

Considerations for 400GBASE-ZR 75GHz Black Link Transfer Functions

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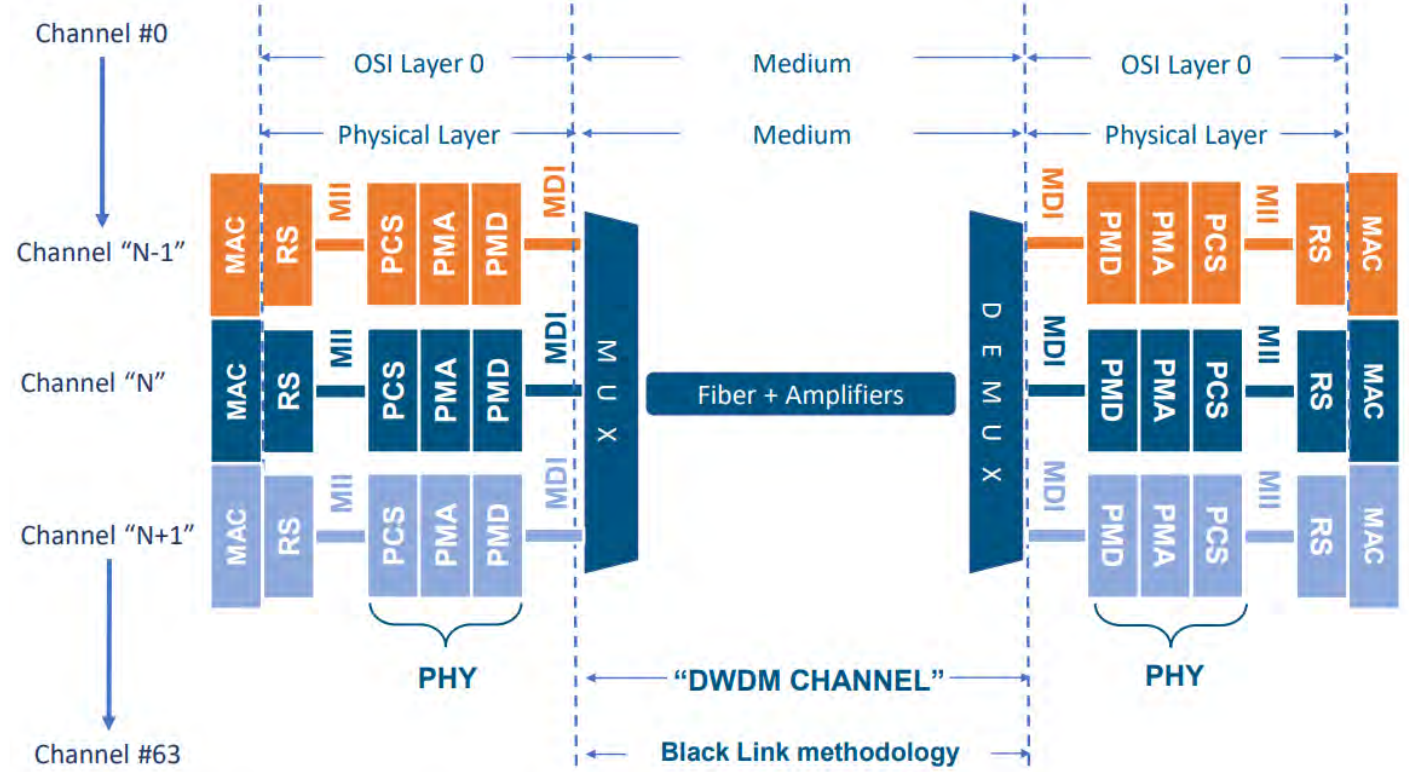
IEEE P802.3cw Optical Crosstalk Ad-hoc

