SNDR Insertion Loss Adjustments

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Agenda

- ❑ Background
- ❑ Simulation Proxy Experiment for Measurements
- ❑ SNDR results
- ❑ Loss Adjustment Factor
- ❑ Summary and Proposal

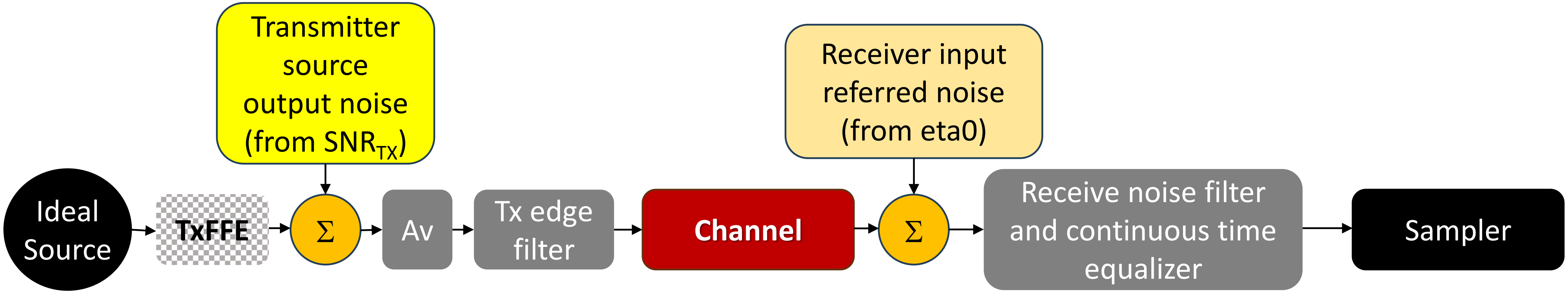
Background

- SNDR is defined in 120D.3.1.55
  - $SNDR = 10 * log_{10}\left(\frac{p_{max}^2}{\sigma_e^2+\sigma_n^2}\right)$
  - Equalization is not required to make the measurement
- Consider broadband noise is the usage model for $\sigma_e^2 + \sigma_n^2$
  - The old assumption is that SNDR does not change with channel insertion loss because the power ratio of pulse peak, As $(h^{(0)}(t_s))$, and the noise will not change with loss. Is this assumption valid?
  - COM Annex 93A computations use a broadband noise impairment, σ_{TX}^2 which is included in the broadband receiver noise variance σ_g^2 used to compute COM
    - $\sigma_{TX}^2 = \left[h^{(0)}(t_s)\right]^2 10^{-SNR_{TX}/10}$
    - Note: For many cases, SNR_{TX} is approximately SNDR

