Black Link Channel edge impairments and channel plan impacts for WDM Links

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Supporters:

- David Lewis, Lumentum
- Jeffery Maki, Juniper Networks
- Gary Nicholl, Cisco Systems

References in this Contribution

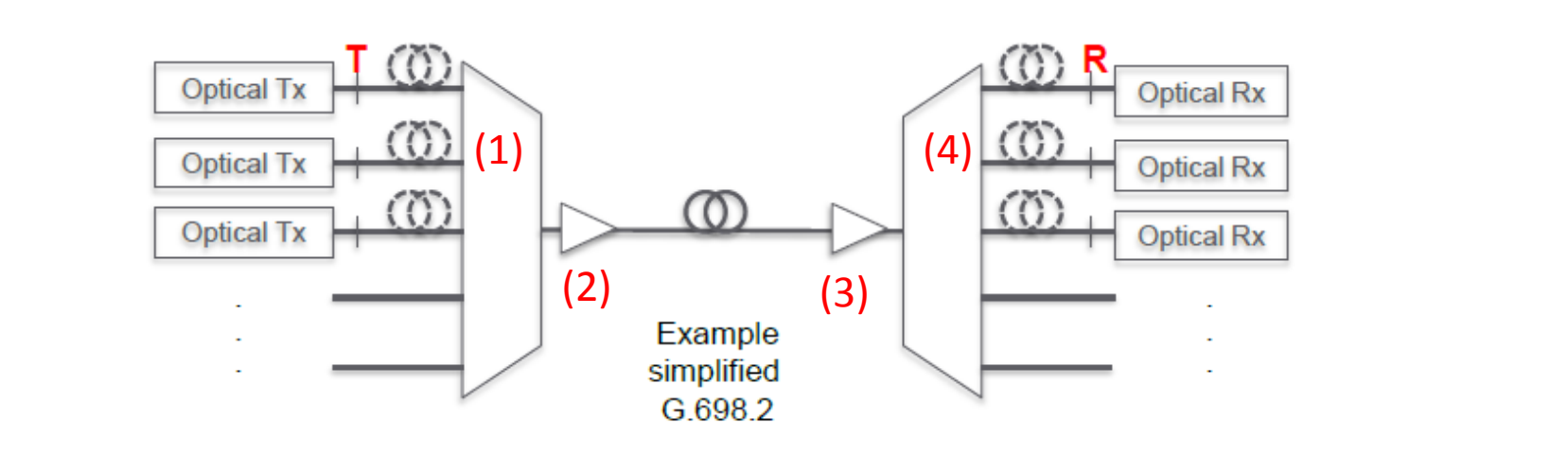
- “Further considerations on objectives for PHYs running over point-to-point DWDM system” http://www.ieee802.org/3/B10K/public/18_03/stassar_b10k_01_0318.pdf
- “Coherent 100G and 400G PMD Layer WDM Considerations” http://www.ieee802.org/3/cn/public/18_11/deandrea_3cn_01c_1118.pdf
- Further baseline considerations and proposals for 100G and 400G DWDM objectives” http://www.ieee802.org/3/ct/public/19_05/stassar_3ct_01a_0519.pdf

Black Link Characteristics:

100GBASE-ZR black link characteristics

Parameter Name	Units	G.698.2 Value	CL PHYv1.0	Proposed strawman
Maximum ripple	dB	2.5	NA	2.5
Maximum (residual) chromatic dispersion	ps/nm	2400	2400	2400
Minimum (residual) chromatic dispersion	ps/nm	–200	NA	–200
Minimum optical return loss at S_s	dB	24	25	TBD
Maximum discrete reflectance between S_s and R_s	dB	–27	–20	TBD
Maximum differential group delay	ps	20	20	20
Maximum polarization dependent loss	dB	1.5	0.5	1.5
Maximum polarization rotation speed	krad/s	50	50	50
Maximum inter-channel crosstalk at R_s	dB	–16	NA	–16
Maximum interferometric crosstalk at R_s	dB	–25	NA	–25
Maximum optical path OSNR penalty	dB	5	3 (?)	TBD