2021-02-01

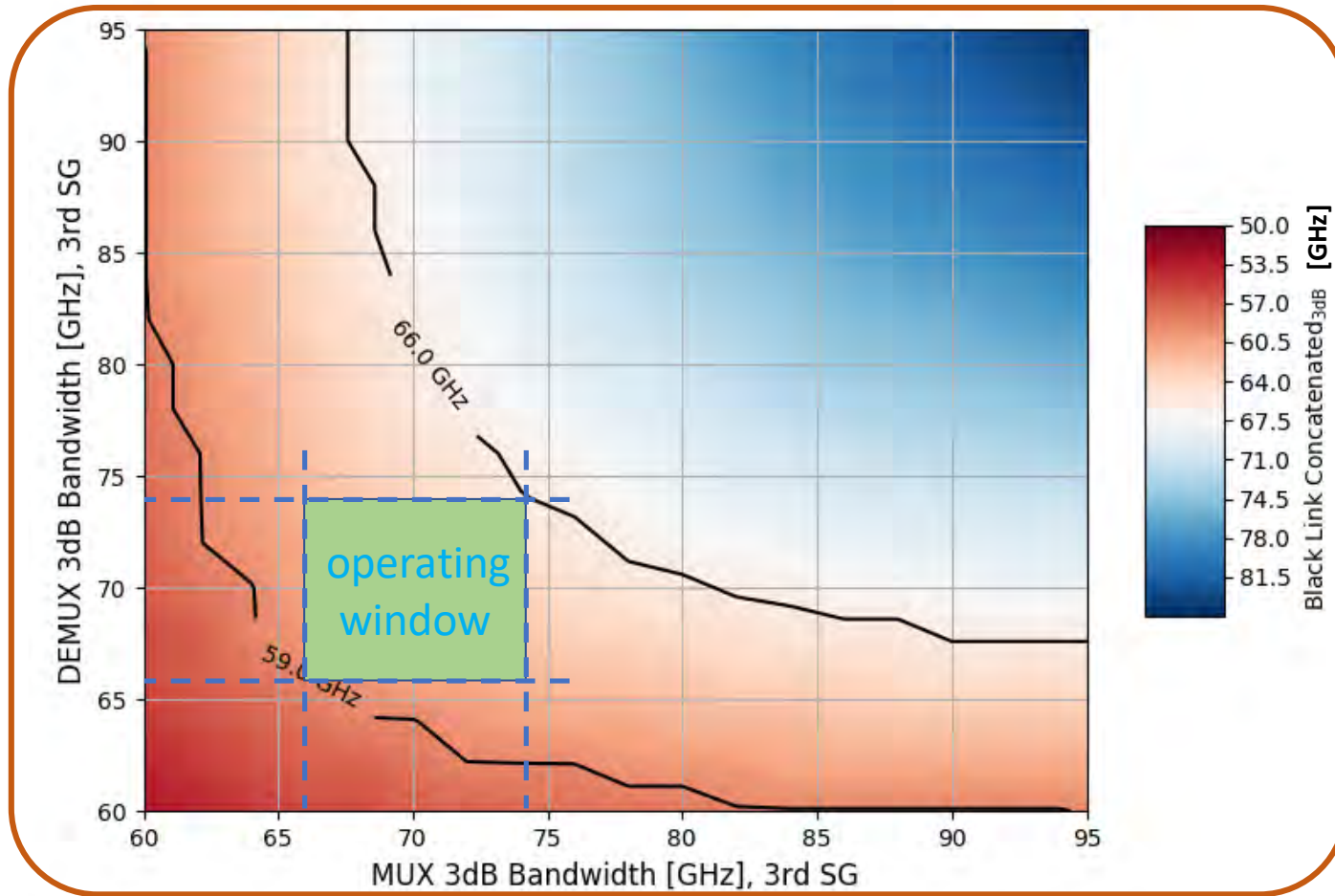
Motivation

- Recent Contributions have recognized the need to honor ‘black link’ methodology to develop specs for both 802.3ct and 802.3cw
https://www.ieee802.org/3/cw/public/adhoc/20_1202/dambrosia_3cw_201202.pdf
- Transfer functions of black link needs to be established
https://www.ieee802.org/3/cw/public/adhoc/20_1209/maniloff_3cw_01_201209.pdf
- This work attempts to provide a systematic approach of deriving a set of transfer functions for the black link and examines the new set of parameters from a black link operating window perspective.
- Goal is to ensure robustness of link design conformance and ease of black link qualification for any new parameters proposed.

Black Link Methodology

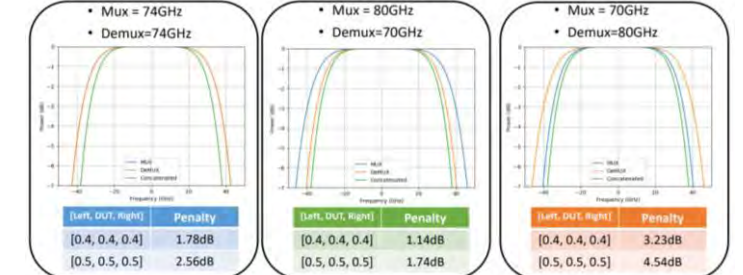


Network Filters -- Operating Window



Slide # 13 of [zhang_3cw_01b_201116](#)

The Problem With a Concatenated link Mask



- Three scenarios all have the same transfer function [Green curve] yet originated from different combinations of Mux/Demux.
- Two cases of Tx RRC vectors [left aggressor, center DUT and right aggressor] generate drastically different penalties under worst case condition detailed in reference table slide (see later slide).
- A concatenated transfer function thus would fail to ensure the different need for Mux and Demux filter characteristics which in turn would generate false positive and break the interoperability.

