Implementation Allocation Estimate IAE computation

Aiding 400 Gb/s/Lane Channel Objective and Baseline Refinement Commit request 4p17_2

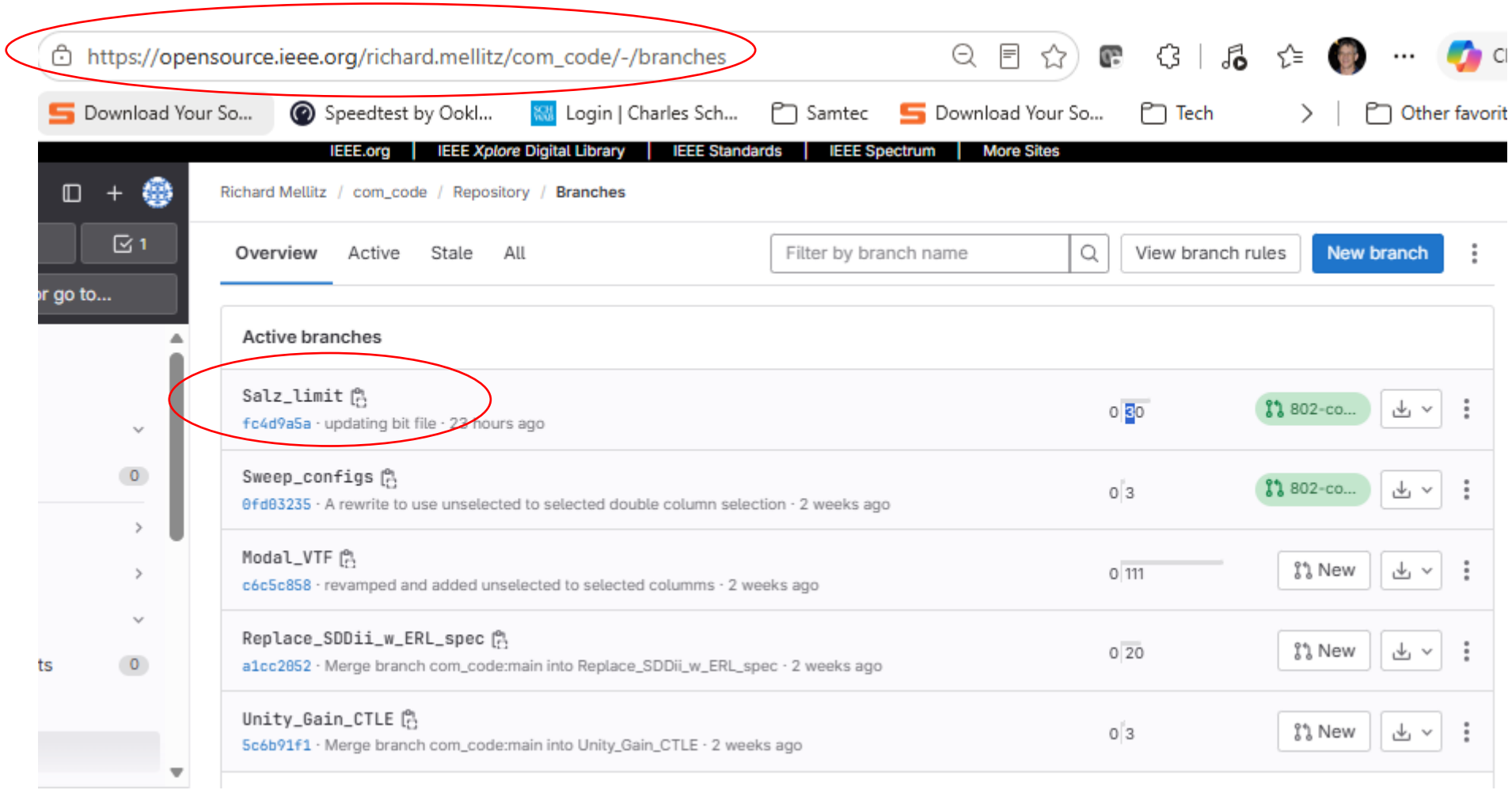
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IEEE 802.3 Channel Operating Margin (COM) Open Source Ad hoc, October 20, 2026

Background and Introduction

- Add computation and reporting of the Implementation Allocation Estimate (IAE).
- Reference: mellitz_400GPL_01a_2609, IEEE 802.3 400GPL Study Group Electronic Interim Meeting, September 2026.
- Use IAE for exploratory analysis.
- IEEE 802.3 has not reached consensus on using IAE.
- IAE may help determine the loss objective as a reference receiver definition takes shape.
- The IAE implementation is isolated from the rest of the COM code.

IAE Branch Location for GIT Merge Request



Implementation Allocation Estimate (IAE) Computation based on mellitz_400GPL_01a_2609

- Implementation Allocation Estimate (IAE).

$$\text{Define: IAE} = SNR_{avail,\text{dB}} - SNR_{req,\text{dB}}$$

  - $SNR_{avail,db}$ is derived from a Salz analysis with assumed transmitter noise, receiver noise, and channel.
  - $SNR_{req,db}$ follows from the target DER and modulation order; implementation penalties are explored separately.

