

Security Level:

Analysis of Dynamic Range in 100G EPON with SOA as Pre- amplifier

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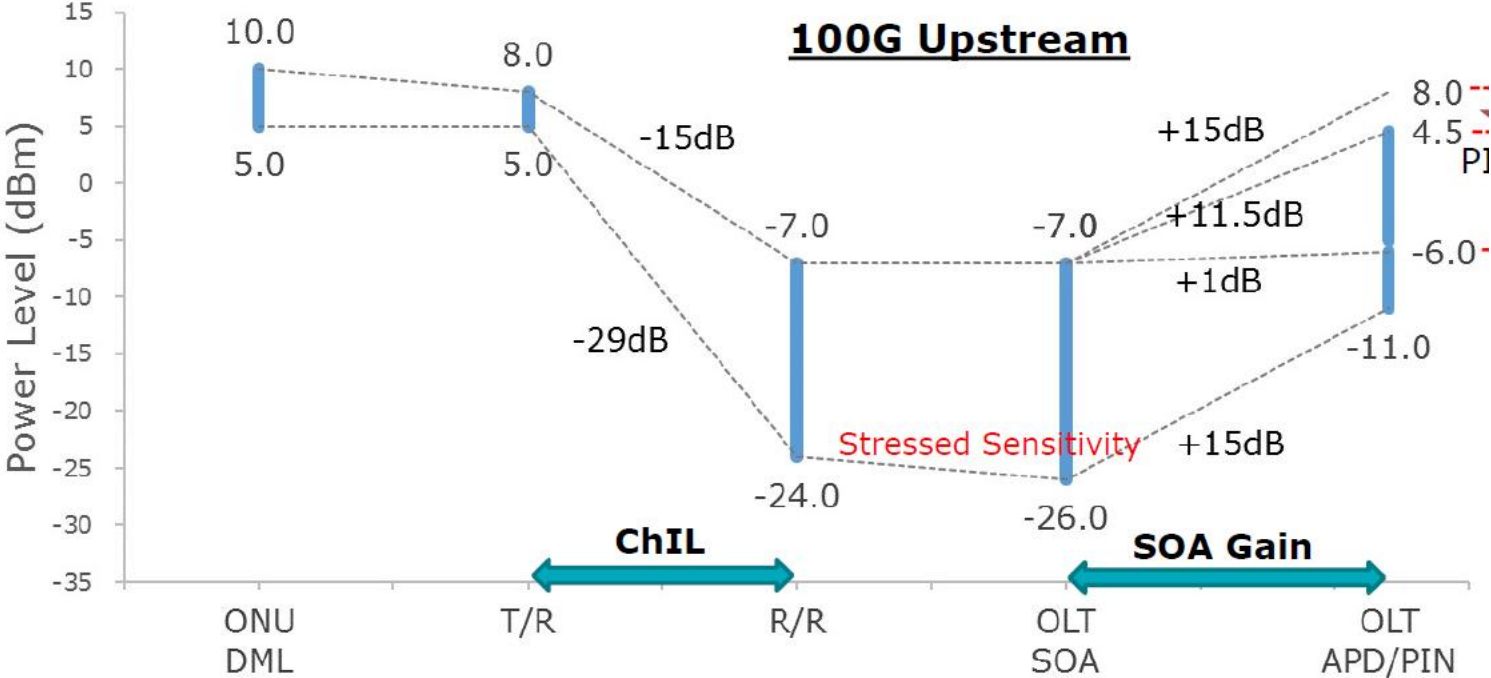
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Background

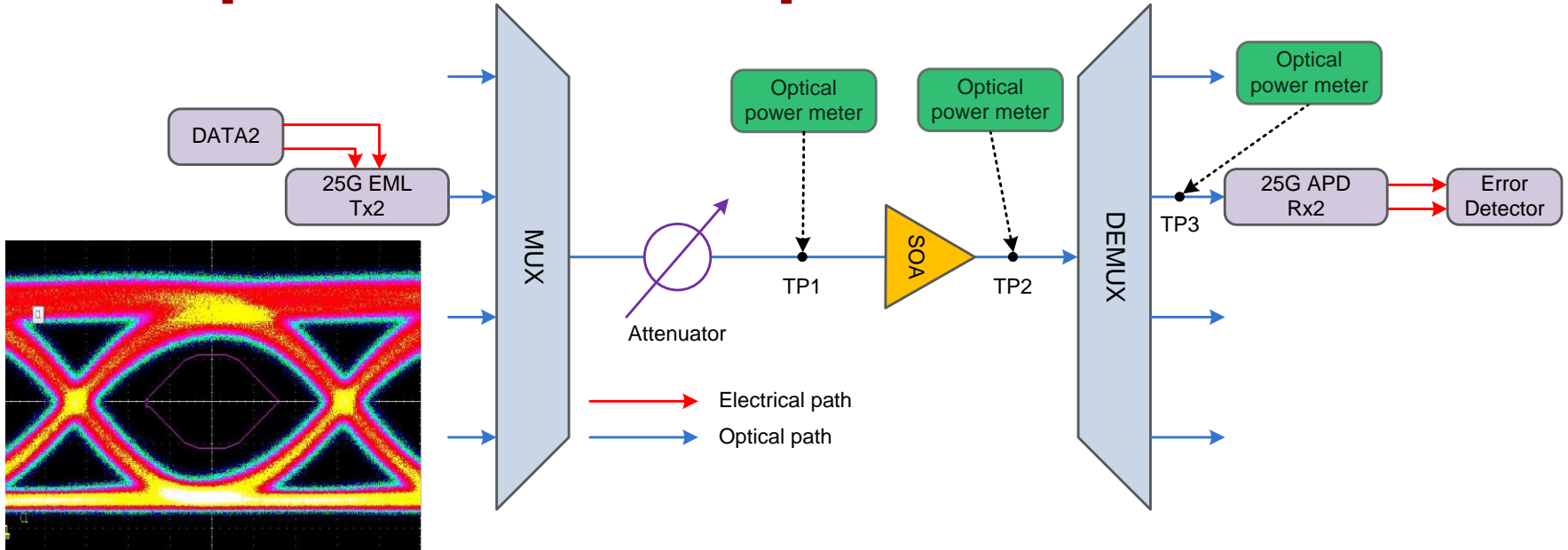
- Preamplifier can improve the receiver sensitivity in OLT , and consequently bridge the power budget gap in upstream, lower down the cost of ONU.
- The dynamic range issue of the SOA preamplifier has been disclosed in several previous contributions (umeda_3ca_1_0717, lee_3ca_1_0517,...)
- This contribution continue to demonstrate the dynamic range issue when a pre-amp. SOA is used in 100G EPON OLT and discuss the potential solutions.