Motivation

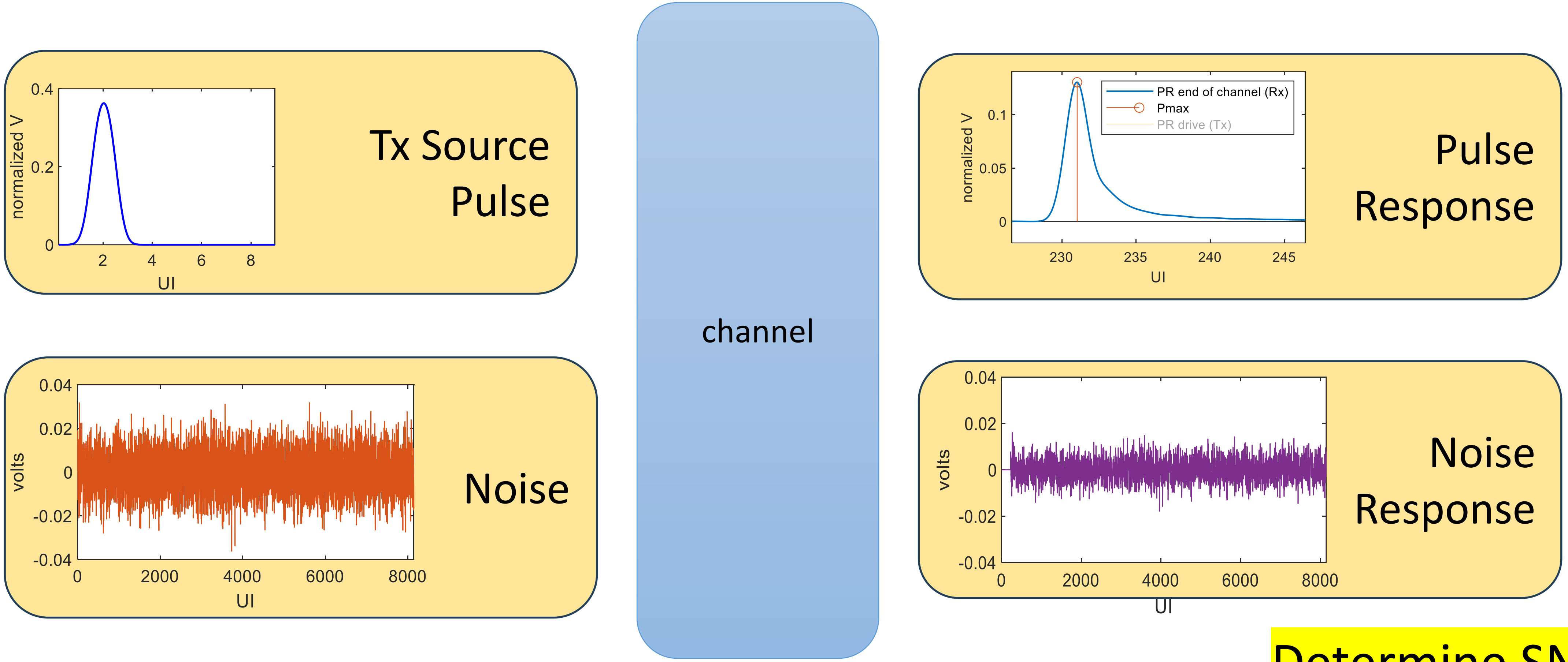
ORIGINALLY PROPOSED IN healey_3dj_01_2401

- Computation for determining noise from a transmitter noise is described in Annex 178A (figure 178A-7)
- This noise is used for the computation of COM in Annex 178A
- As indicated below transmitter noise is injected at the transmitter source



Simple Experiment

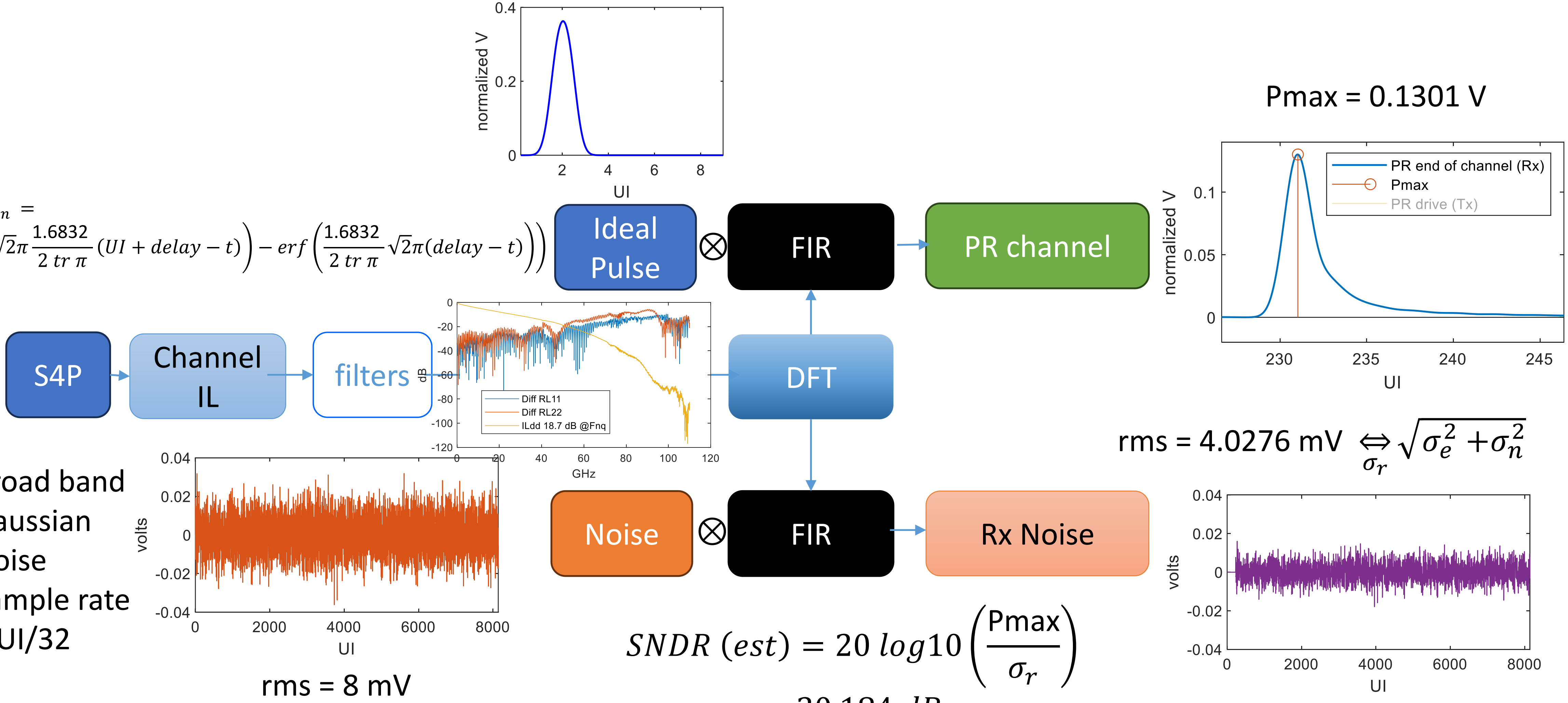
SIMULATION AS A PROXY FOR SNDR MEASUREMENTS



