

Inter-channel Crosstalk/Black Link Definitions

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802.3cw

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Supporters

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Background

- Inter-channel Crosstalk is a significant contribution to the 400GBASE-ZR path penalty – based this being a 75GHz based spec
- This penalty was not a significant concern for 100GBASE-ZR
- Definition of the parameters that can contribute needs consideration and definition

- Simple RRC shaped Tx spectra can be used to illustrate the inter-channel xtalk issue
 - $0 < \text{Roll-off (Alpha)} < 1$
 - Lower Alpha \rightarrow Narrower spectrum

ITU G698.2 Inter-channel Crosstalk

- ITU defines Inter-channel crosstalk as the ratio of the **total power** of all disturbing channels to the wanted channel at the Rx input
 - Disturbing channels should be at worst case power & frequency offsets
- This definition does not correspond to the Rx penalty
 - https://www.ieee802.org/3/cw/public/tf_interim/20_0528/maniloff_3cw_01_200528.pdf

7.3.8 Maximum inter-channel crosstalk

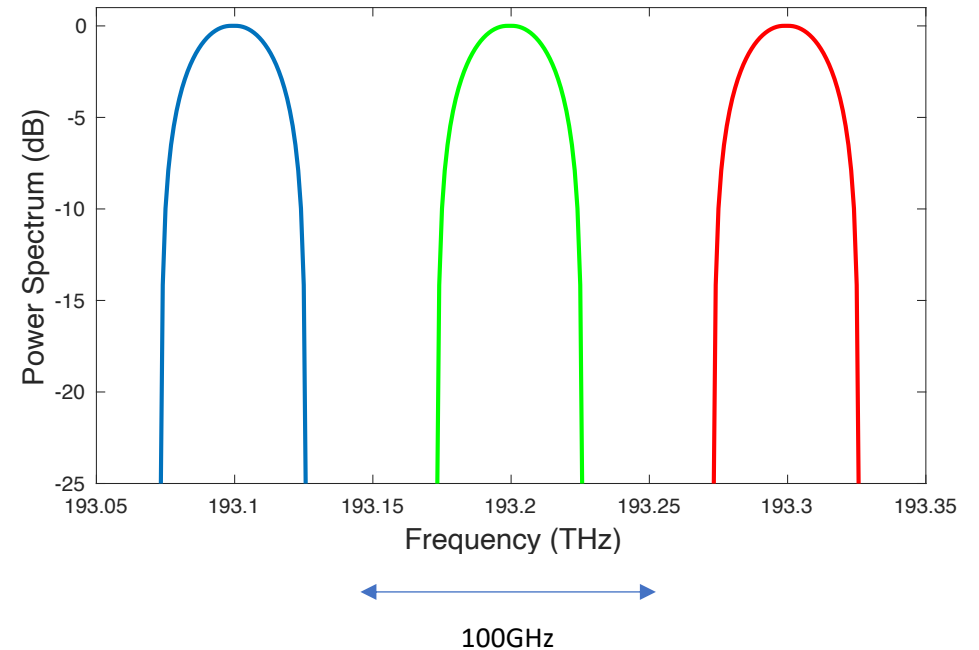
This parameter places a requirement on the isolation of a link conforming to the "black link" approach such that under the worst-case operating conditions the inter-channel crosstalk at any reference point R_S is less than the maximum inter-channel crosstalk value.

Inter-channel crosstalk is defined as the ratio of total power in all of the disturbing channels to that in the wanted channel, where the wanted and disturbing channels are at different wavelengths.

Specifically, the isolation of the link shall be greater than the amount required to ensure that when any channel is operating at the minimum mean output power at point S_S and all of the others are at the maximum mean output power, then the inter-channel crosstalk at the corresponding point R_S is less than the maximum inter-channel crosstalk value.

