SNDR Insertion Loss Adjustments

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May IEEE802.3 interim meeting, Annapolis, MD USA
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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
  - \[ \text{SNDR} = 10 \times \log_{10} \left( \frac{p_{\text{max}}^2}{\sigma_e^2 + \sigma_n^2} \right) \]
  - 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, \( A_s(h^{(0)}(t_s)) \), and the noise will not change with loss. Is this assumption valid?
  - COM Annex 93A computations use a broadband noise impairment, \( \sigma_{TX}^2 \) which is included in the broadband receiver noise variance \( \sigma_g^2 \) used to compute COM
    - \[ \sigma_{TX}^2 = \left[ h^{(0)}(t_s) \right]^2 10^{-\text{SNR}_{TX}/10} \]
    - Note: For many cases, SNR_{TX} is approximately SNDR
Motivation

- 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

Original Proposed in healey_3dj_01_2401

IEEE P802.3dj 200 Gb/s, 400 Gb/s, 800 Gb/s, and 1.6 Tb/s Ethernet Task Force
Simple Experiment

SIMULATION AS A PROXY FOR SNDR MEASUREMENTS

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Simulation Details

**Ideal Pulse**

\[ PR_{Gaussian} = A \left( e^{-\frac{1.6832}{2 \sqrt{\pi}} (UI + \text{delay} - t)} - e^{-\frac{1.6832}{2 \sqrt{\pi} \text{delay}} (delay - t)} \right) \]

- **S4P**
- **Channel IL**
- **Filters**

**Broad band Gaussian Noise**

Sample rate = \( \frac{UI}{32} \)

**rms = 8 mV**

**Pmax = 0.1301 V**

**SNDR (est) = 20 \log_{10} \left( \frac{P_{max}}{\sigma_r} \right) = 30.184 dB**

- **FIR**
- **PR channel**

**Rx Noise**

**rms = 4.0276 mV**

\[ \sigma_r^2 + \sigma_n^2 \]

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Channel list and IL Plots
5.5 dB to 27.9 dB

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Loss reduces SNDR

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SNDR Referred back to transmit source

SNDR CAN BE CORRECTED

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Equations 178A–18 and 178A-31 computes the transmitter noise power variance seen at the receiver

\[ S_{tn}(\theta) = \sigma_X^2 10^{-\frac{\text{SNR}_{TX}}{10}} |\text{DFT}(h_{tn}(n))|^2 / f_b \]

- This is power spectral density from the transmitter noise

\[ \sigma_G^2 = f_b \int_{-\pi}^{\pi} [S_{tn}(\theta) + ...] d\theta \]

- \( \sigma_G^2 \) 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

\[ p(n) = [p(t_p + M(-D_p)) p(t_p - M(1 - D_p)) p(t_p - M(2 - D_p)) p(t_p + M(N_p - D_p - 1)) ] \]

- \( t_p \) is the index of the linear fit pulse where \( p(t_p) \) equals maximum \( p \)
- \( M \) is the oversampling
- This is similar to \( \text{SNR}_{\text{ISI}} \) 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

\[ \sigma_p^2 = \sum_{1}^{M(N_p-D_p-1)} p(n)^2 \]

- Instead of \( p_{\text{max}} \)

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Adjust SNDR for loss

Consider SNDR as a ratio of signal power variance to noise power variance

• Perhaps: SNDR should be $10 \times \log_{10}\left(\frac{\sigma_p^2}{\sigma_e^2 + \sigma_n^2}\right)$

So we don’t change prior standards, adjust SNDR with LCF

• $SNDR = 10 \times \log_{10}\left(\frac{p_{max}^2}{\sigma_e^2 + \sigma_n^2}\right) + LCF$

• $LCF = 10 \times \log_{10}\left(\frac{\sigma_p^2}{p_{max}^2}\right)$

• 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 $\sigma_P^2$
  - 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!