PON).
- ATM based PON
  - '1995 : start from FSAN for studying 155Mbps ATM.
  - In initial stage, named as A-PON(155Mbps), evolved to 622Mbps B-PON.
  - B-PON supports Dn 622M, Up 155M with 32 splits
  - Now GPON suppoets Dn 2.5G/Up 1.25G with 64 splits, using GEM protocol.
  - A/B-PON have been deployed in Verison, SBC. Now, they are deploying G-PON.
  - GPON main Chipset vendor : FlesLight, BroadLight
  - **GPON has been installed less than 2 million ports.**
- Ethernet based GEPON
  - '2001 : EPON standardized in IEEE 802.3 Group.
  - Dn 1.25G/Up 1.25G, 32 splits, using Ethernet protocol
  - **Inexpensive than GPON and has been deployed more than 15 million ports.**

WDM-PON

- Uses multiple optical wavelengths to increase the upstream and/or downstream bandwidth available to end users.
- Dense WDM-PON & Coarse WDM-PON.
- DWDM-PON
  - By help of Injection locking and RSOA, DWDM (previously used in Backbone network only owing to high cost) now can used in access network area as leading to lower prices and without wavelength management.
  - Injection locking uses two bands out of O,E,S,C,L bands for upsteam and downstream each. (16 wavelength with 8.0nm/1.6nm spacing)
  - RSOA uses C band for upstream/downstream. (16 wavelength with 1.5nm spacing)
- CWDM-PON
  - Using more wide wavelength(20nm) than DWDM(0.8nm), it can provide 100M~1Gbps per subscriber with 16 wavelength.(except for 2 Water peak out of 18 wavelengths)
  - Appropriate for H-FTTH owing to cheaper price than DWDM-PON and easier expansion/change in terms of cost-effectiveness.

Ref : Fiber optic system Band

Low loss transmission band of ordinary single mode fiber



Old fiber

AllWave™ fiber

0-band (1260-1360)	E-band (1360-1460)	S⁺-band (1450-1490)	S-band (1490-1530)	C-band (1530-1570)	L-band (1570-1610)	L⁺-band (1610-1650)	U-band (1625-1675)

O : Original, E: Extended, S: Short wavelength, C: Conventional,
L: Long wavelength, U: Ultra-long wavelength

PON : Comparison

Items	AON	DWDM-PON	CWDM-PON	E-PON
Protocol	Ethernet	Doesn't matter	Doesn't matter	Ethernet
Multiplexing	P2P	WDM	WDM	TDMA
Standard	IEEE 802.3	FSAN 2004 1Q. G.694.1	ITU-T G.695/ITU-T G.694.2	IEEE802.3ah(2004.6)
OLT-ONU(ONT) Bandwidth	1G – 100M	1G/622/155M – 100M	1G – 100M	1G – 100M
OLT-ONU(ONT) Core	2Core	1Core	1Core	1Core
OLT split	1	16/32	16	16/32
Distance limit	70Km	20Km	20Km	10/20Km
Spacing	-	0.8nm/1.6nm	20nm	-
Subs per ONU	24	24	24	24
Multiple split	Easy	Easy	Easy	With limit
Speed after split	Doesn't matter	Doesn't matter	Doesn't matter	Little down
QoS(Real)	Secure	Secure	Secure	Secure (Moderate)
Evolve to Real FTTH	Hard	Easy	Possible	Easy

Features of RSOA

Two forms of Color-less

- **Injection Locking**
  - ✓ If a specific wavelength would be injected to multi mode light source(FP-LD), the multi mode in FP-LD is changed into single mode and allows to do WDM. It is said “injection locking”
  - ✓ Two EDFA need to be installed at the CO to inject external optical signal to OLT and CPEs.

- **RSOA**
  - ✓ After ONT(ONU) equalizing the downstream data signal from CO, ONT(ONU) send it back toward CO with upstream data.

Features of RSOA

Pros/Cons of RSOA compare with Injection Locking

- **Benefits from recycling**
  - ✓ No additional expensive optic device such as EDFA required.
  - ✓ Relatively cheaper than Injection lockong mode.
- **Benefits from the same up/down wavelength**
  - ✓ Because of using the simple OADF(Optical Add/Drop Filter), Ring topology can be easily configured.