Coherent Detection

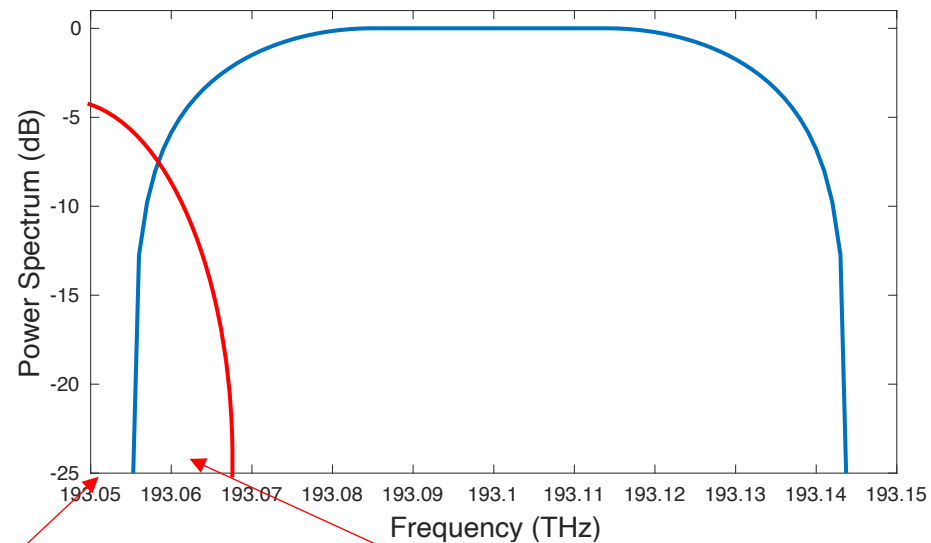
- Illustration based on 100GBASE-ZR shows:
 - 3x28Gbaud channels' Tx spectra
 - 100GHz spacing
 - RRC/0.9 roll-off used for illustration



- Coherent detection provides an inherent filtering capability
 - The coherent detection / Rx BW will filter channels removed from the local oscillator
 - Digital filtering further removes noise – matched filter removes noise outside Tx spectra
- Crosstalk **within** Tx spectrum results in a penalty

Rx Filtering impact on inter-channel crosstalk

- The impact of inter-channel crosstalk depends on its spectral location
- Only some of the frequency content of the crosstalk shown below will result in a penalty

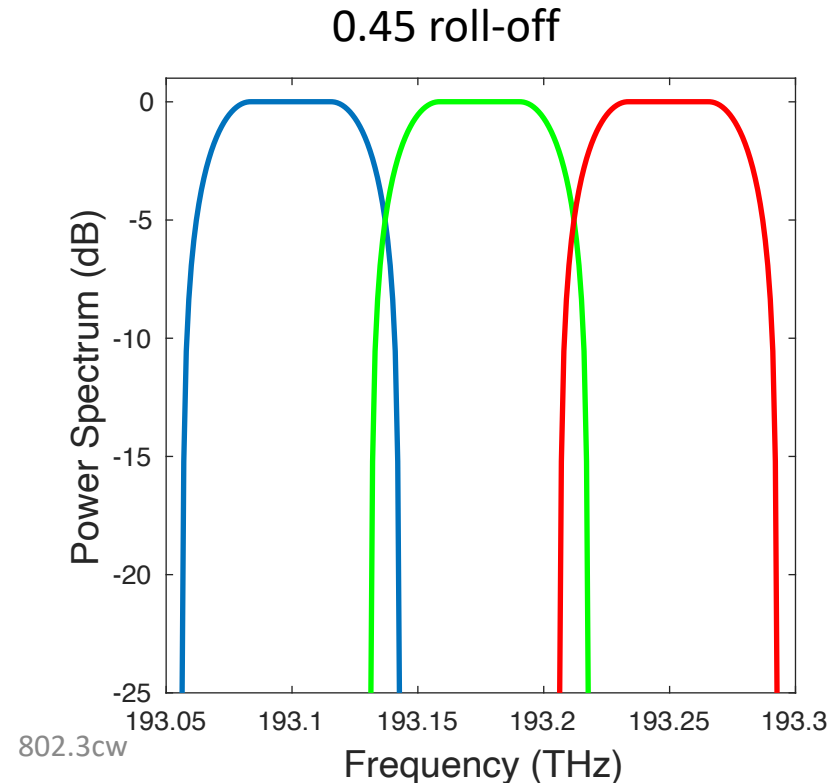
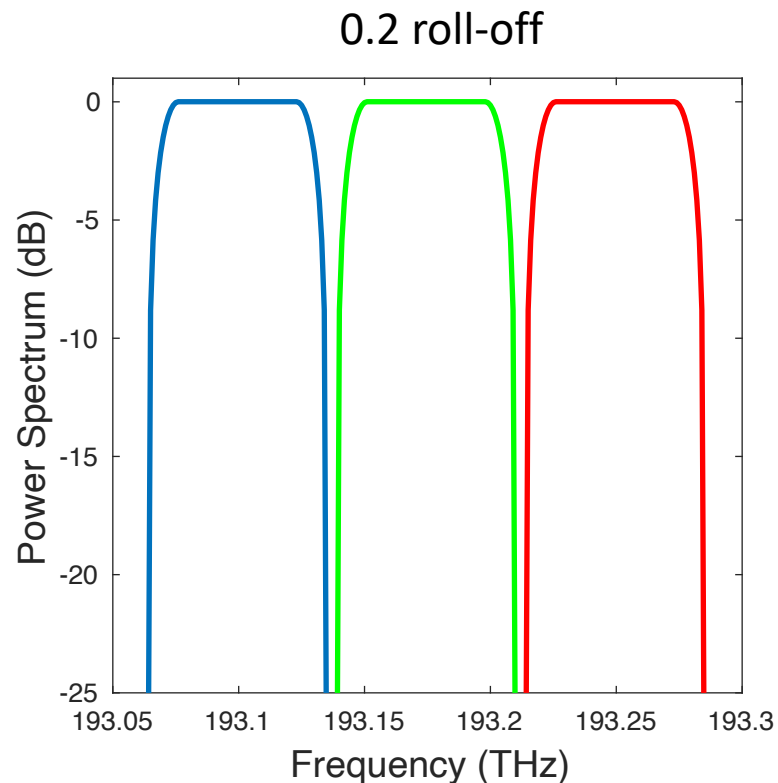