Previous analysis

umeda_3ca_1_0717



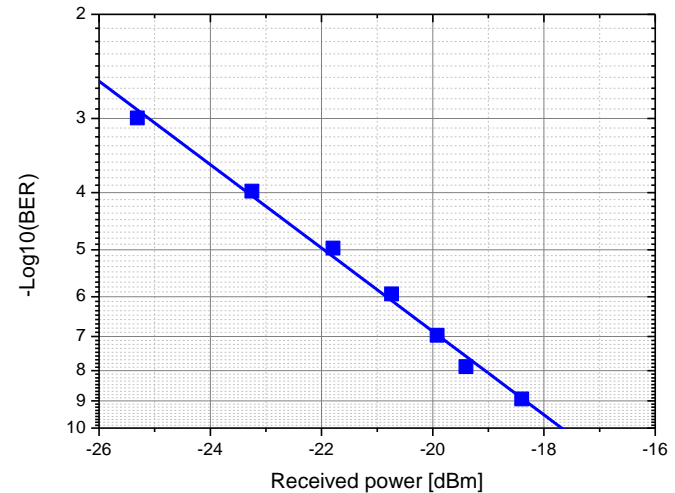
Experimental setup



Test conditions: back-to-back, NRZ, PRBS= $2^{31}-1$

Parameter	Value	Unit
Tx bit rate	25.78125	Gb/s
Tx wavelength	1295.1	nm
Tx output power	2	dBm
Tx ER	8.5	dB
APD overload	0	dBm

Rx. Sen. without SOA



Input dynamic range of SOA

lee_3ca_1_0517

IEEE Std 802.3av

Table 75-1—Power budgets

Description	Low Power Budget		Medium Power Budget		High Power Budget		Units
	PRX10	PR10	PRX20	PR20	PRX30	PR30	
Number of fibers	1						—
Nominal downstream line rate	10.3125						GBd
Nominal upstream line rate	1.25	10.3125	1.25	10.3125	1.25	10.3125	GBd
Nominal downstream wavelength	1577						nm
Downstream wavelength tolerance	-2, +3						nm
Nominal upstream wavelength	1310	1270	1310	1270	1310	1270	nm
Upstream wavelength tolerance	±50	±10	±50	±10	±50	±10	nm
Maximum reach ^a	≥10		≥20		≥20		km
Maximum channel insertion loss	20		24		29		dB
Minimum channel insertion loss	5		10		15		dB