The fundamentals of RSOA

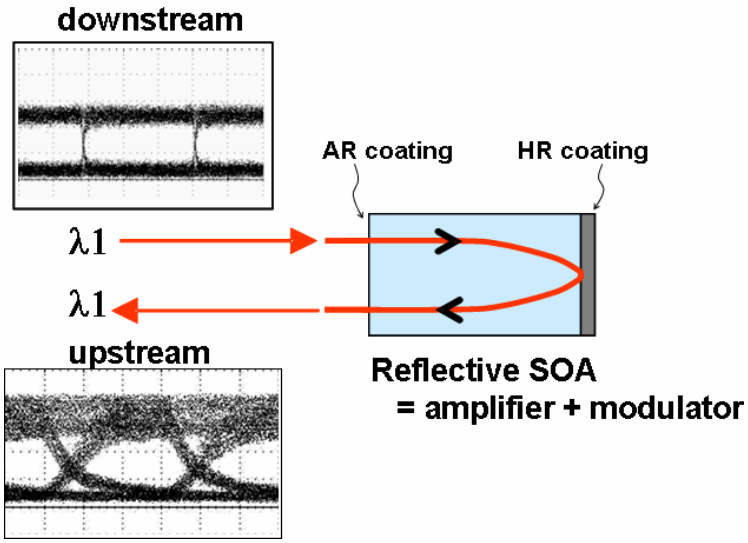
Equalization

- **Equalization**
  - ✓ In order to recycle downstream optical signal, equalizing the signal already modualated into digital signal.
- **Optical equalization**
  - ✓ Taking advantage of optical saturation attributes of RSOA.
- **Electrical equalization**
  - ✓ Due to insufficient optical equalization, the current injected to RSOA will be injected along with downstream optical signal amplitude.