Crosstalk outside filter BW
doesn't result in a penalty

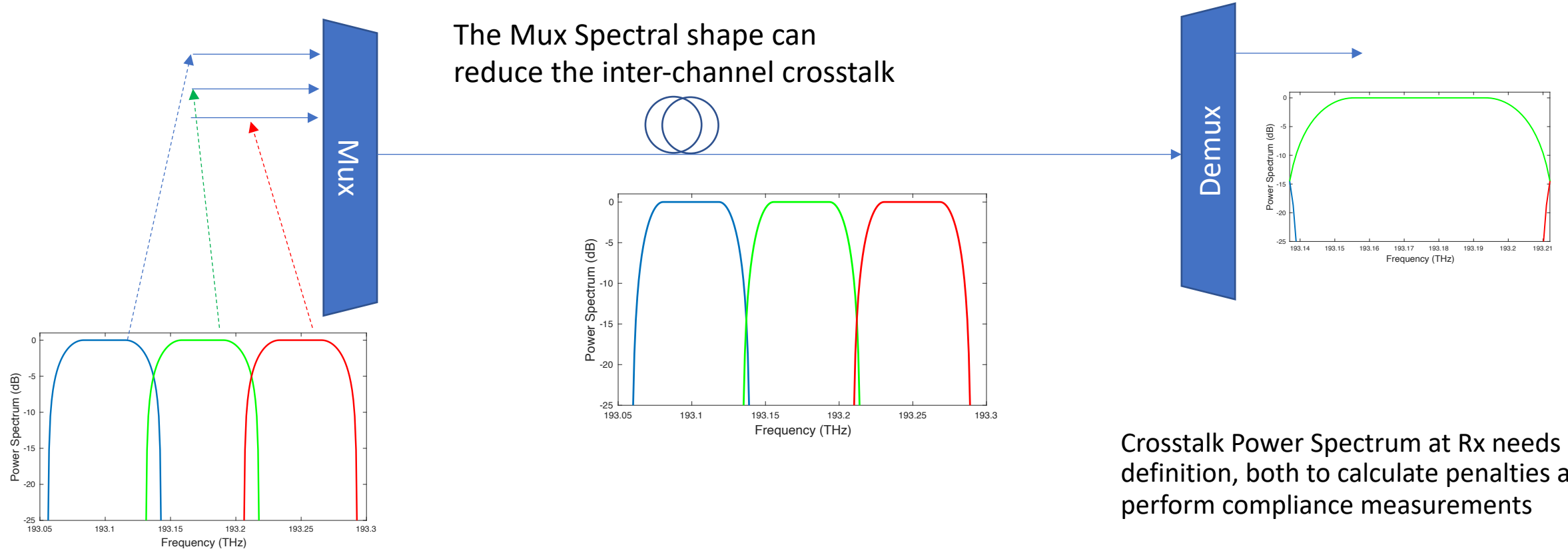
Crosstalk within the filter BW
results in a penalty

400GBASE-ZR spectra

- 400GBASE-ZR is specifying ~ 60 Gbaud channels with 75GHz spacing
- As opposed to 100GBASE-ZR, inter-channel crosstalk can result in a significant penalty.