Determine SNDR from Pulse and Noise

Simulation Details

$$PR_{Gaussian} = A\left(erf\left(\sqrt{2}\pi\frac{1.6832}{2\ tr\ \pi}(UI + delay - t)\right) - erf\left(\frac{1.6832}{2\ tr\ \pi}\sqrt{2}\pi(delay - t)\right)\right)$$



Broad band Gaussian Noise

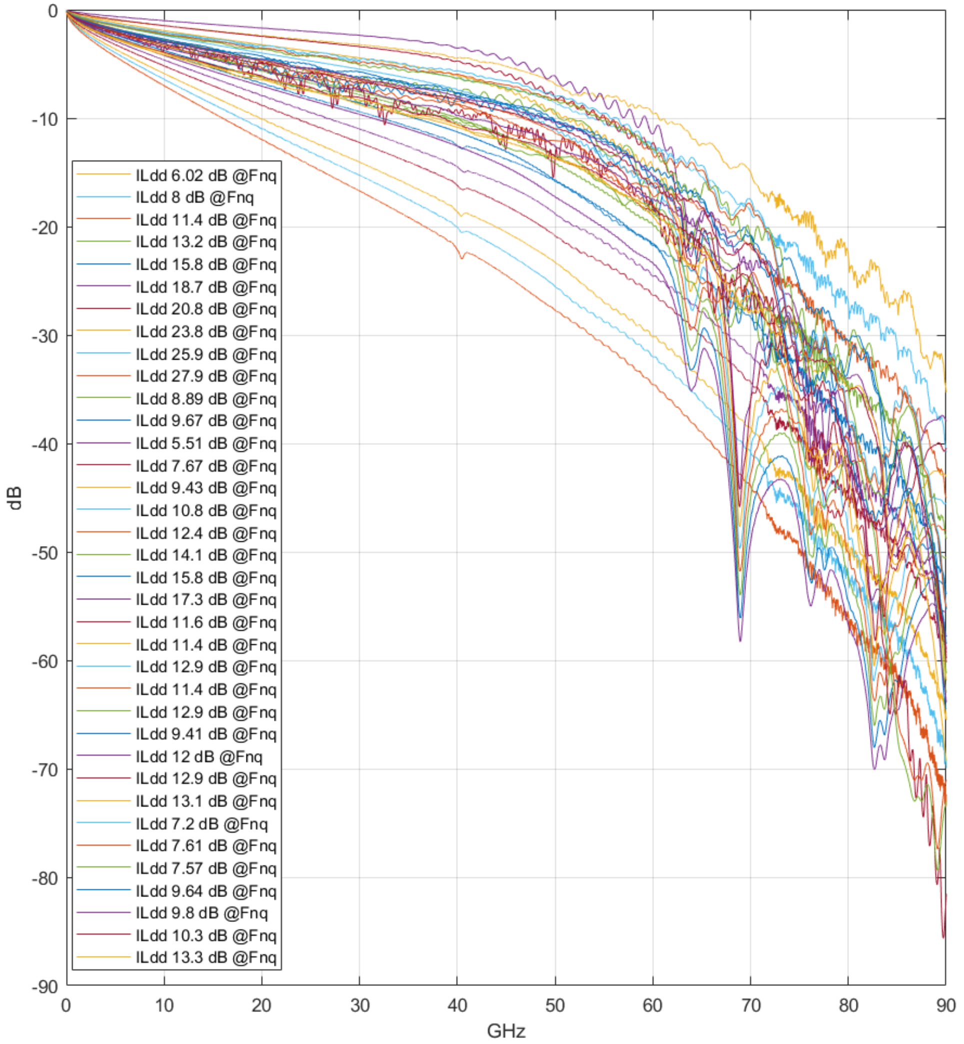
