125.4.0.1 Alien Crosstalk Limited Signal-to-noise ratio criteria

Noise coupled between the disturbed duplex channel in a link segment and the disturbing duplex channels in other link segments is referred to as alien crosstalk noise. To ensure the total alien NEXT loss and alien FEXT loss coupled between link segments are limited a figure of merit denoted as the alien crosstalk limited signal-to-noise ratio criteria ($ALSNR_{criteria}$) is specified. The $ALSNR_{criteria}$ is the numerical difference between the ALSNR derived from measurements of its alien crosstalk and insertion loss parameters, denoted $ALSNR_{link}$ and the link segment SNR sufficient to support the objective BER, denoted $SNR_{linkreq}$.

The $ALSNR_{criteria}$ algorithm enables determination of $ALSNR_{link}$ for disturbed link segments with 2.5G and 5G signalling rates from any number of disturbing link segments with all possible combinations of 1G/2.5G/5G/10G signalling rates. The selection of the number of disturbing link segments and signalling rates to consider are addressed in TBD.

The $ALSNR_{criteria}$ is determined by the following algorithm:

Step 1. Measure the disturbed link segment and the disturbing link segments insertion losses over the specified frequency ranges $1 \le f \le 200 \times S$. Where f is the frequency in MHz, S = 0.5 for 2.5GBASE-T and S = 1 for 5GBASE-T. Denote the disturbed link segment insertion loss as $IL\_disturbed_K$ and the disturbing link segment insertion loss as $IL\_disturbing_{j.}$

Step 2. Determine the transmit power spectral density (PSD) for the disturbed link segment k using Equation (125–1) for 2.5BASE-T and 5GBASE-T.

$$Tx\_PSD\_2.5G/5G_k = X1 + 20\log 10\left(\frac{\left|\sin(\pi f/400 \times s)\right|}{\pi f/400 \times s}\right) - 10\log 10\left[1 + \left(\frac{f}{490}\right)^4\right] \quad (\text{dB}) \qquad (125\text{–}1)$$

where

f is the frequency range in MHz $1 \le f \le 200 \times S$

S is 0.5 for 2.5GBASE-T, 1.0 for 5GBASE-T

$X1$ is -77.9 for 2.5G, -80.7 for 5GBASE-T

Step 3. Determine the transmit power spectral density (PSD) for the disturbing link segment j using Equation (125–1) for 2.5BASE-T and 5GBASE-T and Equation (125–2) for 1000BASE-T.

$$Tx\_PSD\_1G(f)_j = -72.38 + 20\log 10\left(\frac{\left|\sin(\pi f/125)\right|}{\pi f/125}\right) - 10\log\left(10\left[1 + \left(\frac{f}{100}\right)^2\right] + 10\log 10\left(0.625 + 0.375 \times \cos\left(\frac{2\pi f}{125}\right)\right)\right) \qquad (125\text{–}2)$$

where

f is the frequency in MHz, $1 \le f \le 62.5$

Step 4. Determine the minimum transmit power backoff (dB) for the disturbed link segment k and the disturbing link segments j using the Tx_PSD, measured insertion losses of the link segments from Step 1-3 and the methods specified in 126.4.3.1 for 2.5G/5GBASE-T and 55.4.3.1 for 10GBASE-T.
Denote the disturbed link segment minimum power backoff as Tx_PBO_k and the disturbing link segments minimum power backoff as $Tx\_PBO_{j.}$

Editor's note (to be removed prior to Working Group ballot) - PBO considerations –determine PBO based on 4 pair average, single, fixed pair, or worst pair? (TBD).

Step 5. Determine the power backed off transmit PSD for the disturbed link segment *k* for 2.5G and 5G using and Equation (125–3).

$$Tx\_PSD\_2.5G/5G\_PBO(f)_k = Tx\_PSD\_2.5G/5G(f)_k - Tx\_\mathrm{PBO}_k \quad (125–3)$$

where

$Tx\_PSD\_2.5G/5G(f)_k$ is the transmit PSD in (dBm/Hz) for disturbed link segment *k*.

Tx_PBO_k is the minimum transmit power backoff (dB) for the disturbed link segment *k* from Step 4.

Step 6. Determine the power backed off transmit PSD for the disturbing link segments *j* using Equation (125–4) for 2.5/5/10GBASE-T and Equation (125–5) for 1000BASE-T.

$$Tx\_PSD\_2.5G/5G/10G\_PBO(f)_j = Tx\_PSD\_2.5G/5G/10G(f)_j - Tx\_\mathrm{PBO}_j \quad (125–4)$$

where

$Tx\_PSD\_2.5G/5G/10G(f)_j$ is the transmit PSD in (dBm/Hz) of disturbing link segments *j*.

Tx_PBO_j is the minimum transmit power backoff (dB) of the disturbing link segments *j* from Step 4.

$$Tx\_PSD\_1G\_PBO(f)_j = Tx\_PSD\_1G(f) \quad (125–5)$$

where

$Tx\_PSD\_1G(f)$ is the 1000BASE-T transmit PSD in (dBm/Hz) from Step 3.

