Uncorrelated jitter limit at TP2

IEEE P802.3bj Task Force
March 2014

Adam Healey, LSI Corporation

What contributes to uncorrelated jitter?

- Uncorrelated jitter on the transmitter clock
- Uncorrelated noise at the transmitter output
- Uncorrelated noise is also constrained via SNDR
- How do these contributions change from TP0a to TP2?

SNDR definition

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

- $p_{\max}$ is the linear fit pulse peak amplitude
- σ_e^2 is the variance of the linear fit error (includes residual ISI and non-linear distortion)
- σ_n^2 is the variance of the uncorrelated noise

Total noise and distortion

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

- Given $SNDR$ and $p_{\max}$, the allowance for $\sigma_e^2 + \sigma_n^2$ can be derived
- $p_{\max}$ decreases as TP0 to TP2 insertion loss at 12.89 GHz increases
- Let $p_{\max}(x)$ be the value of $p_{\max}$ at test point x
- Let $IL(f)$ be the TP0 to TP2 insertion loss

$$PL = 20\log_{10}\left(\frac{p_{\max}(\text{TP0a})}{p_{\max}(\text{TP2})}\right) = m_{PL}IL(12.89\text{ GHz}) + b_{PL}$$

Uncorrelated noise

- σ_e^2 does not contribute to uncorrelated jitter
- σ_n^2 becomes uncorrelated jitter at the signal transitions
- Let m_0 be the slope [V/UI] of the transition around the baseline

$$\sigma_J = \sigma_n / m_0$$

- m_0 decreases as TP0 to TP2 insertion loss at 12.89 GHz increases
- Let $m_0(x)$ be the value of m_0 at test point x

$$ML = 20\log_{10}\left(\frac{m_0(\mathrm{TP0a})}{m_0(\mathrm{TP2})}\right) = m_{ML} IL(12.89\ \mathrm{GHz}) + b_{ML}$$

Summary

- Allocation for noise and distortion decreases from TP0a to TP2 due to the reduction in p_{max}
- Roughly a 1 dB reduction in p_{max} for each 2 dB increase insertion loss
- SNDR limit at TP2 was reduced to compensate
- Uncorrelated noise yields higher uncorrelated jitter at TP2 due to the reduction in slope
- Roughly a 1 dB reduction in m_0 for each 1 dB increase insertion loss

Some possible scenarios (z_p = 12 mm)

IL, dB	TP0a	TP0a	3 dB	3 dB	9.85 dB	9.85 dB
EBUJ, mUI	0	100	0	100	0	100
$p_{\max}$, mV	317	317	286	286	185	185
SNDR, dB	27	27	26	26	26	26
σ_n, mV	4.5	4.5	7	7	4.5	4.5
σ_e, mV	13.4	13.4	12.6	12.6	8.1	8.1
m_0, V/UI	0.998	0.998	0.808	0.808	0.388	0.388
ERJ, mUI	22.8	10.1	23.9	12.5	25.2	14.7
CRJ, mUI	22.2	8.9	22.2	8.9	22.2	8.9
ETUJ, mUI	180	180	189	200	199	216

EBUJ = effective bounded uncorrelated jitter
ERJ = effective random jitter
CRJ = allowance for transmitter clock jitter derived as $\sqrt{\mathrm{ERJ}^2 - (\sigma_n/m_0)^2}$
ETUJ = effective total uncorrelated jitter derived as $\mathrm{EBUJ} + 7.9 \cdot \mathrm{ERJ}$ (see 92.8.3.9.2)

Some additional scenarios (z_p = 30 mm)

