802.3cb SEI Proposed Draft Details

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Channel Insertion Loss

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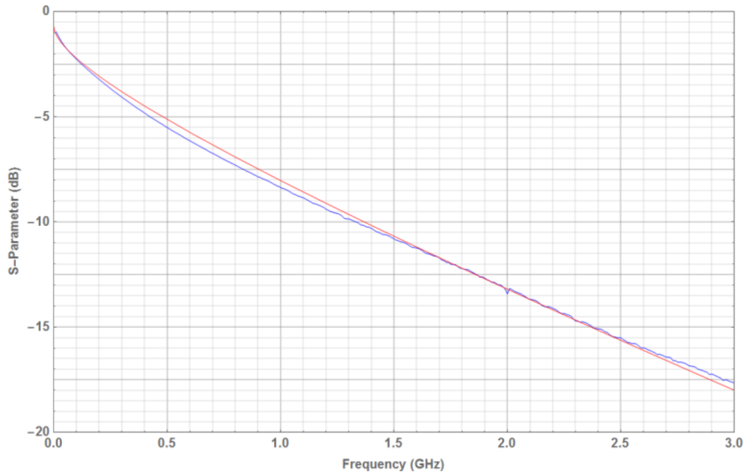
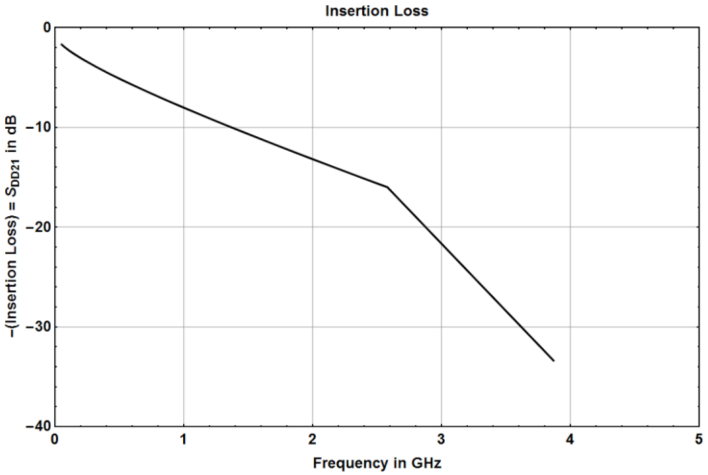
Channel Insertion Loss Spec

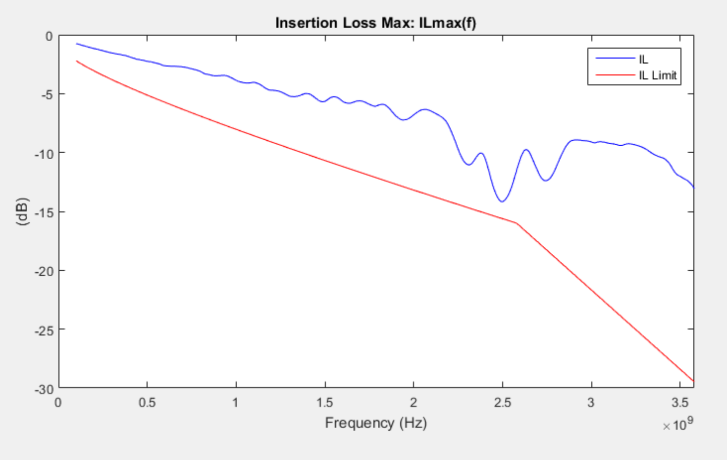
- Ball-to-ball insertion loss up to nyquist is determined by fitting a curve using x + y*sqrt(f) + z*f
  - Fitting against our objectives, that are based on the SAS spec
  - The plot to the right shows the fit against the reference SAS channel
- Insertion loss after nyquist is determined by OIF-CEI 3.1, equation 11-1
  - Slope = 2.694*25.8/fb, where fb = 5.15625
- Objectives vs. equation
  - IL @ 1.5625
    - **Objective: 11 dB**
    - **Equation: 10.99925**
  - IL @ 2.578125
    - **Objective: 16 dB**
    - **Equation: 16.000125**



Channel Insertion Loss Spec Cont'd

- All SAS reference channels pass this spec





$$
\begin{array}{lll}
0.668 + 3.755\sqrt{f} + 3.608 f & 0.05 \le f < 2.578125 & \text{GHz} \\
-18.753 + 13.48 f & 2.578125 \le f \le 3.8671875 & \text{GHz}
\end{array}
$$