Slide # 23 of [zhang_3cw_01b_201116](#)

Proposed New Specifications for 75GHz Use Case

Table XXX-X —400GBASE-ZR transmit characteristics		
Description	Value	Unit
75GHz-induced Tx operating margin (min)	X	dB

Table XXX-X —400GBASE-ZR receive characteristics		
Description	Value	Unit
75GHz-induced Rx Post-FEC BER (max)	1E-15	

Table XXX-X —400GBASE-ZR black link characteristics		
Description	Value	Unit
Mux filter 3dB bandwidth [min, max]	[66, 74]	GHz
Mux filter frequency offset (max)	+/- 4	GHz
Mux filter shape (min)	3 rd	Order (Super-Gaussian)
Demux filter 3dB bandwidth [min, max]	[66, 74]	GHz
Demux filter frequency offset (max)	+/- 4	GHz
Mux filter shape (min)	3 rd	Order (Super-Gaussian)

- The issue with using only a single input and single output (SISO) concatenated black link transfer function on the channel 'N' input/output ports was shown in slide 13 of zhang_cw_01b_201116.
- Using proposed min/max (d)mux 3dB BWs from slide 23 of zhang_cw_01b_201116, we show here a contour with concatenated 3dB BWs. Bounded by min concatenated 59GHz and max 66GHz, one could see the operating window using the SISO approach is prohibitively larger than the individual filter 3dB specs.
- This drives the needs of additional parameters for black link transfer function to bound the operating space.