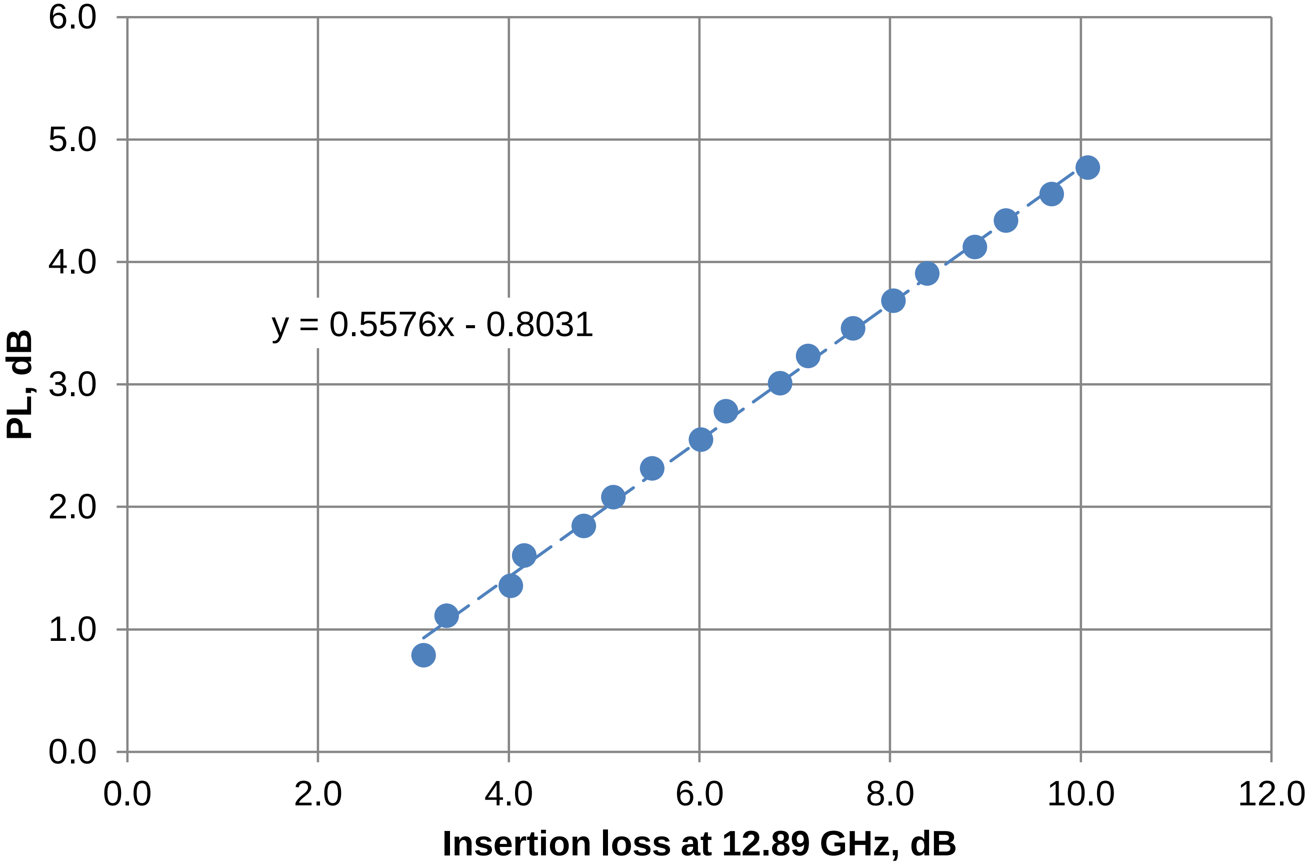
IL, dB	TP0a	TP0a	3 dB	3 dB	9.85 dB	9.85 dB
EBUJ, UI	0	100	0	100	0	100
p_{max}, mV	289	289	260	260	169	169
SNDR, dB	27	27	26	26	26	26
σ_n, mV	4.1	4.1	6.3	6.3	4.1	4.1
σ_e, mV	12.3	12.3	11.4	11.4	7.4	7.4
m_0, V/UI	0.83	0.83	0.707	0.707	0.336	0.336
ERJ, mUI	22.8	10.1	24	12.6	25.4	15.1
CRJ, mUI	22.2	8.9	22.2	8.9	22.2	8.9
ETUJ, mUI	180	180	189	200	200	219

Recommendation

- Increase the TP2 effective uncorrelated jitter limit to 0.22 UI
- Rely on 92A.2 to discourage use of a high jitter transmitter with low TP0 to TP2 loss to achieve the relaxed specification
  - “The transmitter characteristics at TP0 are constrained at TP0a by 93.8.1.”

Backup slides

Pulse loss versus insertion loss



Slope loss versus insertion loss