Sample rate = UI/32

rms = 8 mV

rms = 4.0276 mV $\Leftrightarrow \sqrt{\sigma_e^2 + \sigma_n^2}$ (σ_r)

$$SNDR\ (est) = 20\ log10\left(\frac{\text{Pmax}}{\sigma_r}\right) = 30.184\ dB$$

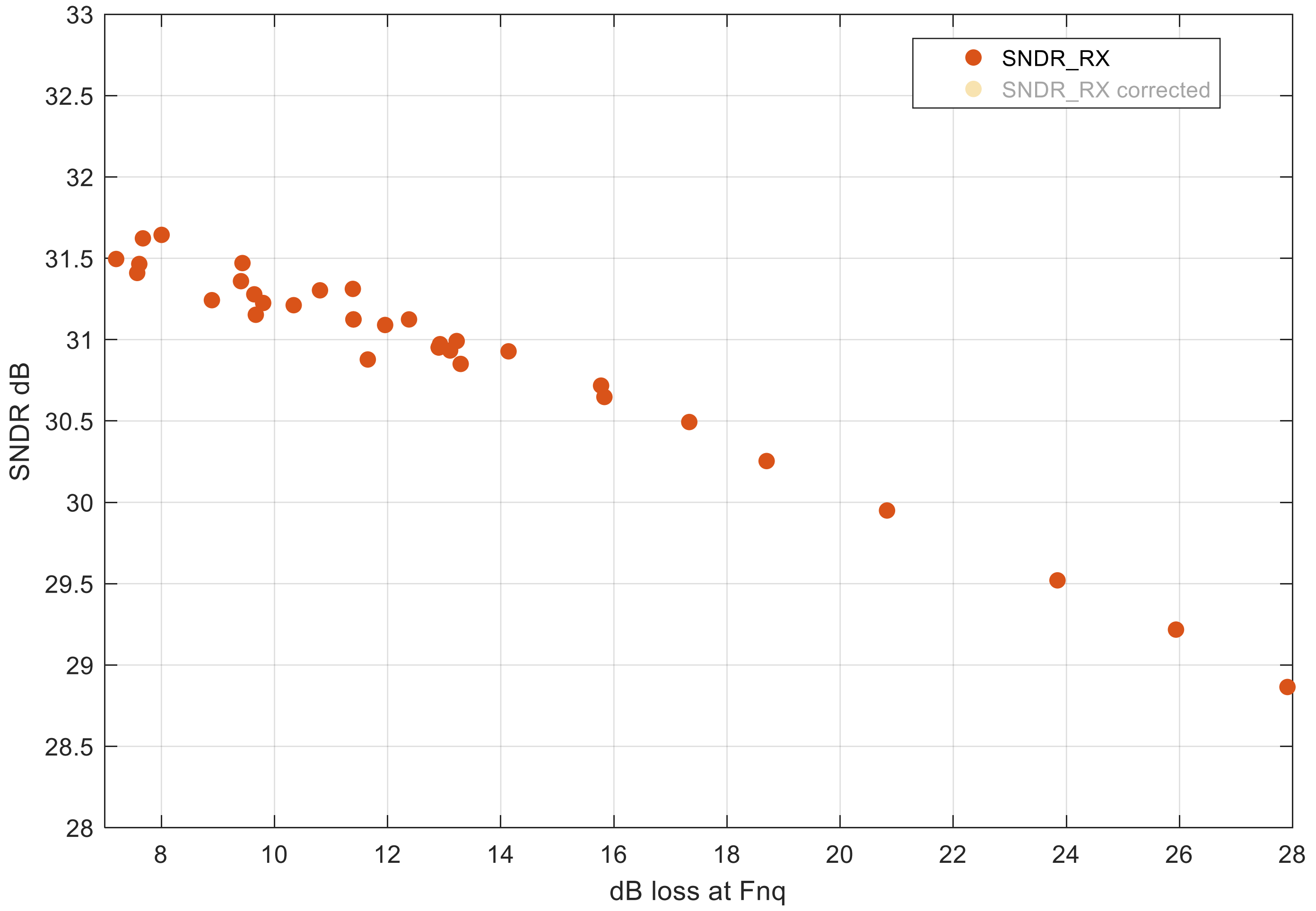
Channel list and IL Plots 5.5 dB to 27.9 dB