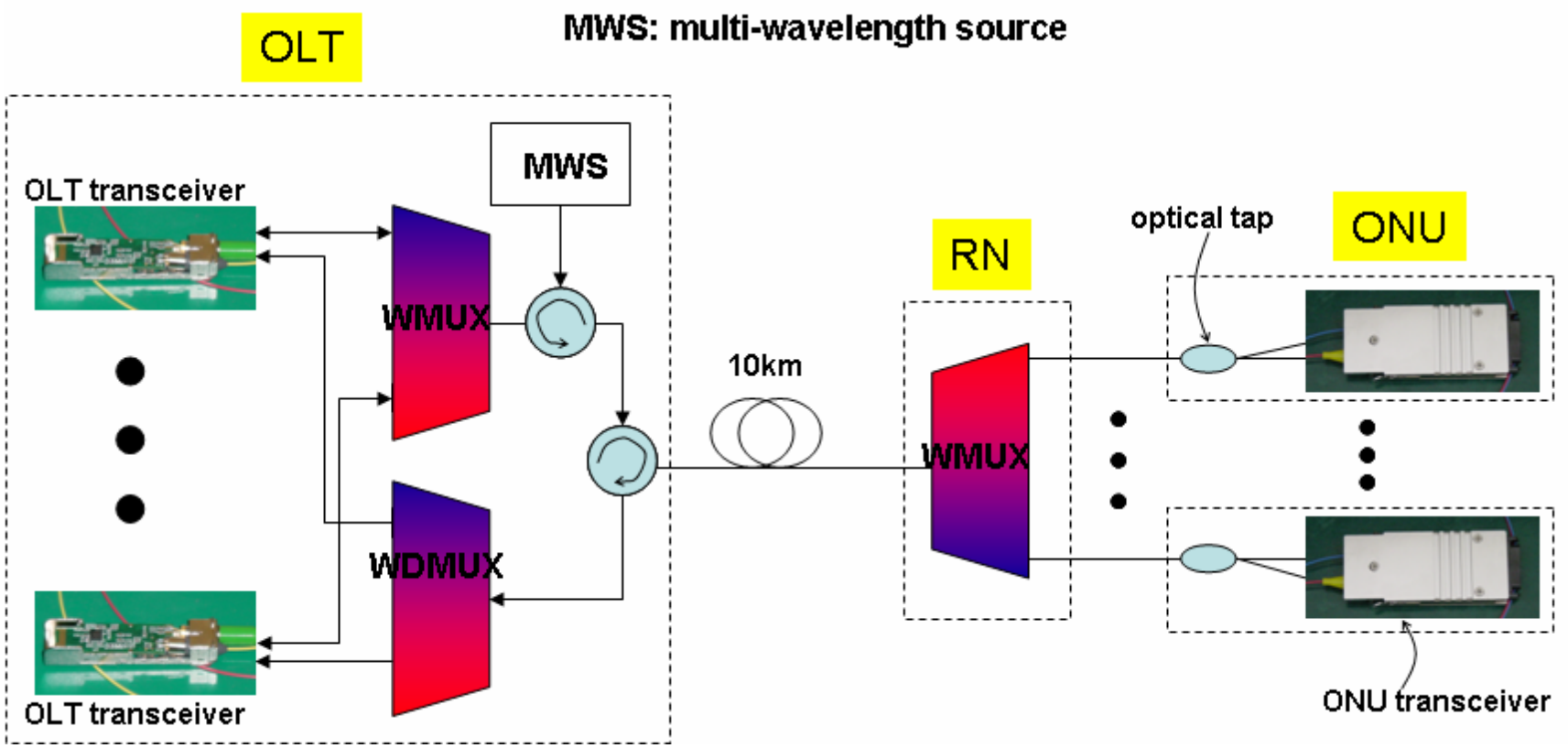
The fundamentals of RSOA

Equalization process

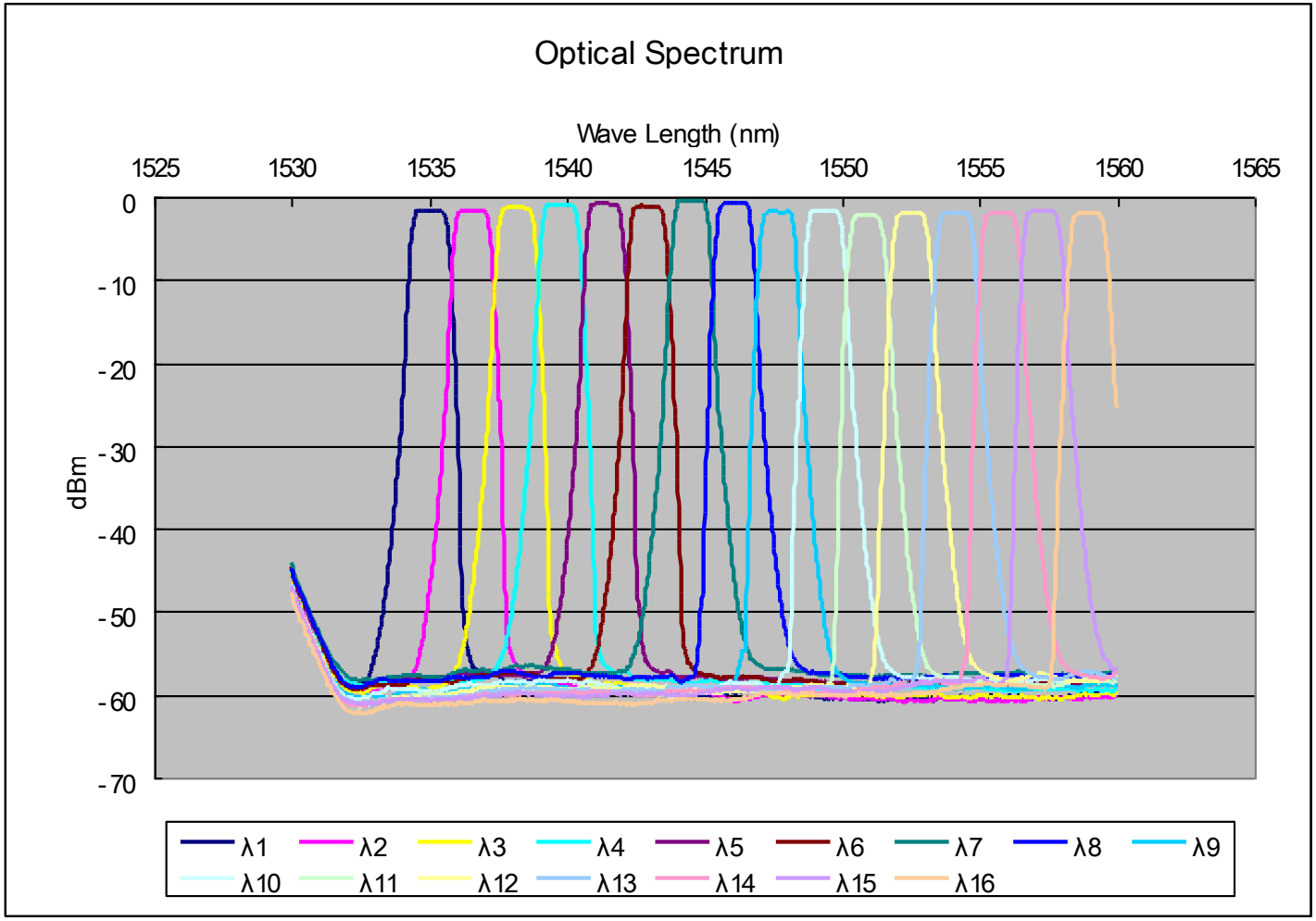
- ✓ The modulated downstream optical signal is injected to RSOA through AR(Anti-Reflection) coated area then emitted to AR coated area after reflecting from HR(Highely-Reflective) coated area.
- ✓ The injected optical signal is to be over-saturated and amplified and come to decrease the level difference between“0” and “1”. When the injected signal is “0”, the DC current injected to RSOA will be increased and electrically equalized.
- ✓ The equalized and amplified downstream signal within RSOA will be transmmited toward CO after directly modulated into upstream data.
- ✓ RSOA features : Optical equalization, amplification, modulation