- IAE is the implementation headroom available for a given channel. Use IAE to investigate 400 GBs improvements for Rx and channel design.
  - Results may help guide future refinement of reference equalizer assumptions, associated penalties, and die-to-die loss objectives.

New Commands

- **IAE**
  - 0: Disable IAE computations (default).
  - 1: Enable IAE computations.
- **IAE_NOISE**
  - Include a term by specifying its token in the text.
  - Default noise terms: Tn (Tx), Rn (Rx), Jn (jitter), Xn (crosstalk).
  - Penalty tokens (not yet vetted):
    IAE PEN, ISI PEN, CTLE PEN, Q PEN, RLM PEN
  - Default penalties: None

- Example

IAE	1	logical
IAE_NOISE	Tn, Rn, Jn, Xn	Lexical

New IAE Outputs

IAE primary results

- IAE - *available SNR minus required SNR, dB*
- IAE_pen_db - *IAE including selected penalties*
- IAE_SNR_avail_db - *Salz available SNR, dB*
- IAE_SNR_req_db - *required SNR at the target DER, dB*
- IAE_SNR_pen_db - *total selected penalty, dB*

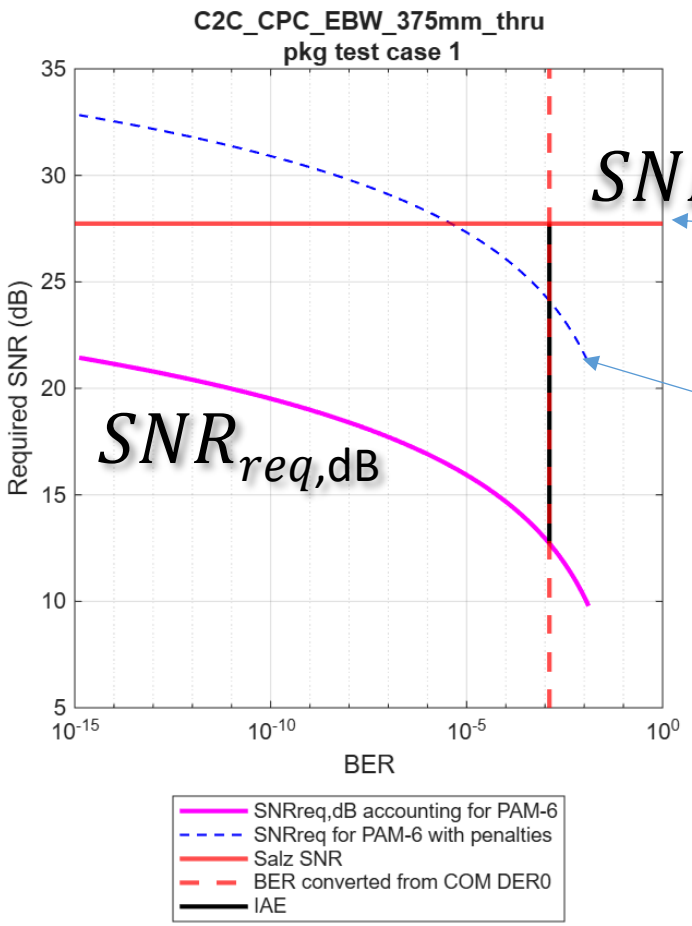
Signal and noise diagnostics

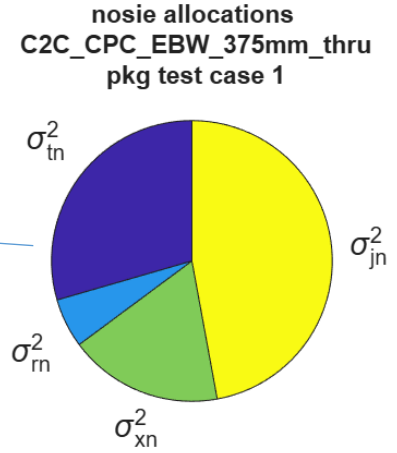
- IAE_S_sig_rms - signal RMS
- IAE_S_n_rms - *total noise RMS*
- IAE_S_tn_rms - *transmitter-noise RMS*
- IAE_S_xn_rms - *crosstalk-noise RMS*
- IAE_S_jn_rms - *jitter-noise RMS*

Individual penalties

- IAE_P_precursor_isi - *precursor-ISI penalty*
- IAE_P_CTLE - *CTLE cursor-loss penalty base on SNR_{ISI} computation*
- IAE_P_Quantization - *quantization penalty*
- IAE_P_RLM - *RLM penalty*