Tx Characteristics

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Tx Characteristics

- Tx characteristics came from references shown in the table

Table 130A-1 5GSAUI host output characteristics ($TP4_{H-D}$)

Parameter	Reference	Value	Units	Reference
Signaling rate per lane (range)	130A.3.1.1	5.15625 ± 100 ppm	GBd	Lo_3cb_02a_0116.pdf
DC common-mode output voltage (max)	130A.3.1.2	1.9	V	CL 92.8 (Table 92-6)
AC common-mode output voltage (max, RMS)	130A.3.1.2	30	mV	CL 92.8 (Table 92-6)
Differential peak-to-peak output voltage (max) Transmitter disabled Transmitter enabled	130A.3.1.2	 35 1200	mV	 CL 92.8 (Table 92-6) CL 92.8 (Table 92-6)
Differential output return loss (min.)	130A.3.1.3	See Equation	dB	Slide 7
Output waveform Transmitter steady-state voltage, *vf* (max.) Transmitter steady-state voltage, *vf* (min.) Linear fit pulse peak (min) Pre-cursor ratio (min)	 130A.3.1.4.2 130A.3.1.4.2 130A.3.1.4.2 130A.3.1.4.2	 600 285 0.41 *vf* 1.25	 mV mV mV -	 Mellitz_cb_01_0516.pdf Mellitz_cb_01_0516.pdf Mellitz_cb_01_0516.pdf Wu_3cb_01_0316a.pdf
Max output jitter (peak-to-peak) Random jitter Deterministic jitter Duty Cycle Distortion Total jitter	130A.3.1.6	 0.15 0.12 0.035 0.3	 UI UI UI UI	 Wu_3cb_01_0316a.pdf Wu_3cb_01_0316a.pdf Wu_3cb_01_0316a.pdf Wu_3cb_01_0316a.pdf
Signal-to-noise-and-distortion ratio (min.)	130A.3.1.7	16	dB	Mellitz_cb_01_0516.pdf

Tx Characteristics – Return Loss

- The return loss was originally going to be based on the SAS spec
- It turns out that a majority of the reference SAS channels fail this spec
- The 10GBASE-KR channel spec (Annex 69B) is a more lenient spec in terms of return loss
  - Some channels still fail this spec, but this is acceptable since the spec should not be stretched to meet suboptimal channel and/or test fixture designs
- Feel the Annex 69B limited to 0.75*5.15625 GHz is the best compromise

$$RL(f) \geq RL_{\min}(f) = 12$$

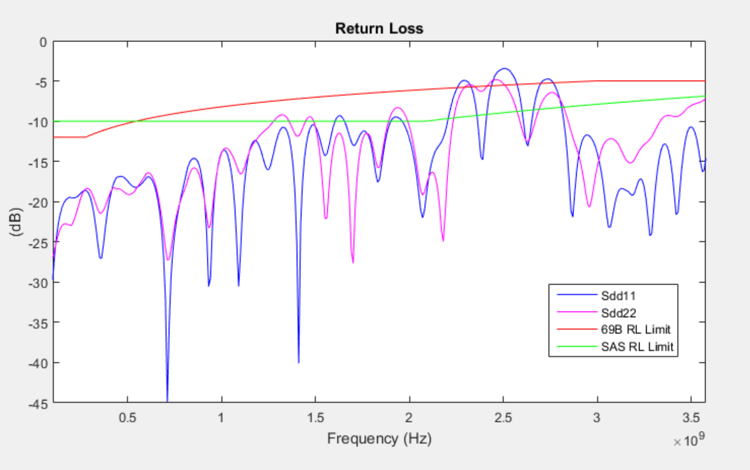
for 50 MHz $\leq f <$ 275 MHz and

$$RL(f) \geq RL_{\min}(f) = 12 - 6.75\log_{10}\left(\frac{f}{275\ \text{MHz}}\right)$$

for 275 MHz $\leq f <$ 3000 MHz and

$$RL(f) \geq RL_{\min}(f) = 5$$

for 3000 MHz $\leq f \leq$ 3867.1875 MHz



Return Loss 69B	Return Loss SAS
1	0
1	0
1	0
1	0
1	0
1	0
1	0
1	0
1	0.5
1	0.5
1	0.5
1	0.5
1	0.5
1	0.5
1	0.5
1	0.5
0.5	0
0.5	0
0	0
0	0
0.5	0
0.5	0
1	1
1	1
1.0	1.0
1.0	1.0
1	1
1	1
1	1
1	1
1	0.5
1	0
1	1
0.5	1
0	0
1	1
0	0.5
0.5	1
0	0
1	1
0	0.5
1	1
0	0.5
1	1
0	0