Architecture of RSOA



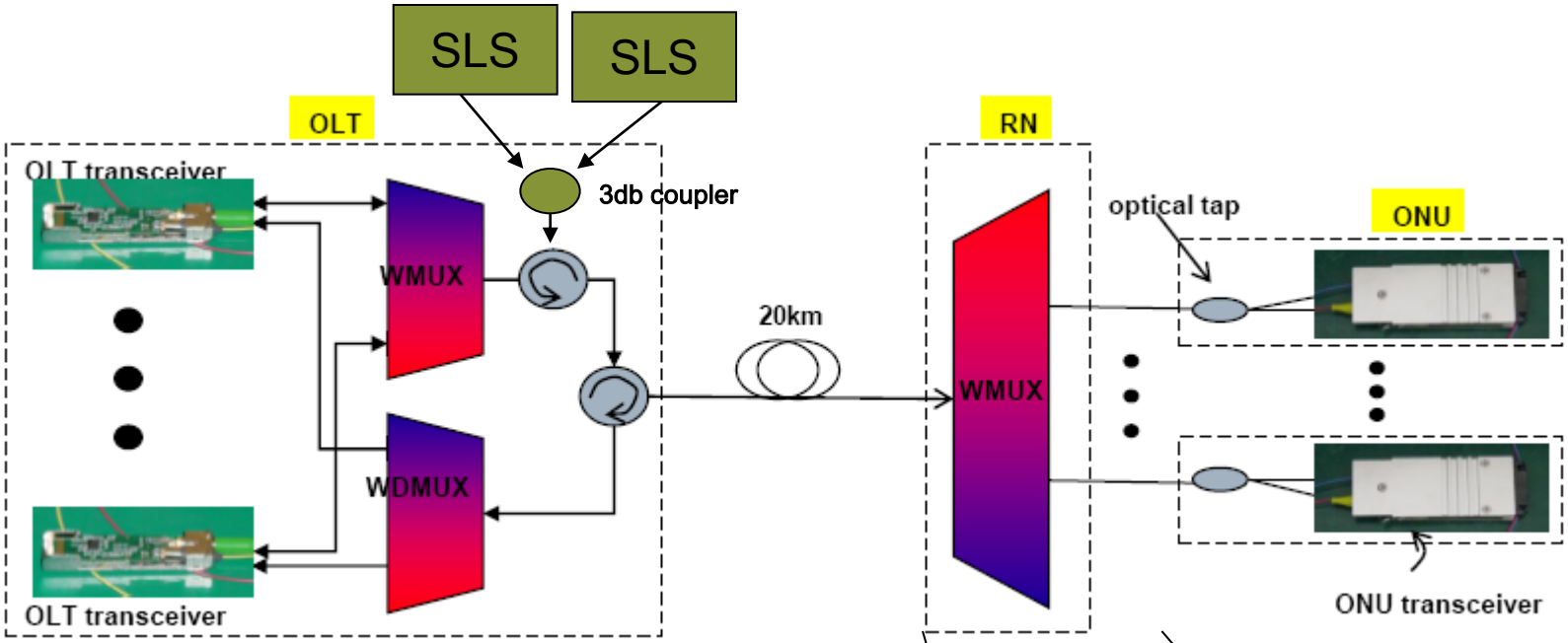
Spectrum


Optical Spectrum
Wave Length (nm)
1525
1530
1535
1540
1545
1550
1555
1560
1565
0
-10
-20
-30
-40
-50
-60
-70
dBm
λ1
λ2
λ3
λ4
λ5
λ6
λ7
λ8
λ9
λ10
λ11
λ12
λ13
λ14
λ15
λ16

Spectrum

channel	ITU Frequency	ITU Wavelength
#01	195.3	1535.04
#02	195.1	1536.61
#03	194.9	1538.19
#04	194.7	1539.77
#05	194.5	1541.35
#06	194.3	1542.94
#07	194.1	1544.53
#08	193.9	1546.12
#09	193.7	1547.72
#10	193.5	1549.32
#11	193.3	1550.92
#12	193.1	1552.52
#13	192.9	1554.13
#14	192.7	1555.75
#15	192.5	1557.36
#16	192.3	1558.98

Optical power budget



Downstream

OLT TX power Max = 5 dBm Min = 3 dBm	Max loss = 3.5 dB Min loss = 2 dB	Max loss = 10 dB Min loss = 0 dB Link margin= 2 dB	Max loss = 4 dB Min loss = 2 dB	Max input = 0 dBm Min input = -16.5 dBm

Upstream

Max input = -2 dBm Min input = -23 dBm	Max loss = 3.5 dB Min loss = 2 dB	Max loss = 10 dB Min loss = 0 dB Link margin= 2 dB	Max loss = 4 dB Min loss = 2 dB	Max = 2 dBm Min = -3.5 dBm

THANK YOU FOR YOUR ATTENTION.

YOUR SUCCESS IS CORECESS

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