Consider the Black Link Components



- Black Link Type 5:
  - Passive ADD filter (1)
  - EDFA Booster Amplifier (2)
  - EDFA Pre-Amplifier (3)
  - Passive Drop Filter (4)

Channel Choice Start and Stop Impacts:

- Transceiver Components:
  - Full Band Tunable Laser
  - Dual Polarization IQM modulator
  - Dual Polarization IQM receiver
- Black Link Components:
  - Passive Add/Drop Optical Filter
  - Optical Amplifier, Booster and Pre Amplifier

Consider the Black Link Components

- Extending the edges for Add Drop Filters:
  - Degrades Black link ripple
  - Degraded Polarization Dependent Loss
- But How Much?
  - Need vendor inputs

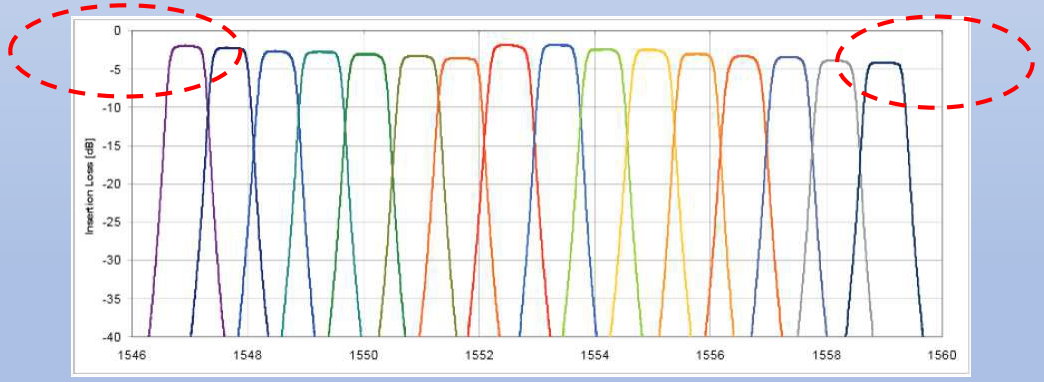


Figure 1, Typical Flat-top Filter

Consider the Black Link Components

- Extending the edges for Optical Booster and Pre Amplifier:
  - Degrades Black link ripple
  - Degrades Polarization Dependent Loss
  - Degrades OSNR
- What are the impairments within the amplifier?