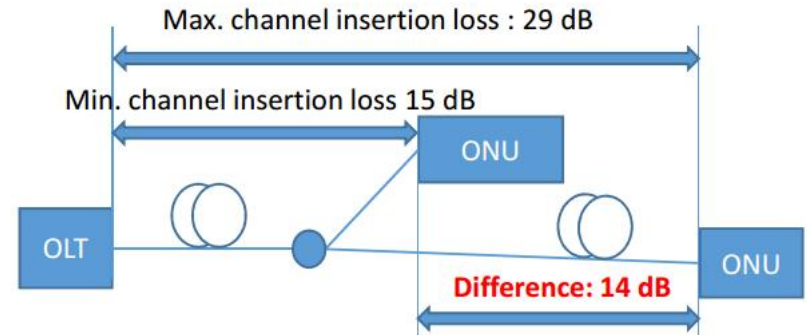


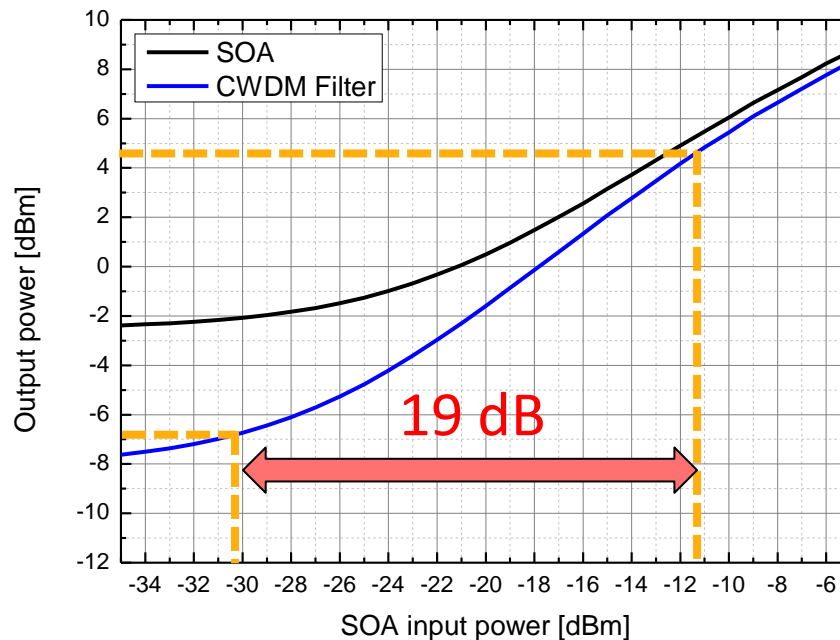
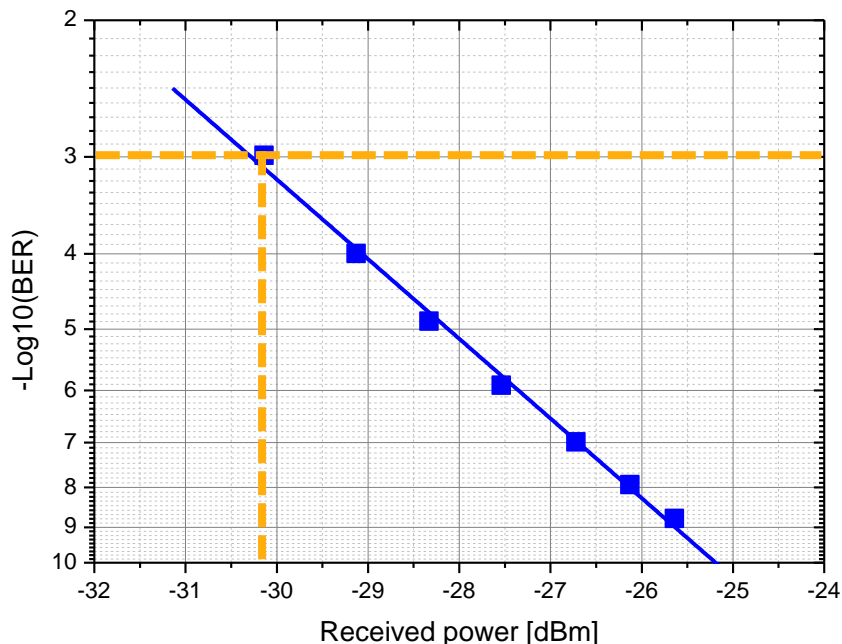
Table 75-8—PR type ONU PMD transmit characteristics

Description	10GBASE -PR-U1	10GBASE -PR-U3	Unit
Signaling speed (range)	10.3125 ± 100 ppm	10.3125 ± 100 ppm	GBd
Wavelength (range)	1260 to 1280	1260 to 1280	nm
Side Mode Suppression Ratio (min) ^a	30	30	dB
Average launch power (max)	4	9	dBm
Average launch power (min) ^b	-1	4	dBm
Average launch power of OFF transmitter (max)	-45	-45	dBm
Extinction ratio (min)	6	6	dB

- In previous contributions, several works have been done about dynamic range.
- 802.3av (10G EPON) has defined 14-dB difference of channel insertion loss and 5-dB difference of upstream signal launch power.
- The input dynamic range of SOA is 19-dB.

Case1: CWDM filter

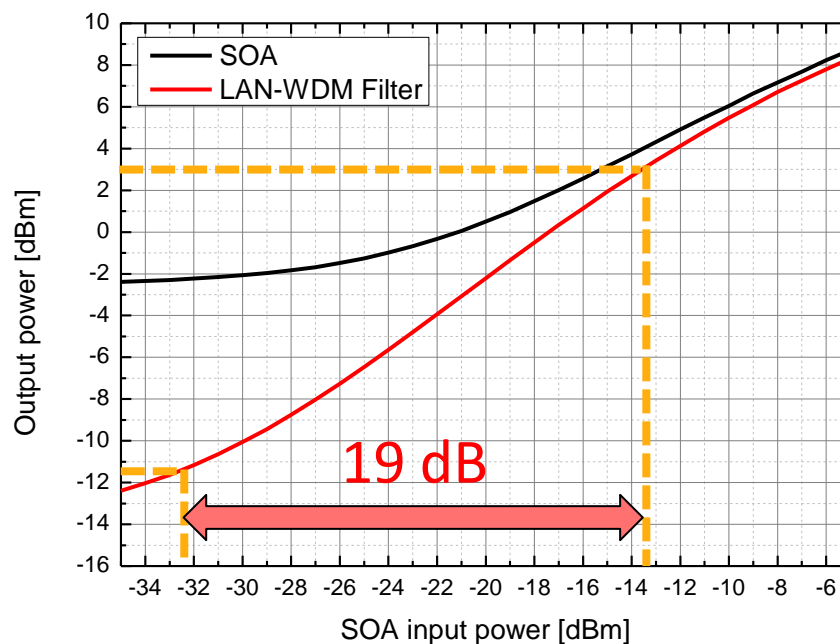
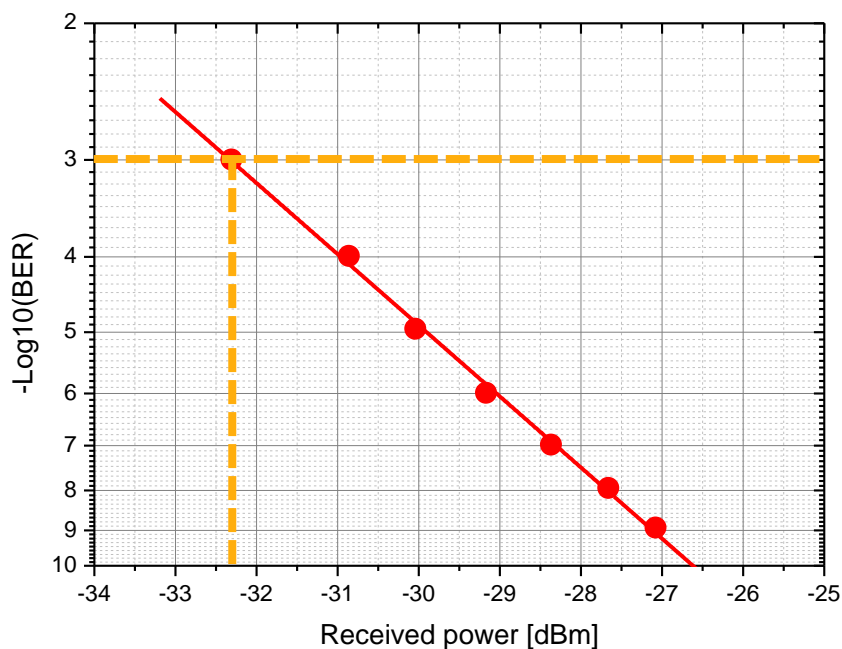
25G APD ROSA, SOA 120mA 45degC