Rx Characteristics

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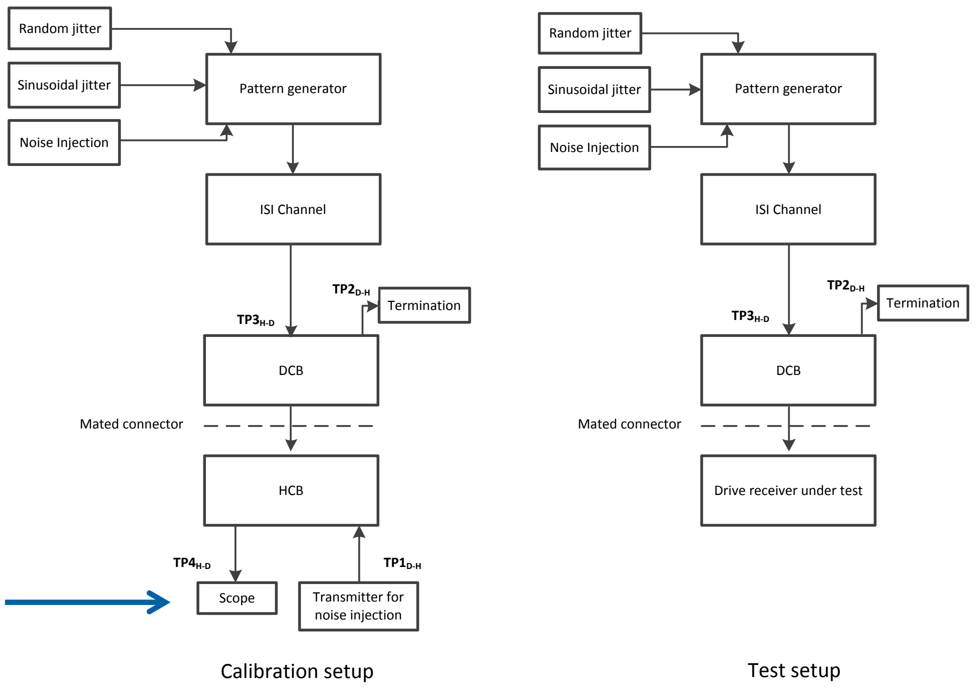
Rx Interference Test

- The drive Rx interference is shown as an example
- Calibrating to worst case host Tx characteristics ensures the drive Rx can handle a worst case signal

Calibrate to worst case host Tx characteristics

Parameter	Value	Units
Transmitter steady-state voltage, *vf*	300	mV
Linear fit pulse peak	0.46 * Vf	mV
Total Jitter	0.3	UI
Random Jitter	0.15	UI
SNDR	20	dB



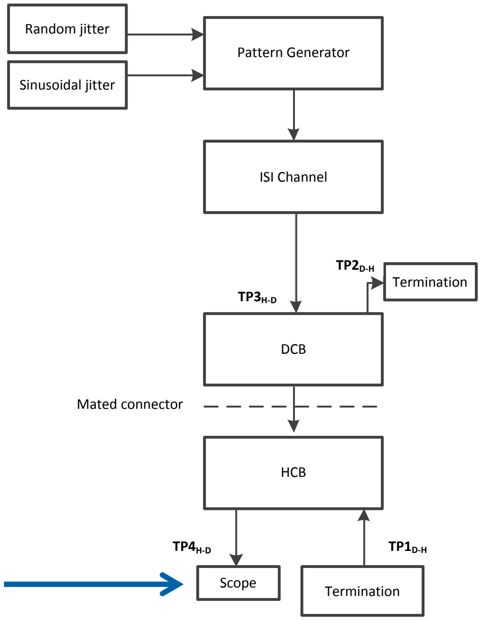
Rx Jitter Tolerance Test

- The drive Rx jittter tolerance is shown as an example
- Calibrating to worst case host Tx characteristics ensures the drive Rx can handle a worst case signal
- Sj is swept to ensure CDR can track low frequency jitter