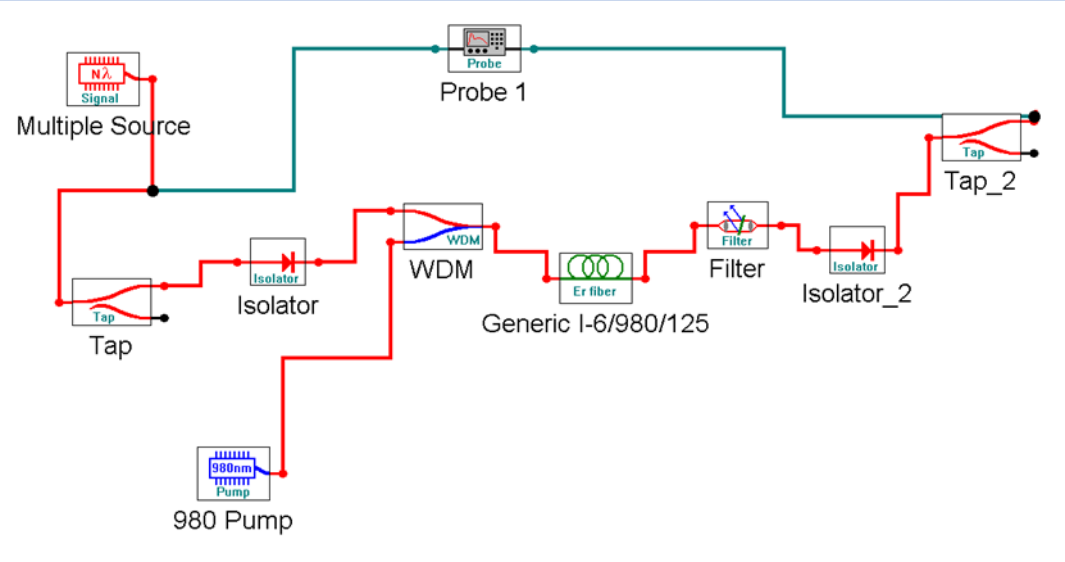


Figure 2, Optical Amplifier Block Diagram

Optical Booster and Pre Amplifier Components

- Optical Isolators
  - PDL, to 0.2 db
  - WDL (flatness across band) to +/-0.2
- Optical Taps
  - PDL to 0.1 db
  - WDL to +/-0.2
- Pump Add Filter, 980/1550
  - PDL to 0.1 db
  - WDL to +/-0.1
- Erbium Fiber
  - Gain Medium, OSNR
  - Noise Figure
- Gain flattening filter
  - PDL to 0.1db
  - WDL (flatness across band) to +/-0.1

Optical Amplifier Erbium Fiber

- Erbium Fiber when pumped with 980 nm laser, amplifies the C-band 1520-1580 wavelengths
- The gain is not flat across the band
- Different pump powers can create "TILT"
- GFF inverse filter must be designed and added for amplifier to flatten Response