- For CWDM case, the Rx. Sen. @ $1\text{E}-3$ is about **-30.2 dBm**.
- Taking 19-dB dynamic range of SOA into account, the output power ranges of after SOA and CWDM filter correspond to **-2~5.5 dBm**, **-6.8~4.7 dBm**, respectively.
- The overload (OMA) of APD Rx is 0 dBm, tested under $\text{BER}=1\text{E}-12$.
- The output power range of CWDM filter is harmful to APD/PIN Receiver at 19-dB dynamic range.

Case2: LAN-WDM filter

25G APD ROSA, SOA 120mA 45degC



- For LAN-WDM case, the Rx. Sen. @1E-3 is about **-32.3 dBm**.
- Taking 19-dB dynamic range of SOA into account, the output power ranges of SOA and LAN-WDM filter correspond to **-2.2~4 dBm**, **-11.4~3 dBm**, respectively.
- LAN-WDM case is better than CWDM case, both Rx. Sen. and output power range, but still harmful to APD for 19-dB dynamic range.

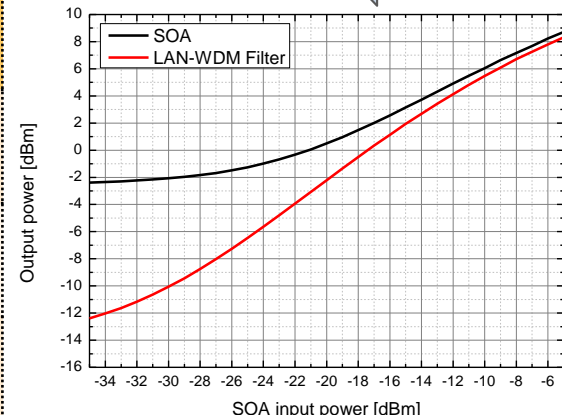
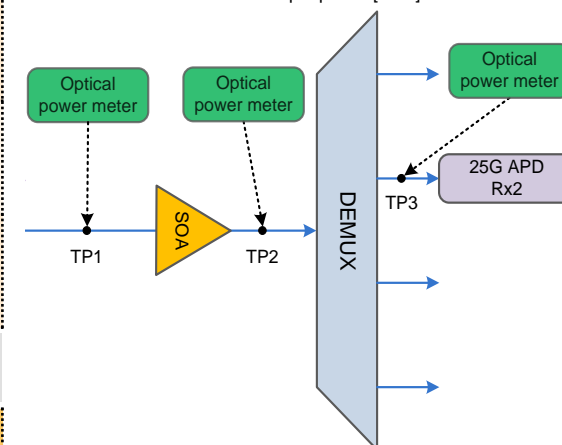
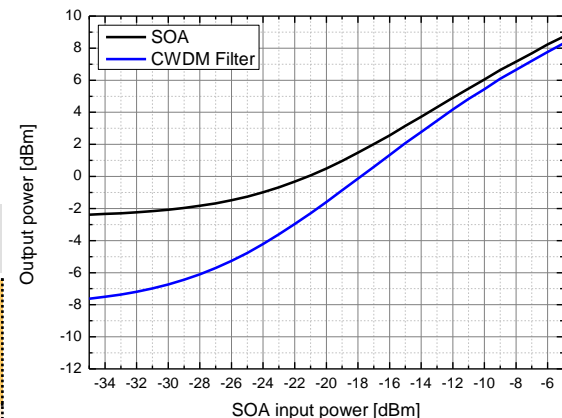
Overview comparison

CWDM case

Min. SOA input power (dBm)	Dynamic range (dB)	Max. SOA input power (dBm)	Max. SOA output power (dBm)	Max. Rx. input power (dBm)
-30.2	19	-11.2	5.5	4.7
-30.2	12.3	-17.9	1.5	0
-30.2	6.5	-23.7	-0.8	-4

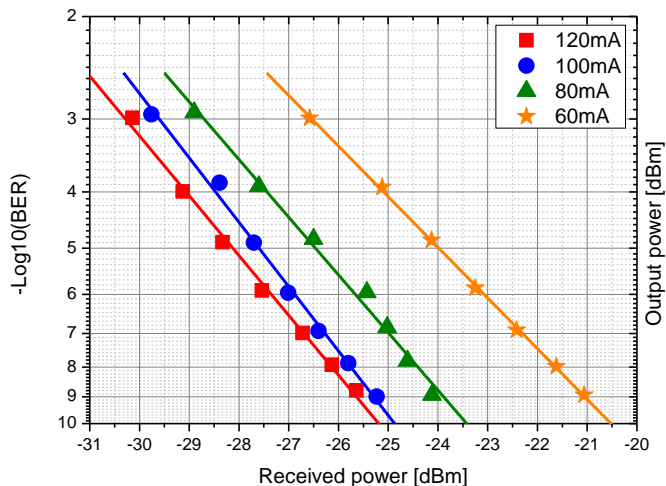
LAN-WDM case

Min. SOA input power (dBm)	Dynamic range (dB)	Max. SOA input power (dBm)	Max. SOA output power (dBm)	Max. Rx. input power (dBm)
-32.3	19	-13.3	4	3
-32.3	15	-17.4	1.8	0
-32.3	10.3	-22	-0.3	-4