channel group	Channel file name
ISI board	L3_025mm.s4p
ISI board	L3_050mm.s4p
ISI board	L3_075mm.s4p
ISI board	L3_100mm.s4p
ISI board	L3_125mm.s4p
ISI board	L3_150mm.s4p
ISI board	L3_175mm.s4p
ISI board	L3_200mm.s4p
ISI board	L3_225mm.s4p
ISI board	L3_250mm.s4p
akinwale_3df_01_2209	C2M_PCB_85ohms_10dB_202208016_v2_thru1.s4p
akinwale_3df_01_2209	C2M_PCB_85ohms_11dB_202208016_v2_thru1.s4p
heck_3dj_02_2403	Tx_2in_Rx_thru1.s4p
heck_3dj_02_2403	Tx_3in_Rx_thru1.s4p
heck_3dj_02_2403	Tx_4in_Rx_thru1.s4p
heck_3dj_02_2403	Tx_5in_Rx_thru1.s4p
heck_3dj_02_2403	Tx_6in_Rx_thru1.s4p
heck_3dj_02_2403	Tx_7in_Rx_thru1.s4p
heck_3dj_02_2403	Tx_8in_Rx_thru1.s4p
heck_3dj_02_2403	Tx_9in_Rx_thru1.s4p
kareti_3dj_02_2309	Cabled_Host_ball_ball_11db.s4p
rabinovich_3df_022422	KEY_C2M_200G_120G_2p5HCB_022422_Thru.s4p
rabinovich_3df_022422	KEY_C2M_200G_120G_4p0HCB_022422_Thru.s4p
rabinovich_3df_022422	KEY_C2M_200G_120G_2p5HCB_022422_Thru.s4p
rabinovich_3df_022422	KEY_C2M_200G_120G_4p0HCB_022422_Thru.s4p
weaver_3dj_elec_02_230831	C2M_X_OSFP224_5in_host_PCB_25C_thru_TP0_Tx7_to_TP1a_Tx7.s4p
weaver_3dj_elec_02_230831	C2M_X_OSFP224_7in_host_PCB_25C_thru_TP0_Tx7_to_TP1a_Tx7.s4p
weaver_3dj_elec_02_230831	C2M_X_OSFP224_7in_host_PCB_80C_thru_TP0_Tx7_to_TP1a_Tx7.s4p
weaver_3dj_elec_02_230831	C2M_X_OSFP224_7in_host_PCB_80C_thru_TP4a_Rx8_to_TP5_Rx8.s4p
weaver_3dj_elec_02_230831	C2M_Y_OSFP224_3in_host_PCB_25C_thru_TP0_Tx7_to_TP1a_Tx7.s4p
weaver_3dj_elec_02_230831	C2M_Y_OSFP224_3in_host_PCB_80C_thru_TP0_Tx7_to_TP1a_Tx7.s4p
weaver_3dj_elec_02_230831	C2M_Y_OSFP224_3in_host_PCB_80C_thru_TP4a_Rx8_to_TP5_Rx8.s4p
weaver_3dj_elec_02_230831	C2M_Y_OSFP224_5in_host_PCB_25C_thru_TP0_Tx7_to_TP1a_Tx7.s4p
weaver_3dj_elec_02_230831	C2M_Y_OSFP224_5in_host_PCB_25C_thru_TP4a_Rx8_to_TP5_Rx8.s4p
weaver_3dj_elec_02_230831	C2M_Y_OSFP224_5in_host_PCB_80C_thru_TP0_Tx7_to_TP1a_Tx7.s4p
weaver_3dj_elec_02_230831	C2M_Y_OSFP224_7in_host_PCB_80C_thru_TP4a_Rx8_to_TP5_Rx8.s4p