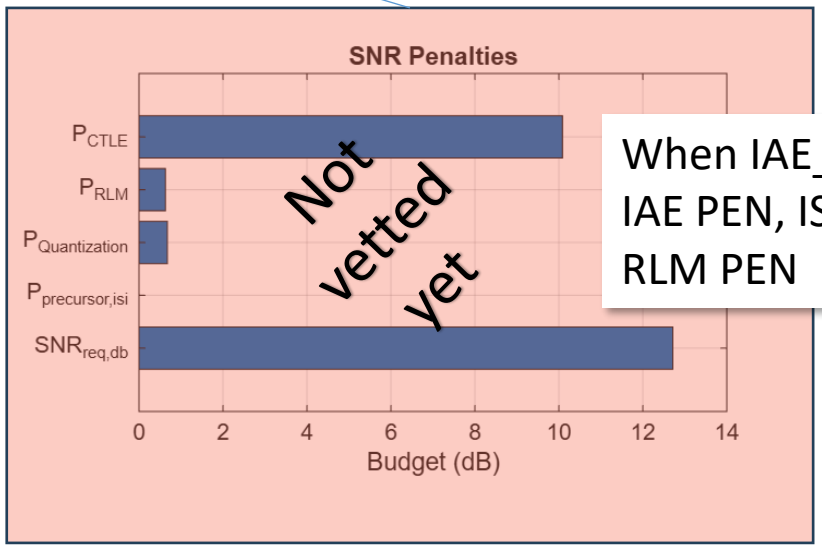
New Plots when DISPLAY_WINDOW=1 and IAE=1





When IAE_NOISE Contains;
Tn, Rn, Jn, Xn

CM noise would could be a future noise source addition.



When IAE_NOISE Contains;
IAE PEN, ISI PEN, CTLE PEN, Q PEN, RLM PEN

COM Source Files Changes: in Branch Salz_limit

Details in backup

- release/com_ieee8023_4p17p1_IAE.m
  - Full invocation COM m file
- src/com_ieee8023_.m
  - Top-level COM workflow that processes the channel, optionally computes IAE, and performs the conventional COM calculation and reporting.
- src/read_ParamConfigFile.m
  - Added 2 keyword: IAE and IAE_NOISE
- src/get_PSDs.m
  - Extends the existing PSD calculation to provide the signal and noise spectra needed for the Salz available-SNR integral.
- src/get_salz_snr.m (new)
  - Computes the Salz available SNR from the channel signal/noise PSD, compares it with the PAM/DER-required SNR to form IAE, and optionally applies precursor-ISI, quantization, RLM, and CTLE penalties.
- src/SNR_ISI_PWR.m (new)
  - A symbol-spaced residual-ISI metric with a CTLE sweep. Then derives two penalty terms from the selected CTLE.

Summary

- IAE supports exploratory analysis of channel and receiver design. IEEE 802.3 has not reached consensus on its use.
- Penalties can help explore implementation effects beyond the Salz available-SNR calculation.
- Penalty models need further discussion and validation before recommended use.
- The current ISI/CTLE penalty approach is receptively overly optimistic/pessimistic and not recommended at this stage.
- Penalties remain optional and open for WG discussion and excluded by default.
- Common-mode (CM) noise warrants further WG discussion

Thank You!

Backup Subfunction Details

src/com_ieee8023_.m (revisions in bold)

- Reads configuration, channel, package, and crosstalk inputs.
- Processes channel frequency- and time-domain responses.
- **Optionally calls get_salz_snr to compute Salz SNR and IAE.**
- Optimizes and applies Tx/Rx equalization for the COM calculation.
- Builds the combined interference and noise PDF/CDF.
- Computes COM and associated channel metrics.
- **Collects Salz/IAE and COM results into the common output structure.**
- Generates optional plots, CSV reports, and diagnostic outputs.

src/get_salz_snr.m (new)

- **Computes an integrated Salz available SNR across the signaling bandwidth.**
  - Uses the frequency-dependent $\chi(f)$:

$$\mathrm{SNR}_{avail} = \exp\left\{\frac{1}{f_b}\int \ln\left[1+\chi(f)\right] df\right\}$$

- **Establishes required SNR from PAM order and target DER, then forms IAE.**
  - The resulting margin-like quantity is
- $\mathrm{IAE} = \mathrm{SNR}_{avail,dB} - \mathrm{SNR}_{req,dB}$
- **Calculates implementation penalties not represented directly by the Salz integral.**
  - Precursor ISI, quantization, RLM, and CTLE penalties.
- **Selectively controls which penalties are included in the IAE calculation.**
- **Returns engineering results and diagnostic information, with optional visualization.**

src/SNR_ISI_PWR.m (new)

Evaluates symbol-spaced residual ISI and CTLE-induced penalties for the Salz IAE calculation.

- **Forms the channel pulse response from $H_{21}(f)$.**
- **Identifies the main cursor and symbol-spaced ISI.**
- **Computes residual ISI power relative to the cursor.**
- **Sweeps CTLE settings to maximize ISI-based SNR.**
- **Calculates precursor-ISI and CTLE cursor-loss penalties.**
- **Returns optimized and reference ISI-based SNR.**

Overly optimistic and not recommended to use at this point

src/get_PSDs.m

- **Enables a dedicated Salz calculation mode.**
- **Uses a baud-sampled frequency axis spanning one Nyquist interval.**
- **Allows individual noise sources to be selectively included.**
- **Forms the total noise PSD from the selected noise components.**
- **Forms the baud-sampled signal PSD without PAM scaling.**
- **Returns the frequency-dependent SNR, $\chi(f) = S_{sig}(f)/S_n(f)$, for Salz integration.**