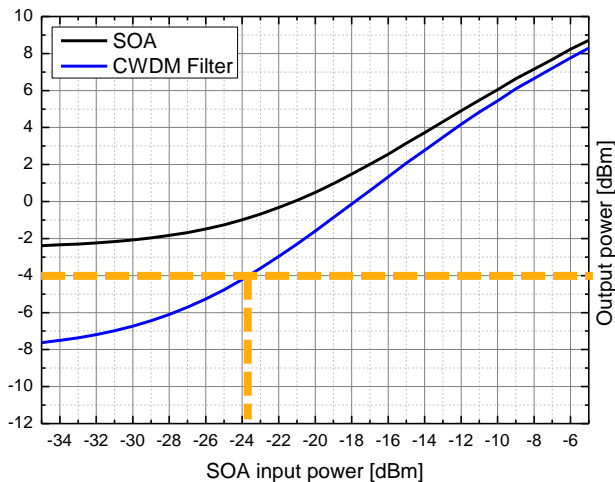


Injection current control(CWDM case)

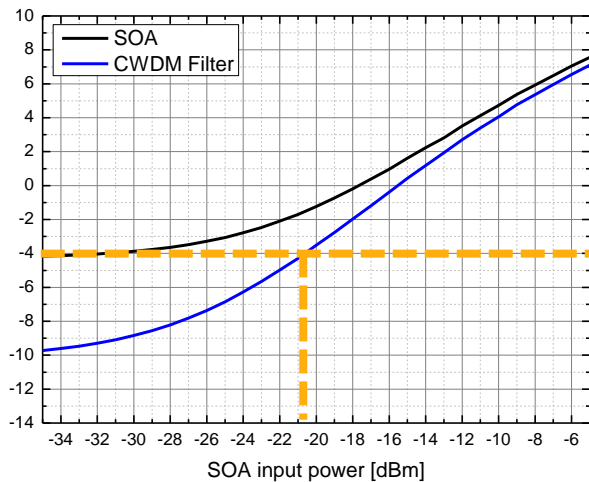
APD



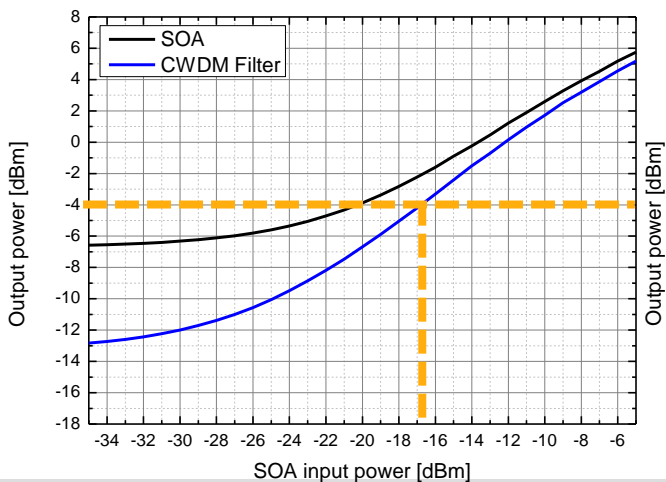
Injection current: 120mA



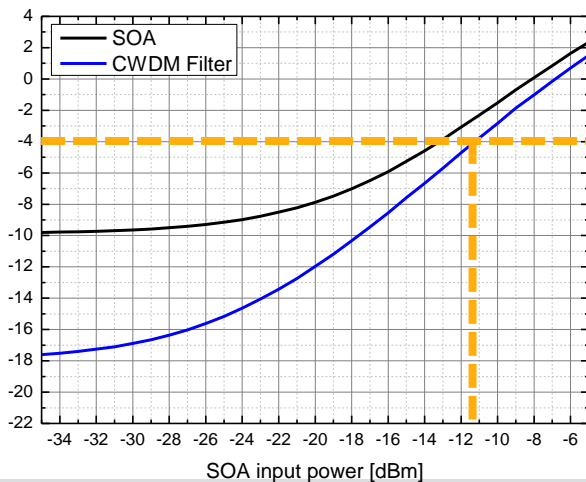
Injection current: 100mA



Injection current: 80mA



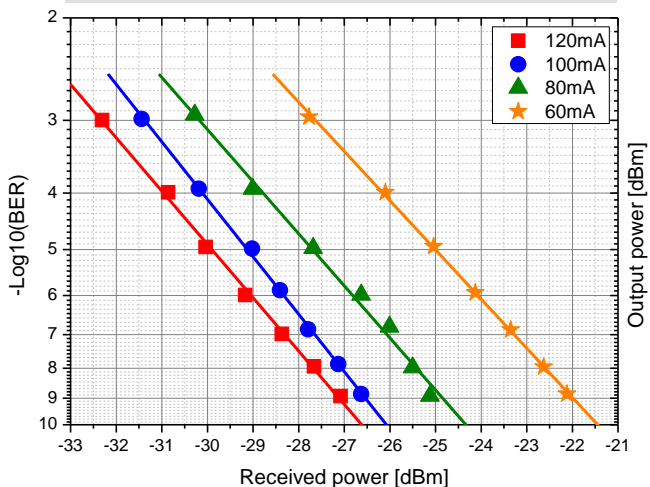
Injection current: 60mA



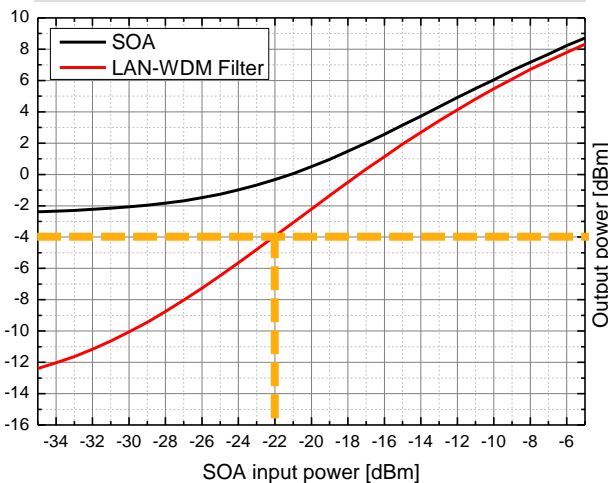
Injection current (mA)	Rx.Sen. @1E-3 (dBm)	Max. Rx. power (dBm)	Max. SOA input (dBm)	Extended dynamic range (dB)
120	-30.2	-4	-23.7	6.5
100	-29.7	-4	-20.8	9.4
80	-28.8	-4	-16.8	13.4
60	-26.6	-4	-11.2	19