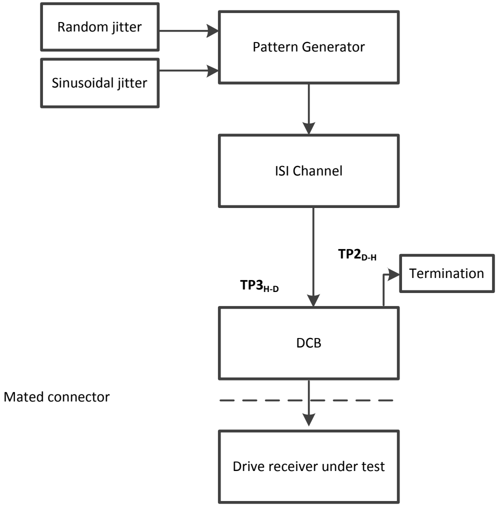
Calibrate to worst case host Tx characteristics

Parameter	Value	Units
Transmitter steady-state voltage, *vf*	300	mV
Linear fit pulse peak	0.46 * Vf	mV
Random Jitter	0.15	UI
Applied pk-pk sinusoidal jitter	Table 130A-5	

Parameter	Case 1	Case 2	Case 3	Units
Jitter frequency	0.02	4	20	MHz
Peak-to-peak jitter amplitude	5	0.15	0.15	UI



Calibration setup



Test setup

Test Fixtures

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Mated Test Fixture Reference Insertion Loss

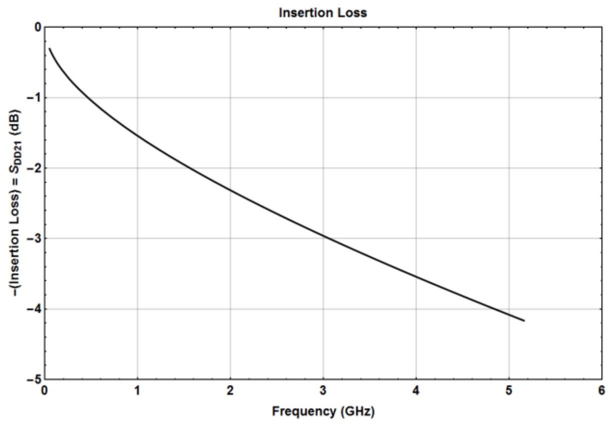
- The reference insertion loss curve is based on Calbone_3cb_01_0316b.pdf
  - 2.7 dB @ 2.578125 GHz
  - 2.0 dB @ 1.5625 GHz
- Equation 132A-1 results
  - 2.7000301211 dB @ 2.578125 GHz
  - 2.000003125 dB @ 1.5625 GHz

$$IL_{tfref}(f) = 1.3134\sqrt{f} + 0.2293f \qquad (132A\text{-}1)$$
$$for\ 0.05 \le f \le 5.15625\ GHz$$

where

f is the frequency in GHz

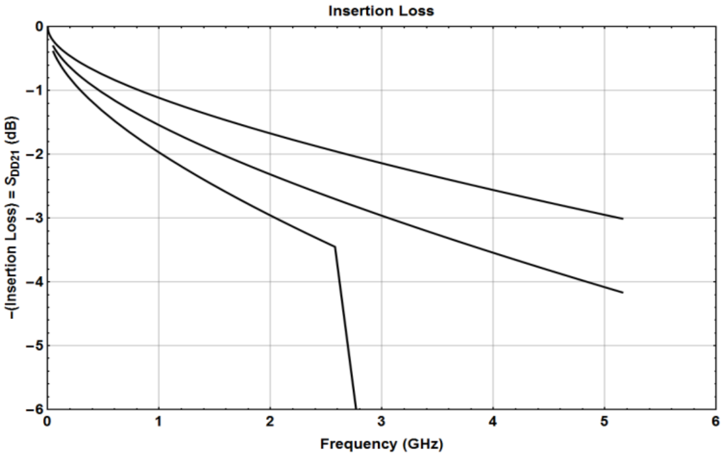
$IL_{tfref}(f)$ is the reference test fixture insertion loss at frequency f