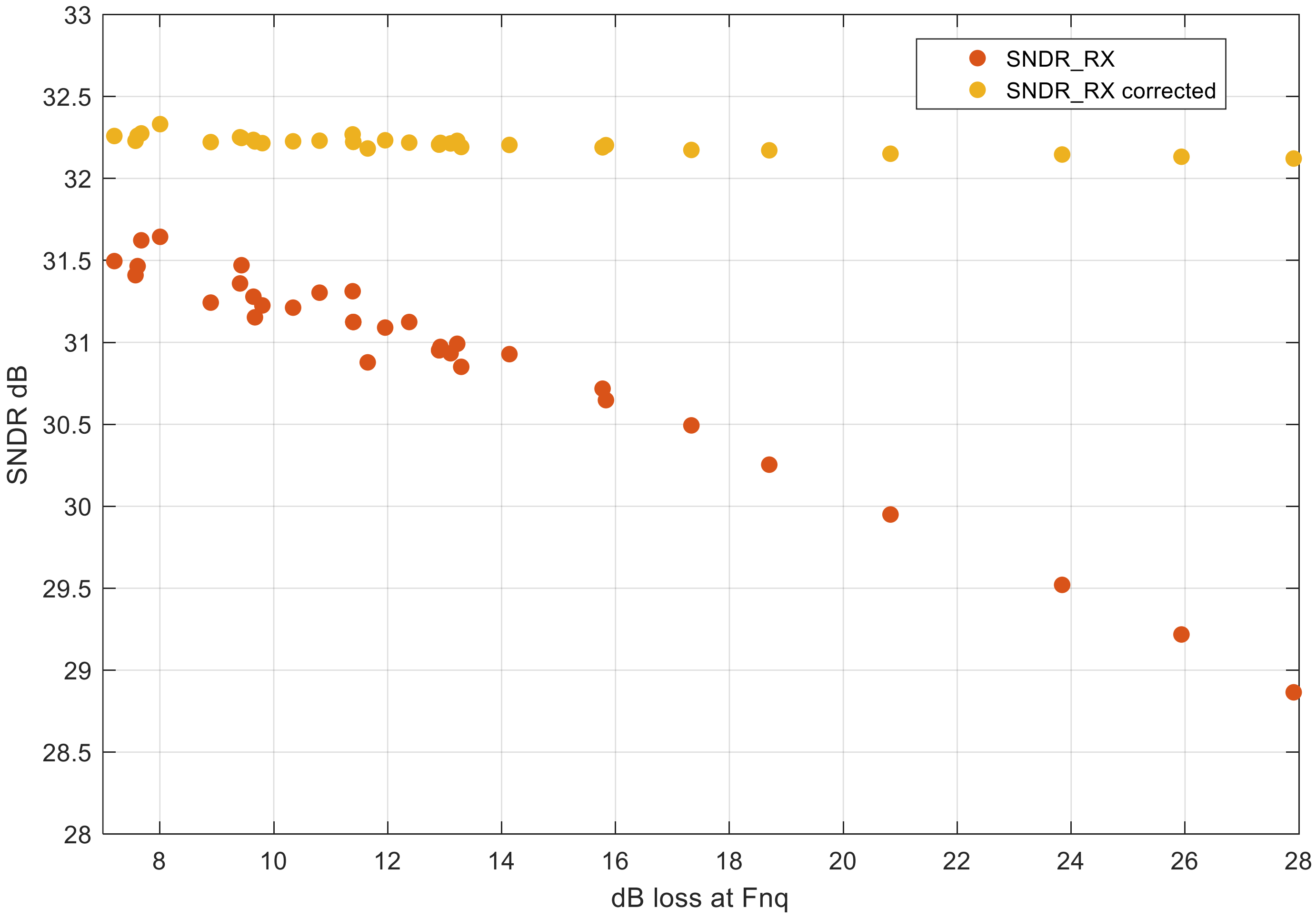
Loss reduces SNDR

RESULTS FOR ALL THE FILES



SNDR Referred back to transmit source

SNDR CAN BE CORRECTED



New concepts for receiver noise

FOR SNDR FROM THE TRANSMITTER NOISE

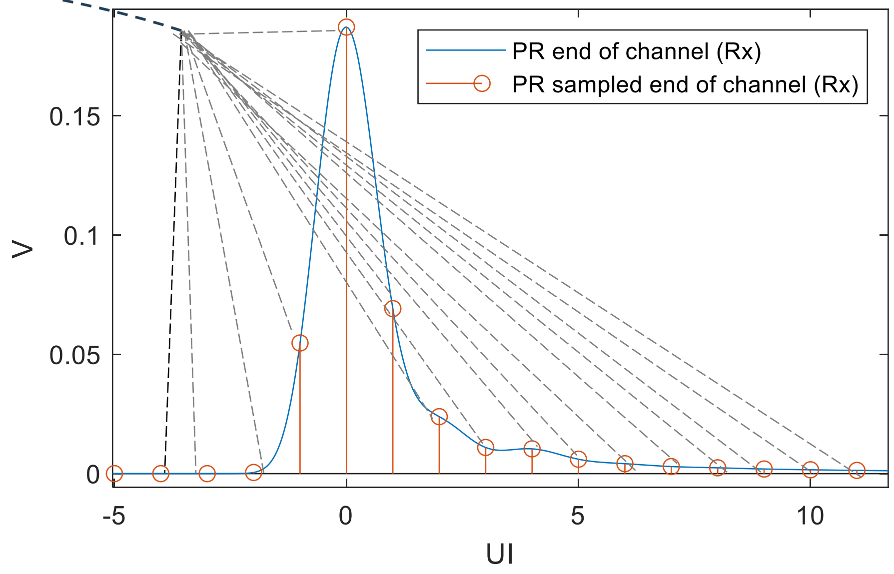
- Equations 178A–18 and 178A-31 computes the transmitter noise power variance seen at the receiver
  - $S_{tn}(\theta) = \sigma_X^2\, 10^{-\frac{SNR_{TX}}{10}} \left|DFT\left(h_{tn}(n)\right)\right|^2 / f_b$
    - This is power spectral density from the transmitter noise
  - $\sigma_G^2 = f_b \int_{-\pi}^{\pi} [\, S_{tn}(\theta) + \ \ldots]\, d\theta$
  - σ_G^2 is a noise variance used to compute COM as in 93A but computed differently
    - $f_b \int_{-\pi}^{\pi} [\, S_{tn}(\theta)]\, d\theta$ is the transmitter noise power variance computed in the frequency domain

Use power of the time domain fitted sampled pulse response

- Use the sampled pulse

$$p(n) = [p(t_p + M(-D_p)\ \ p(t_p - M(1 - D_p)\ \ p(t_p - M(2 - D_p) \quad p(t_p + \mathrm{M}(N_p - D_p - 1)\ ]$$

  - t_p is the index of the linear fit pulse where $p(t_p)$ equals maximum p
  - M is the oversampling