Injection current control(LAN-WDM case)

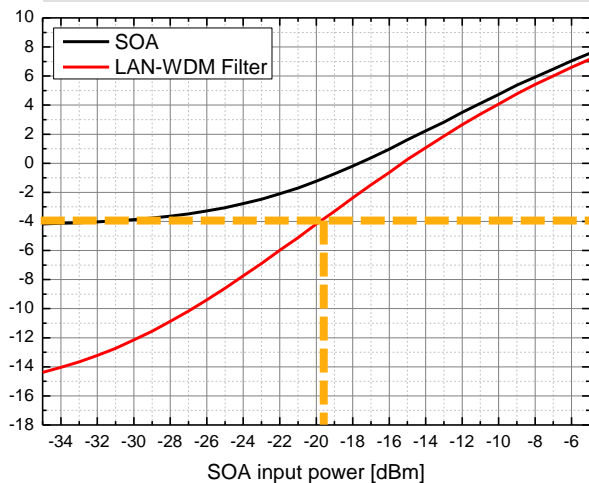
APD



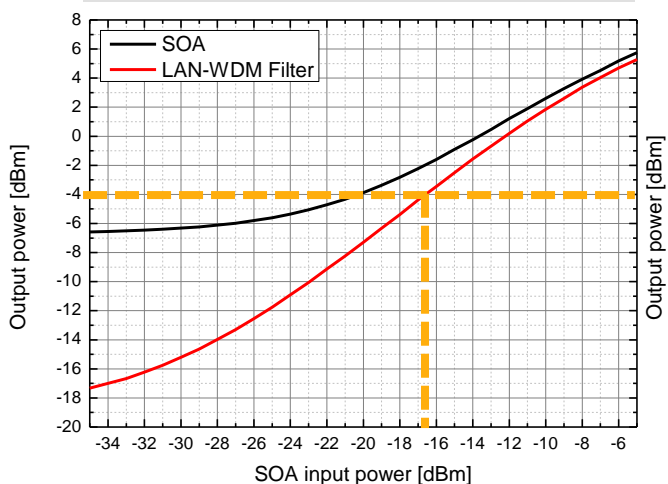
Injection current: 120mA



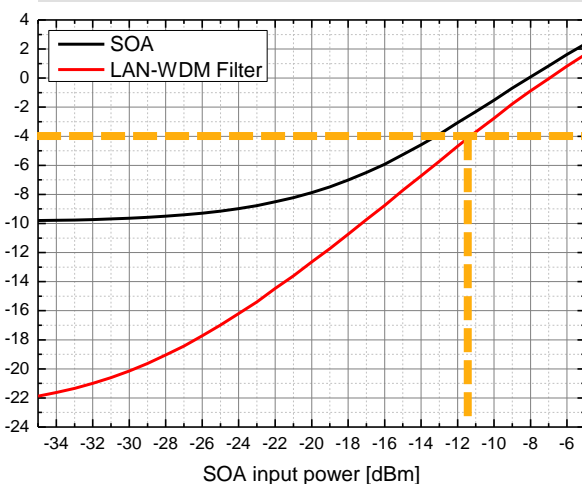
Injection current: 100mA



Injection current: 80mA



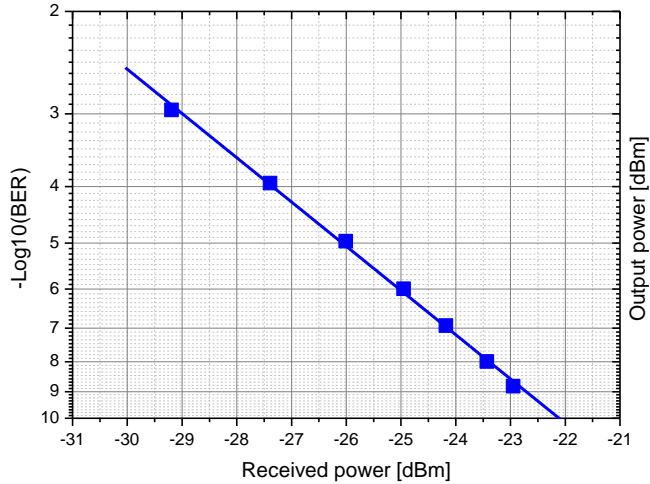
Injection current: 60mA



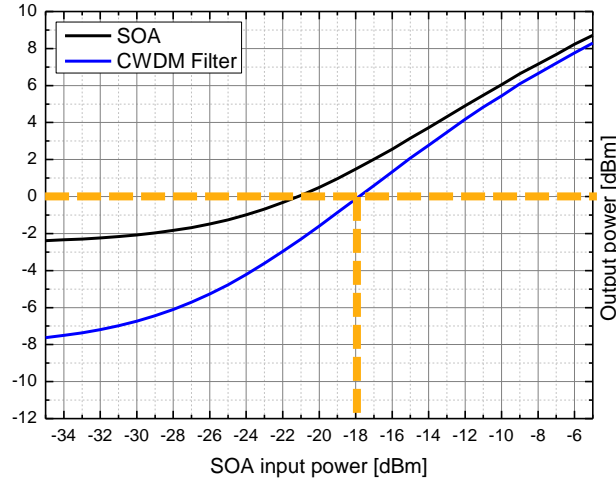
Injection current (mA)	Rx.Sen. @1E-3 (dBm)	Max. Rx. power (dBm)	Max. SOA input (dBm)	Extended dynamic range (dB)
120	-32.3	-4	-22	10.3
100	-31.4	-4	-19.8	12.5
80	-30.2	-4	-16.8	15.5
60	-27.7	-4	-11.2	21.1