This is actual 40ch data, not simulated

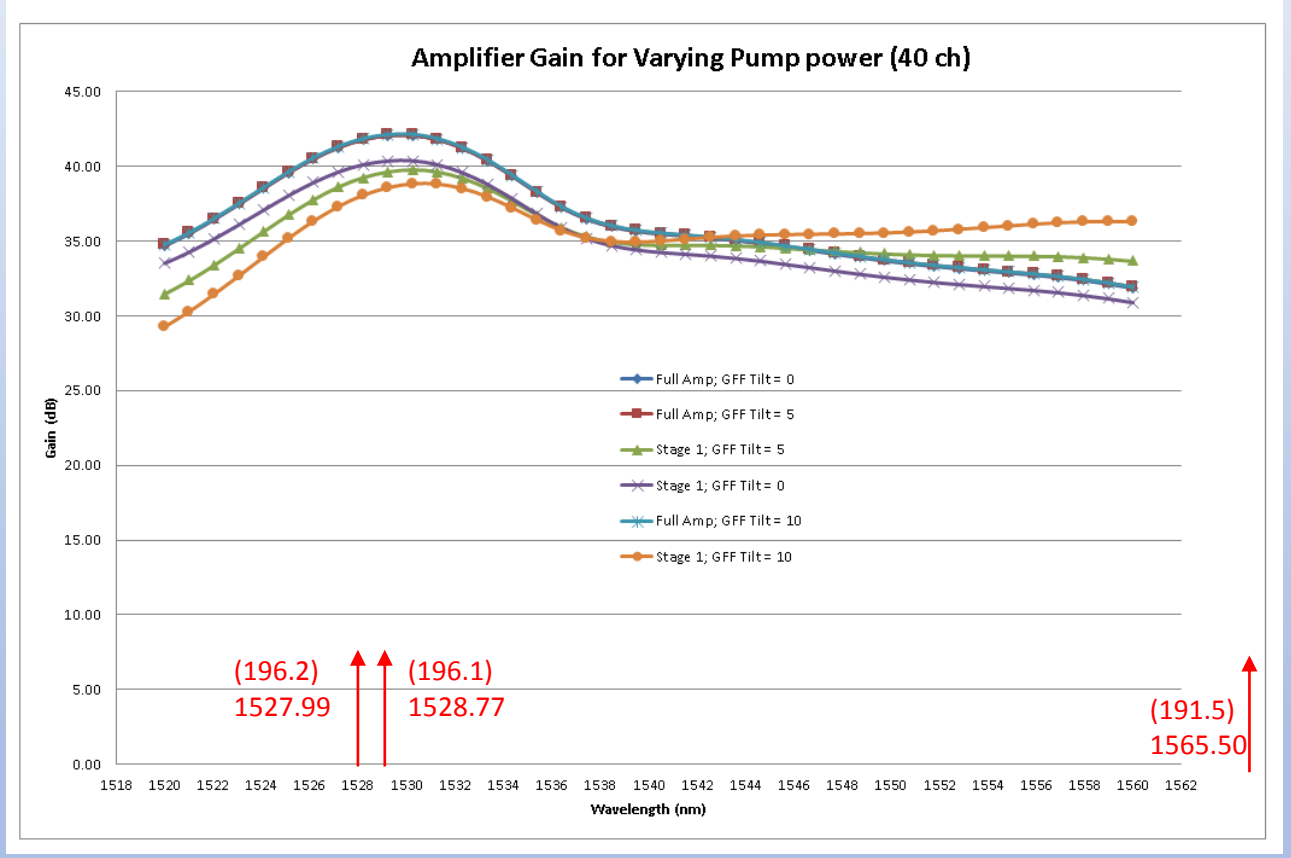


Figure 3, Erbium Fiber Gain and Tilt

Optical Amplifier Data with GFF

- All the components are spliced together to build the optical amplifier