  - This is similar to SNR_{ISI} in Annex 120D



- For the "S" in SNDR use the power variance of the signal at the measurement point as follows which is the in time and frequency domain
  - $\sigma_P^2 = \sum_1^{\mathrm{M}(N_p - Dp - 1)} p(n)^2$
  - Instead of p_{max}

Adjust SNDR for loss

LOSS CORRECTION FACTOR (LCF)

- Consider SNDR as a ratio of signal power variance to noise power variance
  - Perhaps: SNDR should be $10 * log_{10}\left(\frac{\sigma_P^2}{\sigma_e^2+\sigma_n^2}\right)$

- So we don't change prior standards, adjust SNDR with LCF
  - $SNDR = 10 * log_{10}\left(\frac{p_{max}^2}{\sigma_e^2+\sigma_n^2}\right)$ + LCF
  - $LCF = 10 * log10\left(\frac{\sigma_P^2}{p_{max}^2}\right)$
  - This was the basis for the previous graphs of SNDR and the corrected SNDR

Summary

- ❑ SNDR was shown to reduce with channel insertion loss
- ❑ SNDR remains constant with loss if adjusted with σ_P^2
  - Assuming the transmitter noise is broadband
- ❑ Proposal: Change SNDR specifications to adjust measurement at TP0V and TP2 with LCF
  - As defined in the previous slide
  - This aligns SNDR to measurements to usage model in equation 178A-18

Thank You!