Adjacent Mux ports to center Demux port

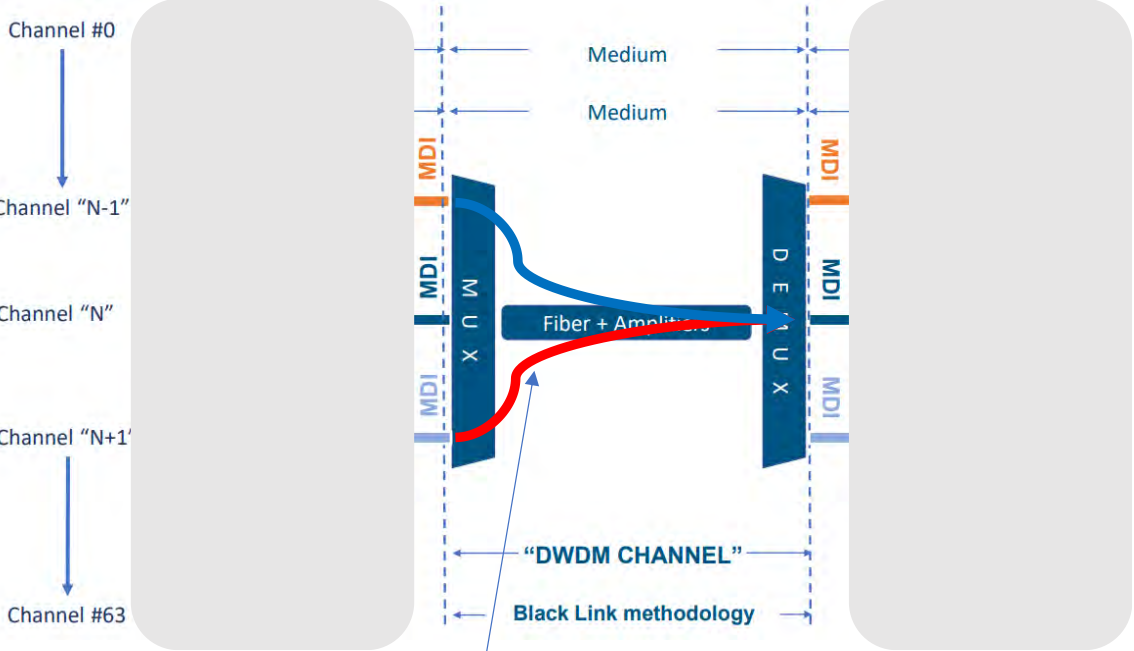
Stimulus

DWDM Link

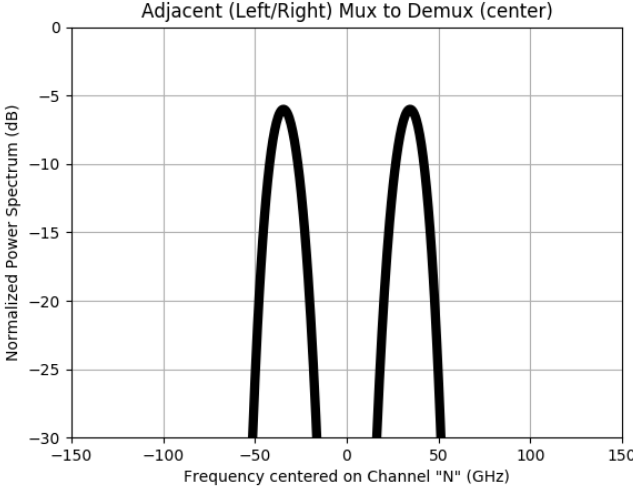
Response

Broadband ASE

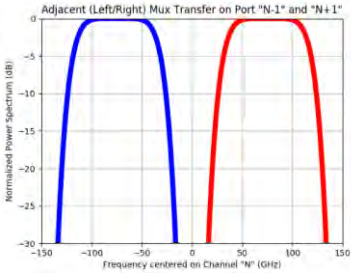
Broadband ASE



Optical Crosstalk Transfer



Illustrative Example: MUX = 80GHz, DEMUX = 70GHz

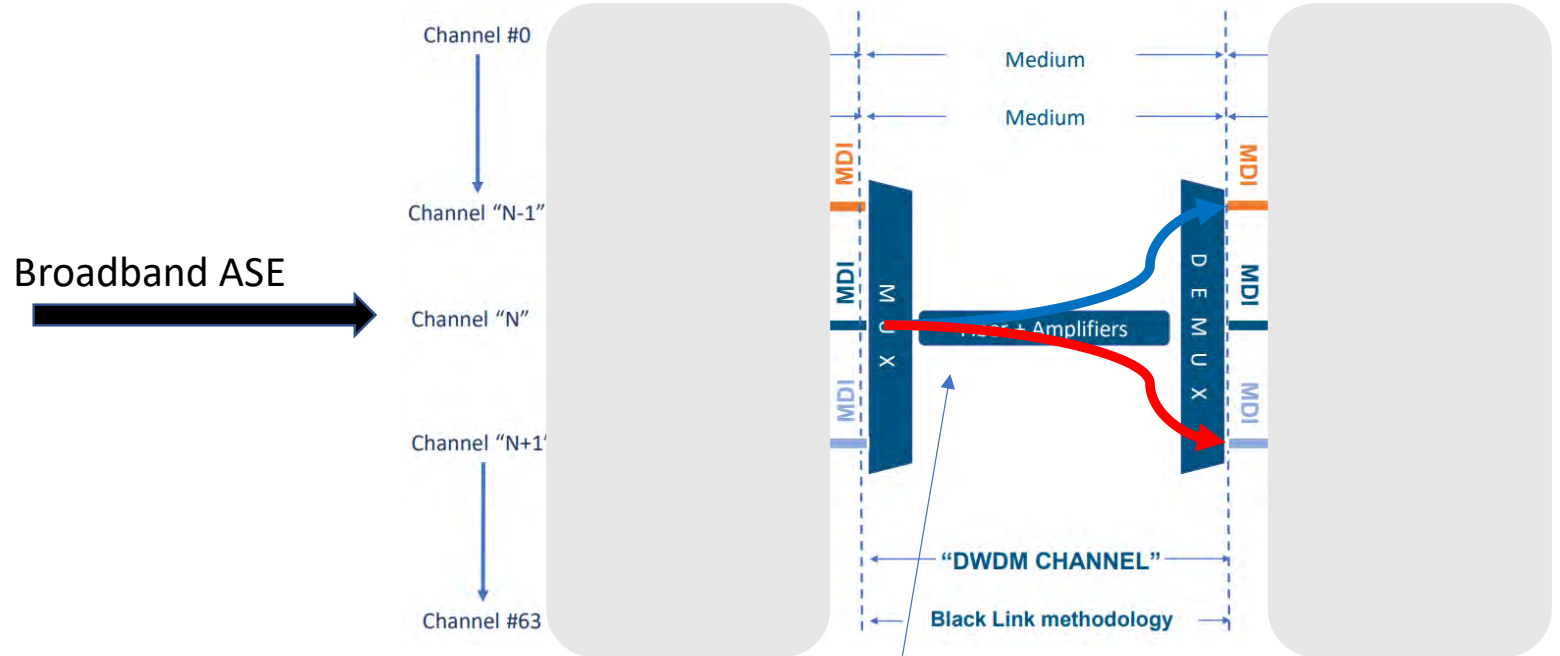


Center Mux ports to adjacent Demux ports

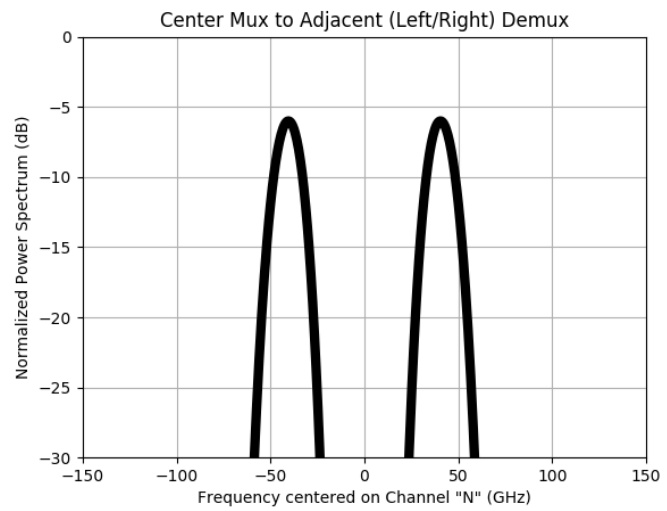
Stimulus

DWDM Link

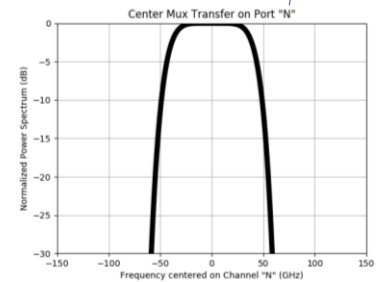
Response