System View



Transmit spectra are shown together to illustrate overlap, but each channel is incident on one Mux port

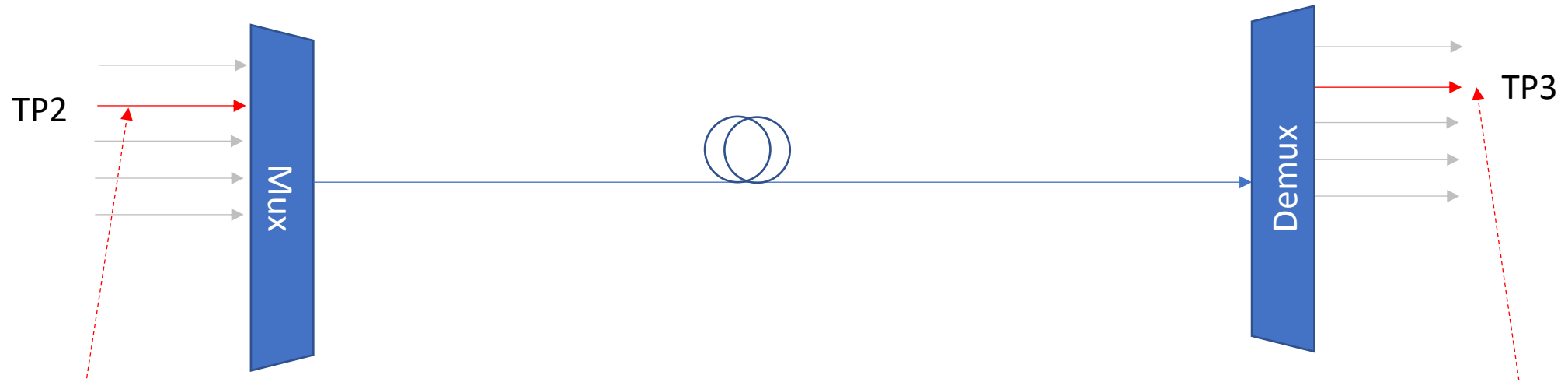
Calculating Inter-channel Crosstalk Penalty

- Calculation of inter-channel crosstalk penalty requires information on more than the integrated crosstalk power – its spectral distribution is needed
- https://www.ieee802.org/3/cw/public/tf_interim/20_0528/maniloff_3cw_01_200528.pdf calculated the crosstalk distribution after Rx filtering matching the Tx spectrum, and applied an AWGN penalty based on this NSR term.
- https://www.ieee802.org/3/ct/public/20_09/kota_3cw_01_200921.pdf applied an optimal equalizer approach to the crosstalk for a variety of Tx shapes and link filters
- The specifics of how crosstalk is mapped into penalty is needed to determine spectral masks.
- The methodology of how we specify the elements is needed to progress.
- Eventually we will define a penalty in 802.3cw, and ensure that the conditions are sufficiently well specified to allow Rx compliance measurements.

802.3cw definitions

- All parameters (Tx, Link, Rx) should be independently specified & measurable
- Parameters should be sufficiently well defined to allow Rx design to meet spec requirements (i.e. inter-channel crosstalk penalty)
- Tx spectra and black link passband are coupled through filtering penalty
- Tx spectra and adjacent channel isolation are coupled through inter-channel crosstalk penalty
- Definition of Tx spectral mask and **a well-defined channel isolation** will bound inter-channel crosstalk, allowing penalty calculations
 - The actual specs will be based on agreed-on penalty calculations

Black Link Spectral Characterization



Broadband or tunable light is transmitted into one port

Power is measured on the corresponding Demux port

Spectral mask is defined and measured from Mux input (TP2) to Demux Output (TP3)

An initial value for the isolation can be obtained from the combined Mux/Demux mask for the highest BW (76GHz) from:

https://www.ieee802.org/3/ct/public/20_11/way_cw_01b_201116.pdf

Thanks!