Injection current control(CWDM case)

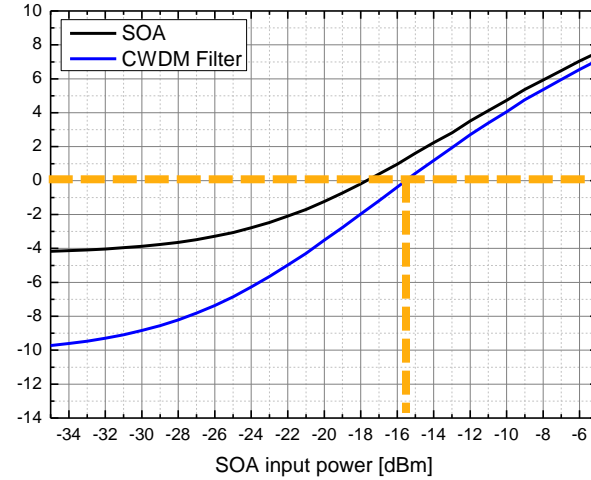
PIN



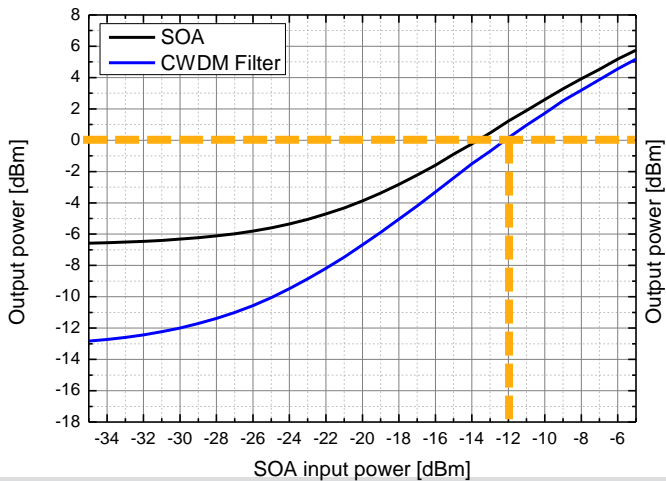
Injection current: 120mA



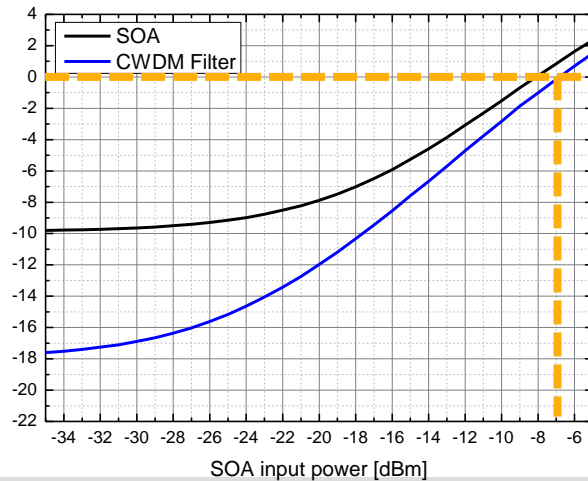
Injection current: 100mA



Injection current: 80mA



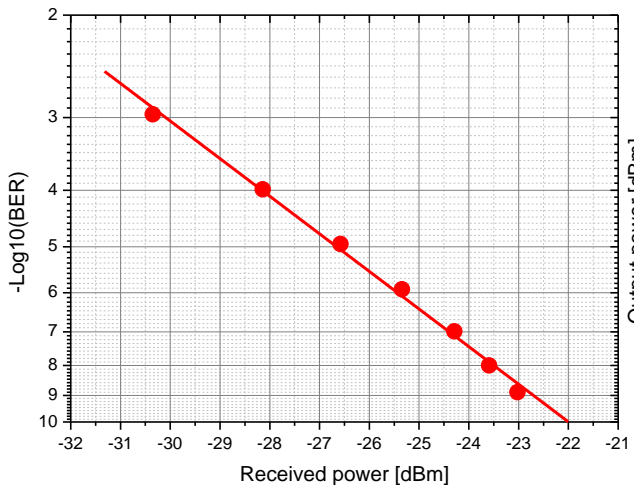
Injection current: 60mA



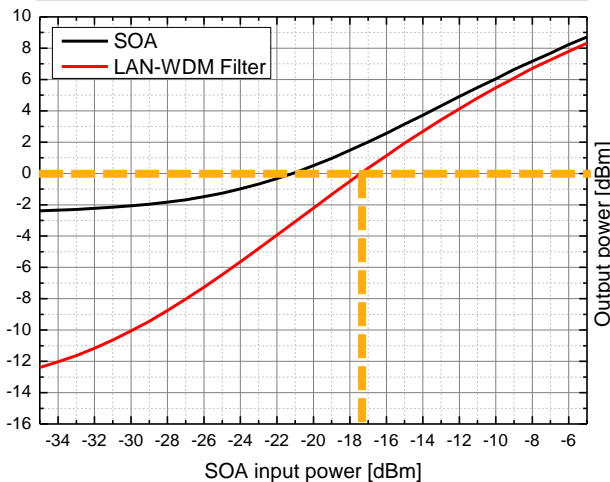
Injection current (mA)	Rx.Sen. @1E-3 (dBm)	Max. Rx. power (dBm)	Max. SOA input (dBm)	Extended dynamic range (dB)
120	-29.3	0	-17.9	11.4
100	--	0	-15.6	13.7
80	--	0	-12	17.3
60	--	0	-7	22.3