Optical Crosstalk Transfer

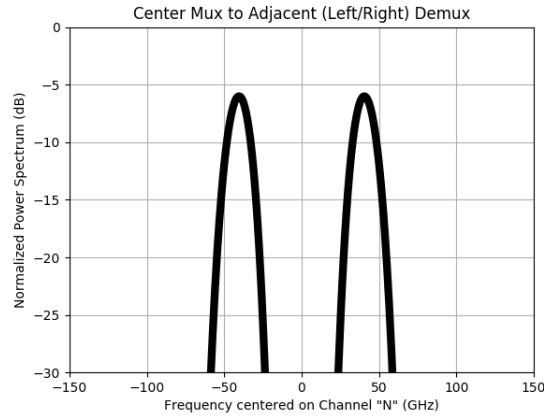


Illustrative Example: MUX = 80GHz, DEMUX = 70GHz

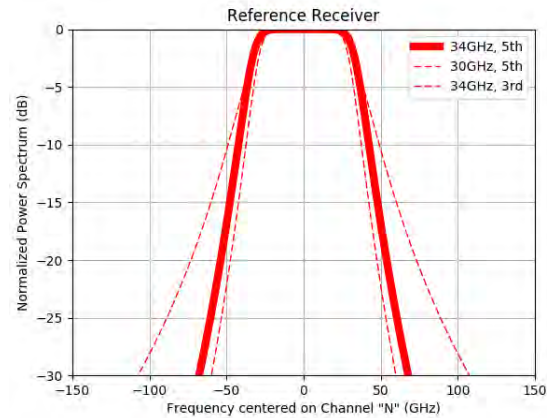


Reference receiver consideration

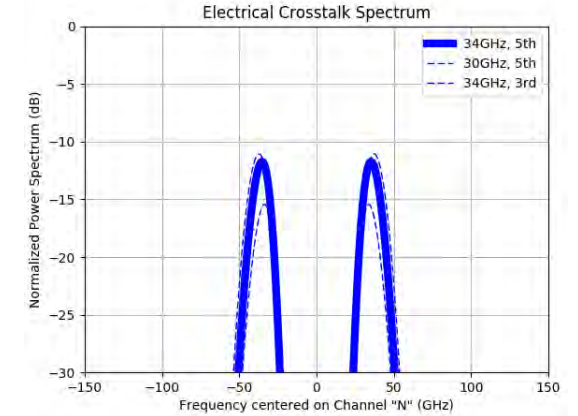
Optical Crosstalk Transfer



Reference Receiver



Electrical Crosstalk Transfer



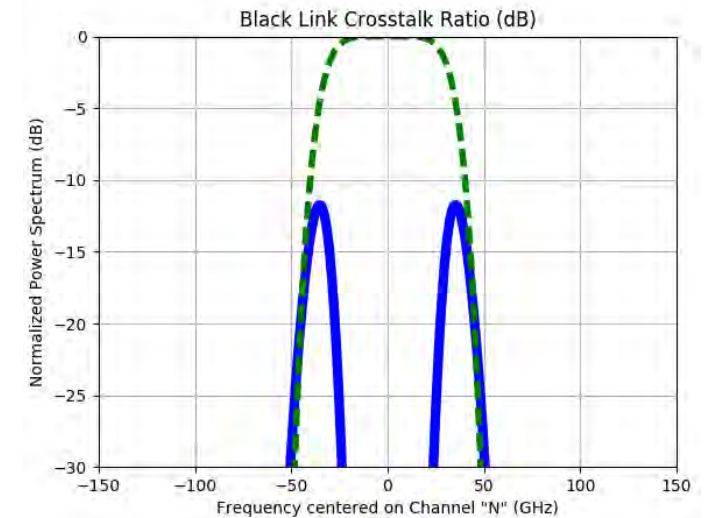
Compute
Crosstalk Ratio

$$Black_Link_CenterM2AdjD = abs(H_{MUX})^2 * abs(H_{DMUX_LEFT})^2 + abs(H_{MUX})^2 * abs(H_{DMUX_RIGHT})^2$$