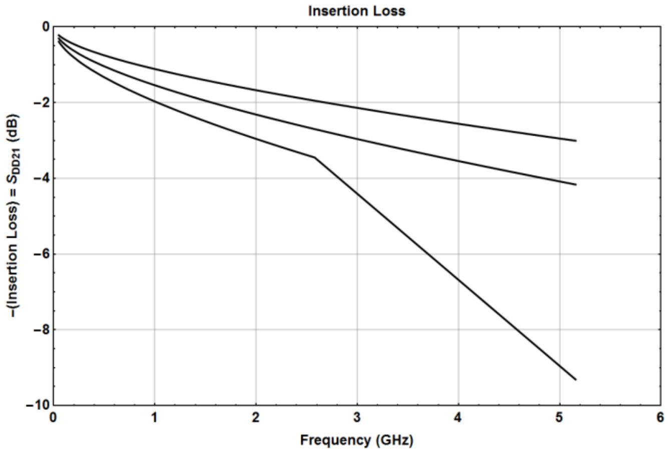
Mated Test Fixture Min and Max Insertion Loss

- The min and max insertion loss curves are bases on a scaled version of the reference insertion loss
  - +/-0.75 dB @ 2.578125 GHz was chosen as the scaling factor
- The max plot has a breakpoint @ 2.578125 GHz as does the channel insertion loss
- OIF methodology was 1st used, but the slope was too steep for a test fixture
- A scaled version of the OIF was used to reduce the slope after 2.578125 GHz
  - The OIF slope was scaled by the difference in IL @ 2.578125 GHz between the test fixture and ball-ball channel (2.7/16)

Slope using OIF directly

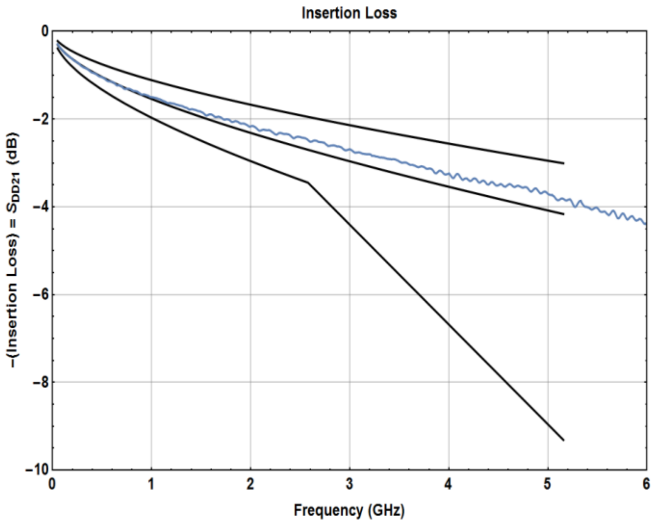


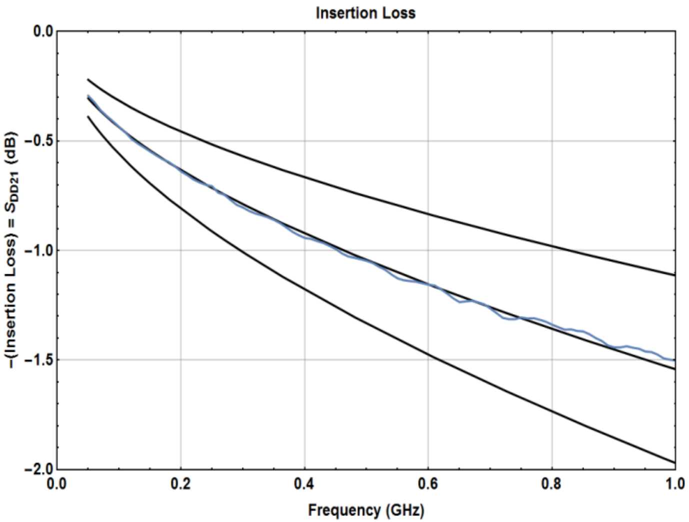
Slope using scaled version of OIF



Spec Vs. Measured Test fixture – Insertion Loss

- The spec correlates very well to the measured test fixture





Mated Test Fixture Return Loss

- The mated test fixture return loss was based on CL92.11
  - Equation was shifted by 3 dB to allow for margin
  - Frequency was truncated to 5.15625 GHz
- Test fixture return loss is significantly better then the drive and host return loss spec