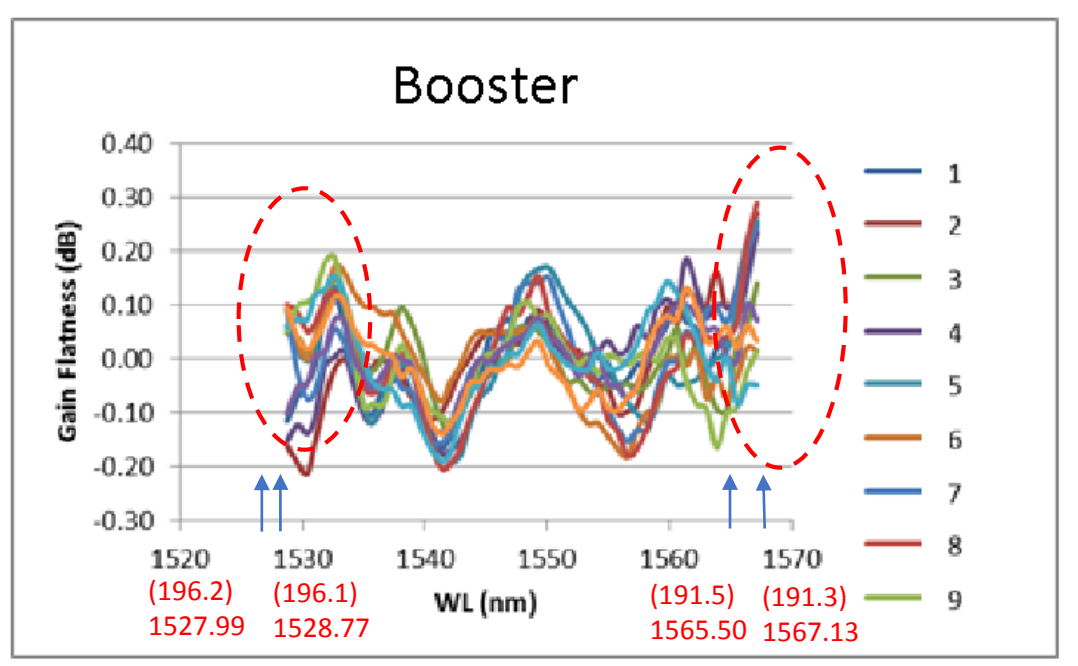


Figure 4, Gain Flattened Booster

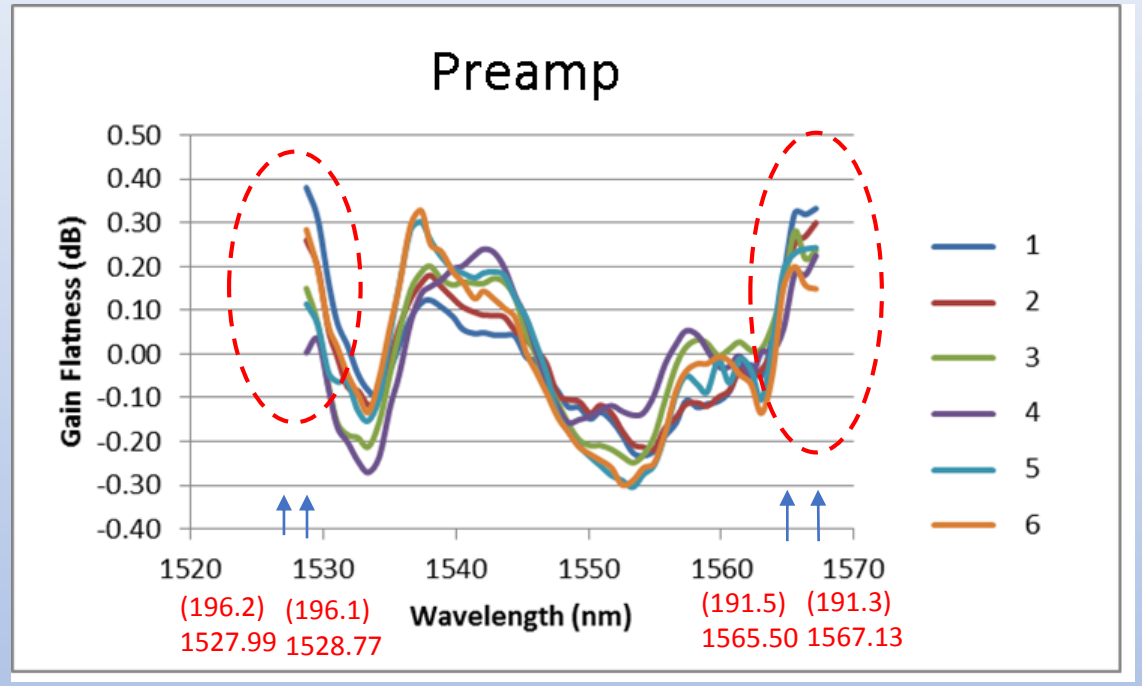
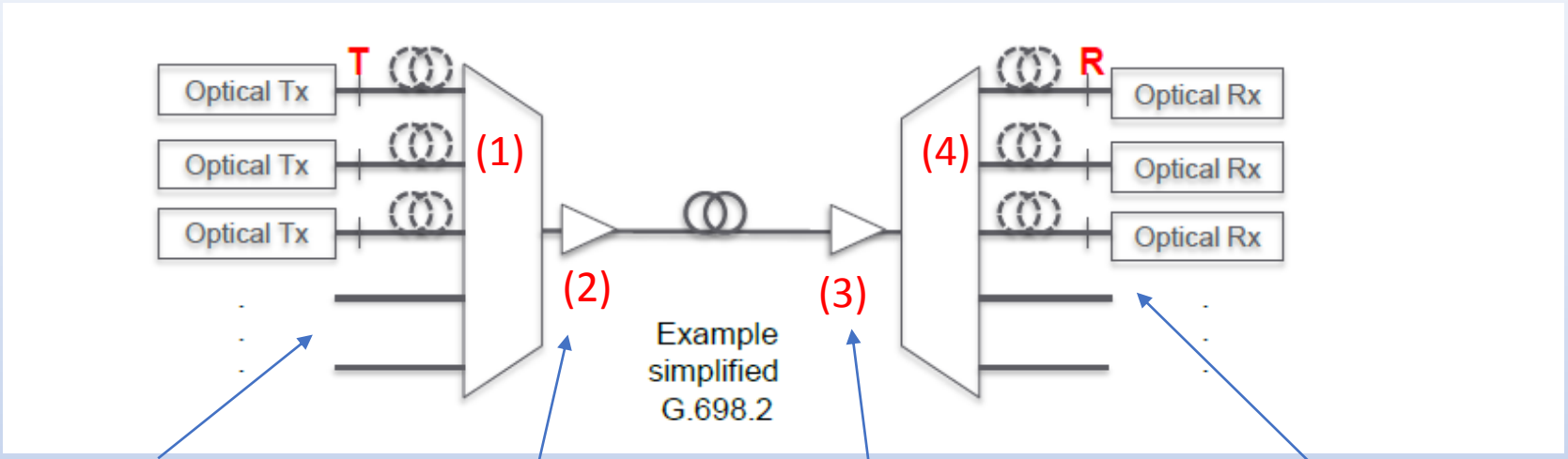
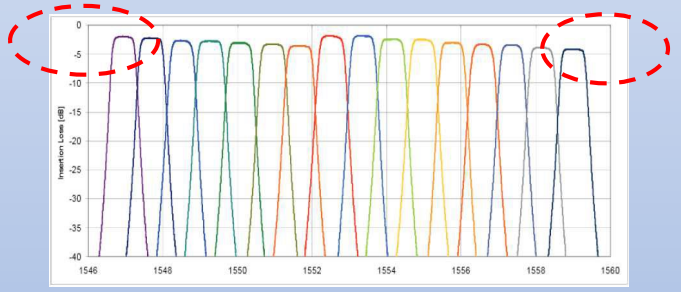