$$H_{RX} = \text{Butterworth_filter}(ref_rx_bandwidth, ref_rx_order)$$

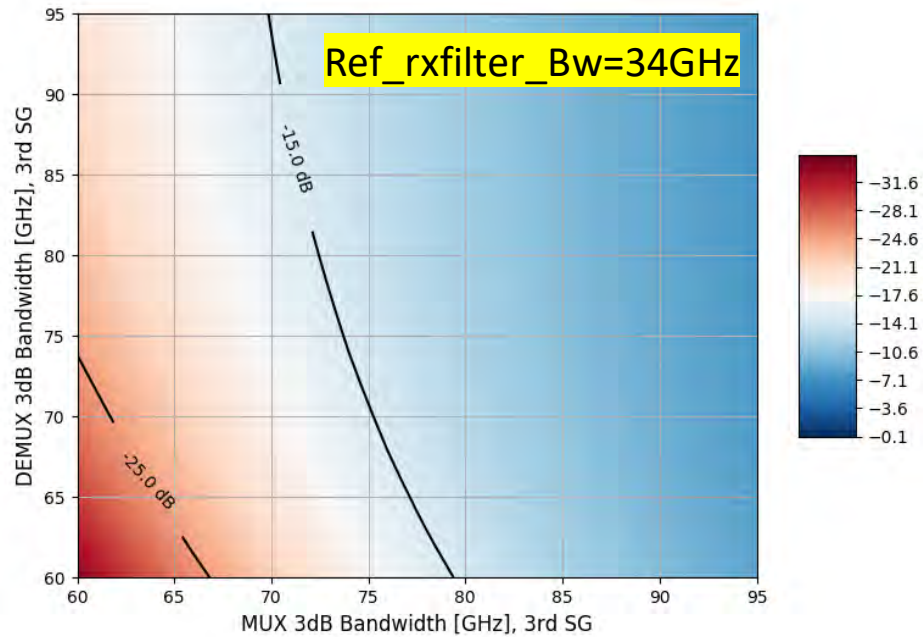
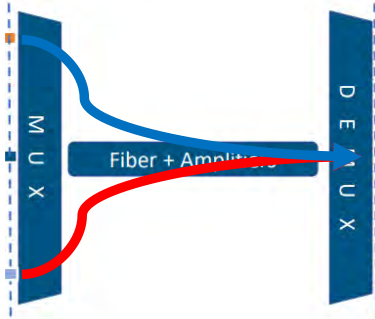
$$Black_Link_Concatenated = abs(H_{MUX})^2 * abs(H_{DMUX})^2$$

$$Crosstalk\ Ratio\ (dB) = 10 * \log_{10} \left\{ \frac{\int_{-f}^{+f} [Black_Link_CenterM2AdjD * abs(H_{RX})^2]}{\int_{-f}^{+f} Black_Link_Concatenated} \right\}$$

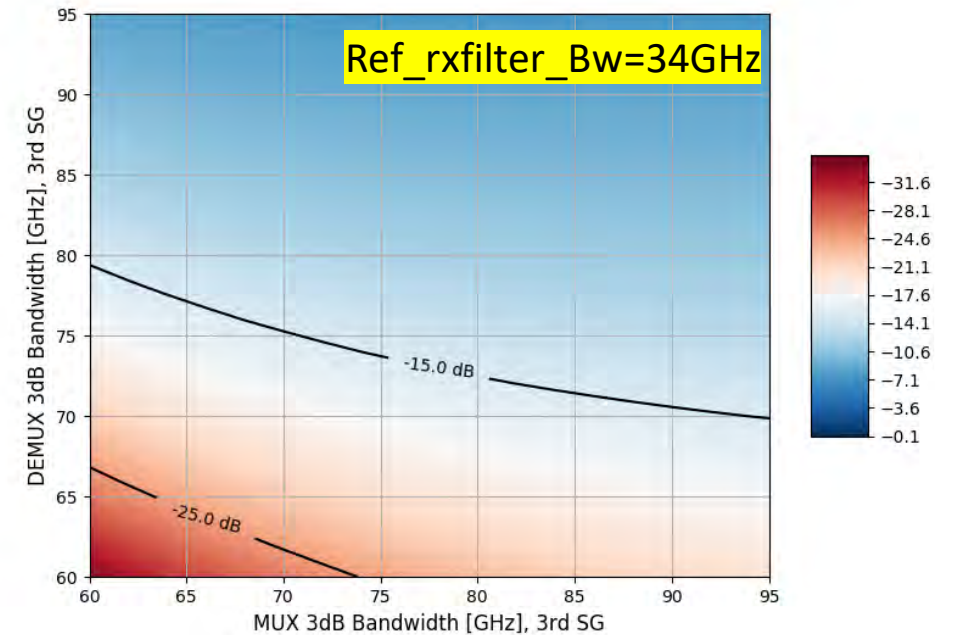
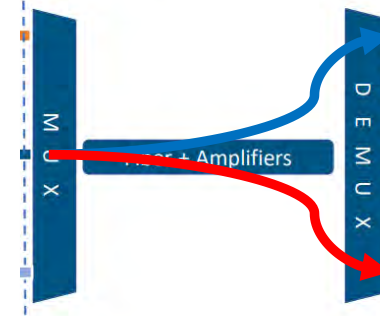