Injection current control(LAN-WDM case)

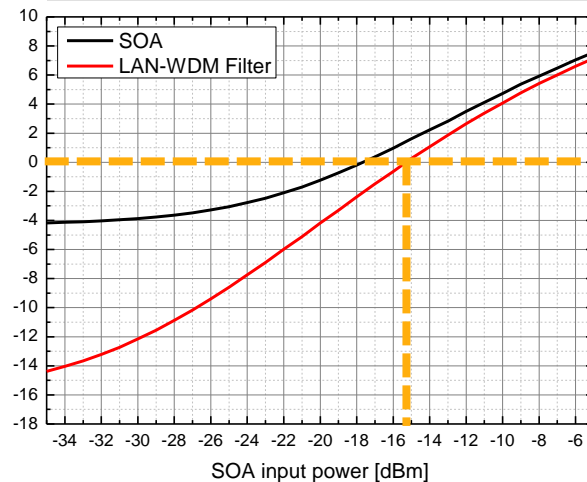
PIN



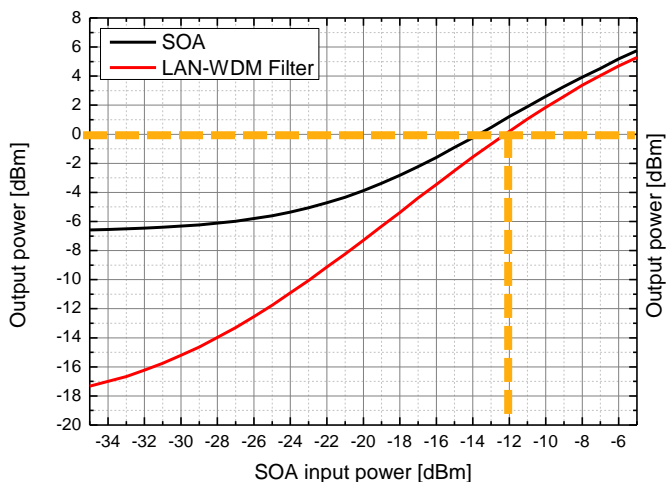
Injection current: 120mA



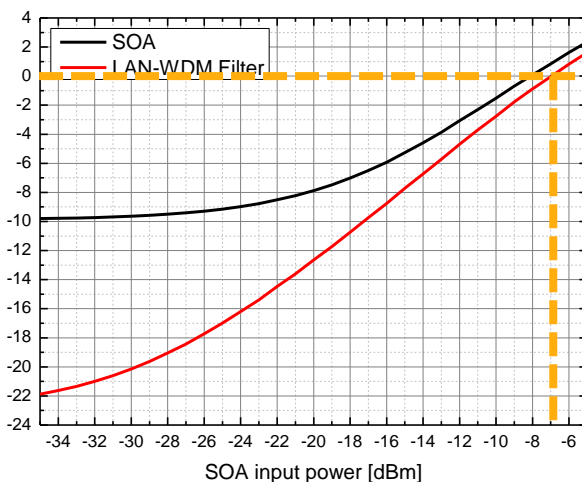
Injection current: 100mA



Injection current: 80mA

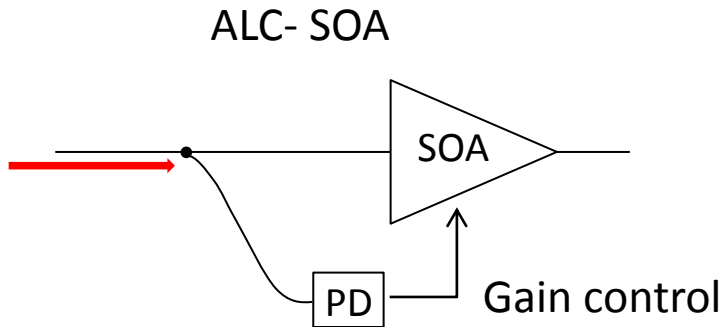


Injection current: 60mA

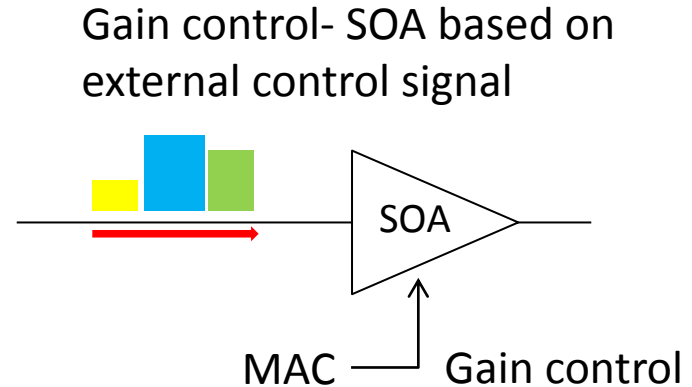


Injection current (mA)	Rx.Sen. @1E-3 (dBm)	Max. Rx. power (dBm)	Max. SOA input (dBm)	Extended dynamic range (dB)
120	-30.2	0	-17.2	13
100	--	0	-15.2	15
80	--	0	-12	18.2
60	--	0	-7	23.2

SOA gain control



Automatic gain control



Gain control signal from MAC

- There are two ways to control the SOA gain in the OLT:
 - OLT receiver detect the input signal and control the SOA gain automatically
 - OLT Mac provide an external signal to control the SOA gain

Summary

- We have measured the power ranges before and after the preamplifier under CWDM case and LAN-WDM case respectively
- LAN-WDM case has advantage than CWDM case, in both Rx. Sen. and output power range, but still doesn't have enough dynamic range for 100G EPON upstream
- “Dynamic SOA gain control” can effectively improve the dynamic range for the preamplifier receiver and help to meet 100G EPON requirement.

Thank you
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