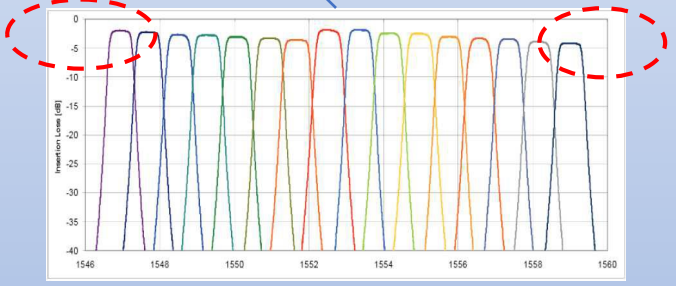
Figure 5, Gain Flattened Preamp

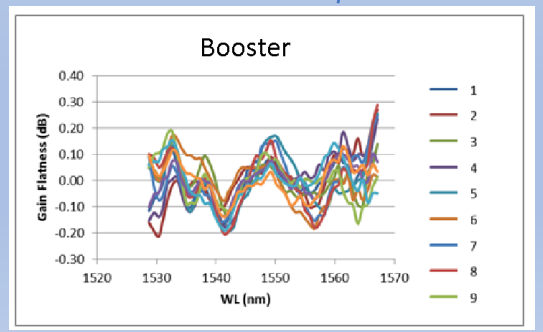
- Notice the imperfect match across the band and at the channel edges, this gets more difficult as
- channel count increase on both sides
- These two devices add together with and drop filters, and degrade black link ripple

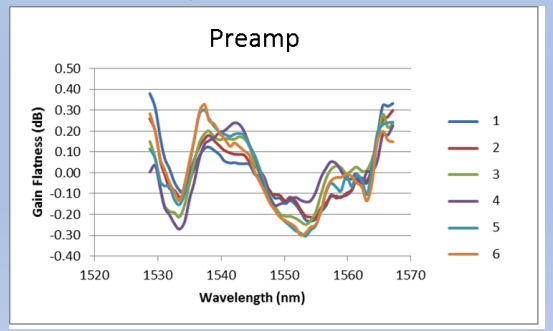
Cascaded Black Link Effects











Summary

- Channel choice for start and stop frequencies in the black link will degrade channel ripple of the cascaded optical amplifiers and the passive Add/Drop Filters
- Consideration for volume manufacturing and potential issues at these edges should kept in mind for optical amplifier vendors and add/drop mux filter vendors
- This does not consider the affect of transceivers at these edges, which can also affect our link model and interoperability
- Further study and vendor input should be considered