Compute Two Types of Crosstalk Ratio

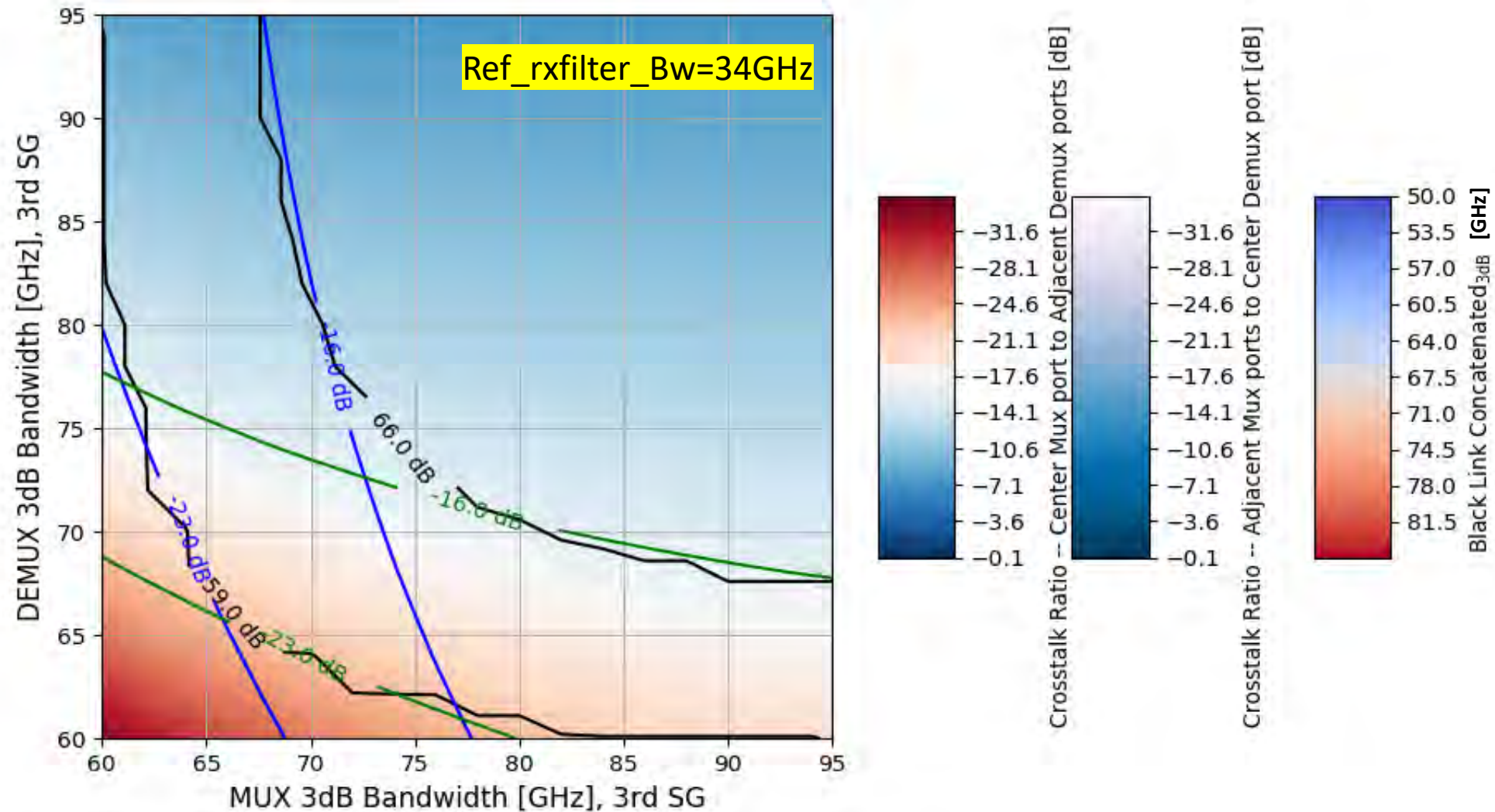
Type I:
Adjacent Mux ports to
Center Demux port