Step 7. Determine the signal PSD of each disturbed link segment *k* from the 2.5G or 5G transmit PSDs and the insertion loss of the disturbed link IL_V_M from step 1 and the transmit PSDs from step 6 using Equation (125–6).

$$Signal\_\mathrm{PSD}_N(f) = Tx\_PSD\_PBO(f)_k - IL\_V_M \quad (\mathrm{dB}) \quad (125–6)$$

where: f is the frequency in MHz,

$Tx\_PSD\_PBO(f)_k$ is the power backed off transmit PSD for the disturbed link segment *k* for 2.5G/5G from Step 4.

IL_V_M is the insertion loss of the disturbed link IL_V_M from Step 1.

Step 8. For disturbed signalling rate 2.5G and all possible combinations of disturbing signalling rates 1G and 2.5G denoted $\vec{R}$ determine the PSANEXT PSD and the PSAFEXT PSD from the measured ANEXT and AFEXT and the power backed off transmit PSDs for disturbed pair N = 1, 2, 3, 4 of a link segment using Equation (125–7) and Equation (125–8) respectively.

$$\text{PSANEXT\_PSD}_{N,\vec{R}}(f) = 10\log_{10}\sum_{j=1}^{m}\sum_{i=1}^{4} 10^{\frac{(Tx\_PSD\_PBO(f)_{j,r} - AN\_\text{pr(f)}_{i,j,N})}{10}} \quad \text{(dB)} \qquad (125\text{–}7)$$

$$\text{PSAFEXT\_PSD}_{N,\vec{R}}(f) = 10\log_{10}\sum_{j=1}^{m}\sum_{i=1}^{4} 10^{\frac{(Tx\_PSD\_PBO(f)_{j,r} - AF\_\text{pr(f)}_{i,j,N})}{10}} \quad \text{(dB)} \qquad (125\text{–}8)$$

where

f is the frequency range in MHz $1 \le f \le 200 \times S$

S is 0.5 for 2.5GBASE-T, 1.0 for 5GBASE-T, for 10GBASE-T use S of disturbed signal rate

$AN\_\text{pr}(f)_{i,j,N}$ is the measured ANEXT of the individual pair combination i (1 to 4) of the disturbing link j (1 to m) for each disturbed pair N.

$AF\_\text{pr}(f)_{i,j,N}$ is the measured AFEXT of the individual pair combination i (1 to 4) of the disturbing link j (1 to m) for each disturbed pair N.

$Tx\_PSD\_PBO(f)_{j,r}$ is the power backed off transmit PSD for the disturbing link segments j for rate r from Step 4.

Step 9. For disturbed signalling rate 5G and all possible combinations of disturbing signalling rates 1G, 2.5G, 5G and 10G denoted $\vec{R}$ determine the PSANEXT PSD and the PSAFEXT PSD from the measured ANEXT and AFEXT and the power backed off transmit PSDs for disturbed pair N = 1, 2, 3, 4 of a link segment using Equation (125–7) and Equation (125–8) respectively.

Step 10. Determine the total noise PSDs from the transmit PSDs and the background noise for each disturbed pair N, $\vec{R}$ using from Step 9 and Step 10 using Equation (125–9).

$$Total\_\text{noise\_PSD}_{N,\vec{R}}(f) = 10\log_{10}\left(10^{\frac{\text{PSANEXT\_PSD}_{N,\vec{R}}(f)}{10}} + 10^{\frac{\text{PSAFEXT\_PSD}_{N,\vec{R}}(f)}{10}} + 10^{\frac{background\_noise(TBD)}{10}}\right) \text{ (dB)} \qquad (125\text{–}9)$$

where: f is the frequency in MHz,

$PSANEXT\_PSD_{N,R}(f)$ is PSANEXT PSD in dBm/Hz determined in Equation (125–7) adjusted for the insertion loss power backoff,

$\text{PSAFEXT}_{N,R}(f)$ is the PSANEXT PSD in dB determined in Equation (125–7) adjusted for the insertion loss power backoff,

background_noise is the assumed background noise (TBD) in dBm/Hz

Step 11. Determine the $\text{ALSNR}_{\text{link}}$ from the total noise PSDs from Step 6 and the signal PSDs from Step 8 and Step 9.

$$ALSNR_{linkN,\hat{R}} = \frac{1}{W}\int_{0}^{W} -10\log 10\left(\frac{10^{\frac{Signal\_PSD_N(f)}{10}}}{10^{\frac{Total(noise\_PSD_{N,\hat{R}})(f)}{10}}}\right) df \quad (125\text{–}10)$$

f is the frequency in MHz,

Totalnoise_PSD$_{N,R}(f)$ is total noise PSD in dBm/Hz from Step 10.

Signal_PSD$_N(f)$ is signal PSD in dBm/Hz from Step 7.

W is 100 for 2.5GBASE-T and 200 for 5GBASE-T.

Step 11. Determine the ALSNR$_{criteria}$ using Equation (125–11). The ALSNR$_{criteria}$ shall be greater than zero

$$ALSNR_{criteria} = SNR_{linkreq} - ALSNR_{linkN,\hat{R}} \quad (125\text{–}11)$$

where

SNR$_{linkreq}$ is 32 dB (TBD)

ALSNR$_{linkN,R}$ is ratio of the signal PSD to total noise PSD in dBm/Hz from Step 11.