Type II:
Center Mux port to
Adjacent Demux ports



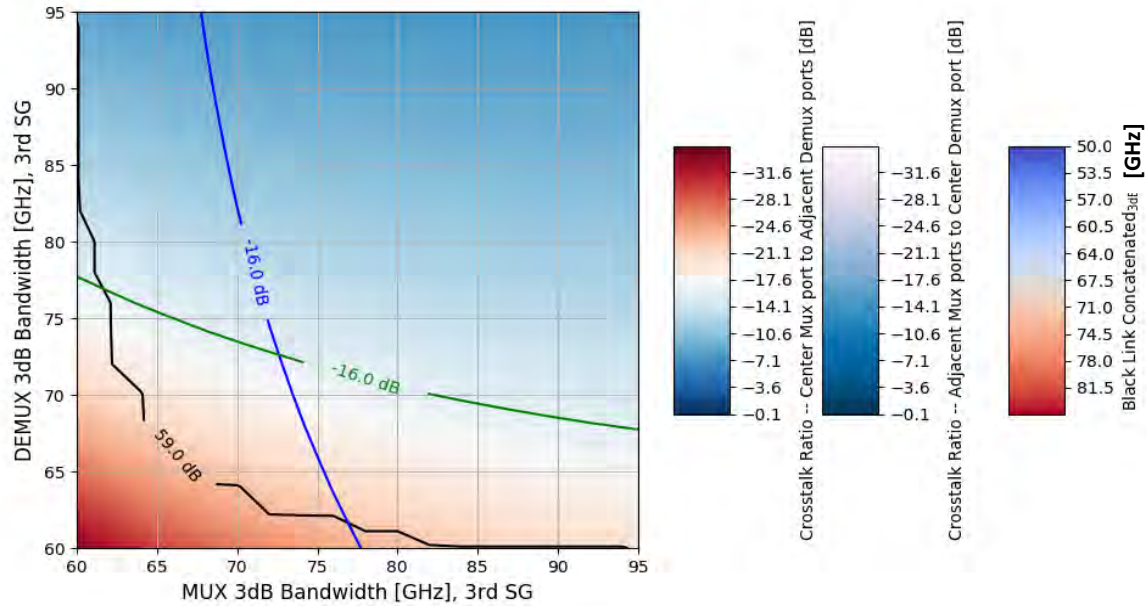
Putting the contours all together – Baseline [Left, Center, Right]



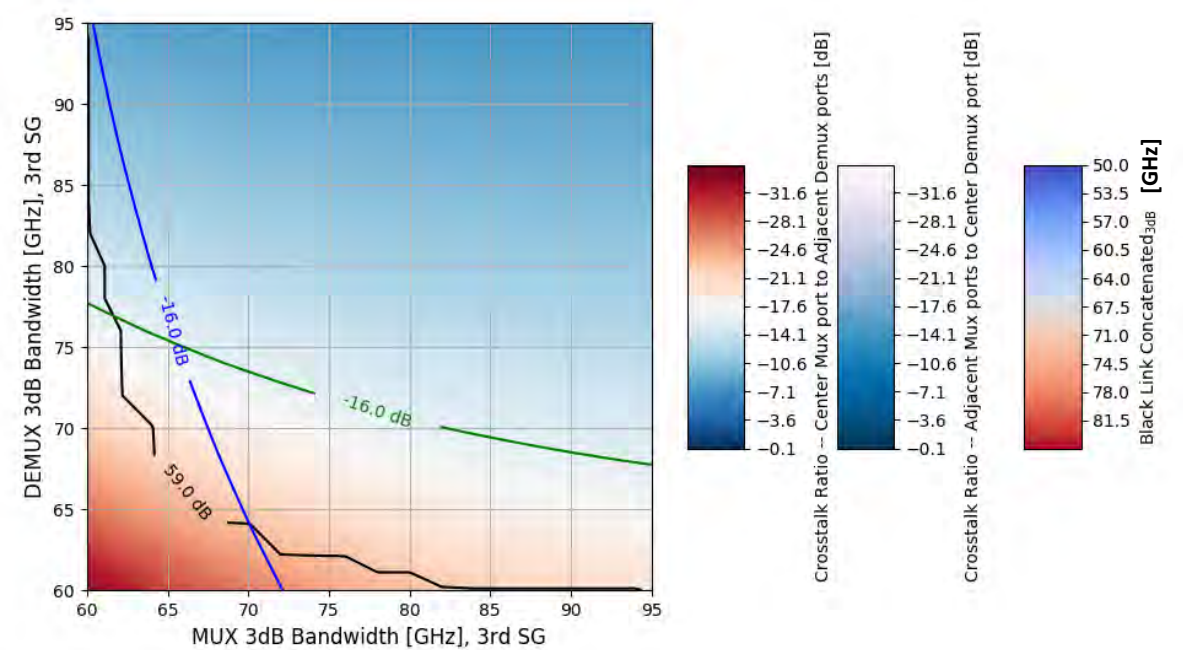
- The through concatenated transfer function (**black**) with the two types of cross transfer crosstalk ratio (**green** and **blue**) could serve as bounds for overall **operating window**.

Impact of Filter Insertion Loss Deviation

MUX Insertion Loss Deviation (port to port) = 0dB



MUX Insertion Loss Deviation (port to port) = 4dB



- This port-to-port insertion loss deviation (ILD) is to be distinguished with power imbalance from the transmitter channels.
- Higher ILD case results in reduced operating window, as compared to the baseline.

Summary

- MIMO (multiple input multiple output) treatment of the black link transfer function is a must, as opposed to SISO (single input single output) analysis.
- This will generate a new set of black link parameters
 - Need to examine their compliance methodology
 - Need to check their impact to modeling (could generate confusion before the new set of parameters are stable)
- Operating window for allowable Mux/Demux spaces should be served as governing criterion when examining new black link parameter proposals.