TP3 Stressed Receiver Noise Specification and Calibration and Note on RIN and Modal Noise Power Penalties

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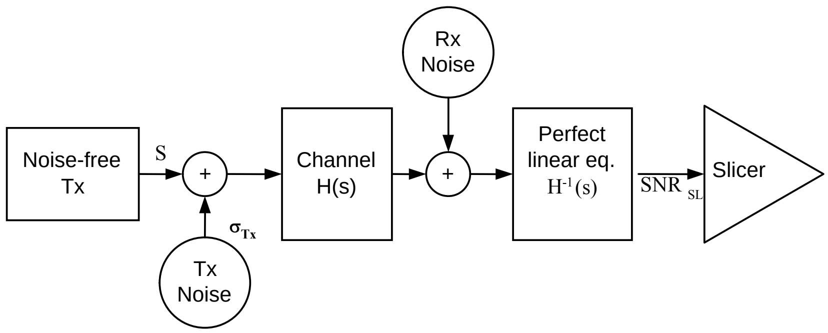
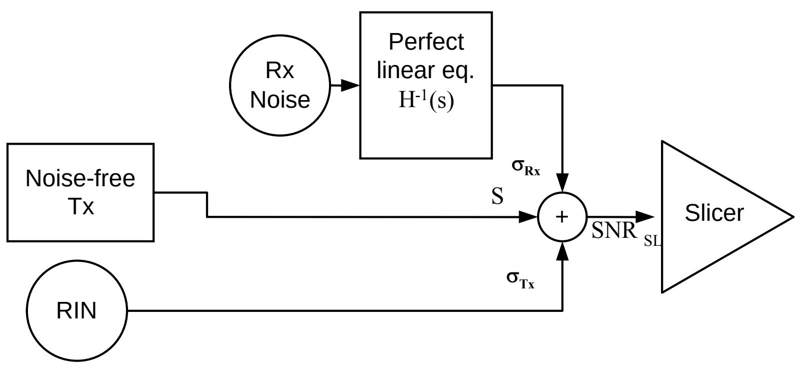
Here is some further analysis, following Lew's note on the topic of noise for the TP3 test, Tom subsequent email and conversations with Piers .

1) Block diagram, in which the equalizer response is exactly the inverse of the channel response:



Where: S is the transmitted signal amplitude (OMA);
σ_{Tx} is standard deviation of the transmitted noise
H(s) is the channel response, with 0dB dc gain;
SNR_{SL} is the signal to noise ratio (modulation amplitude/rms magnitude of noise) at the slicer input.

2) For analysis, re-cast the system as follows:



Where: σ_{Rx} is the receiver noise, *after* equalizer noise enhancement.

3) To allow for the transmitted noise we increase transmitted signal amplitude by factor M (compared to amplitude needed for the case with no transmitted noise).

Letting R be value of SNR_{SL} necessary to achieve the required BER, we have:

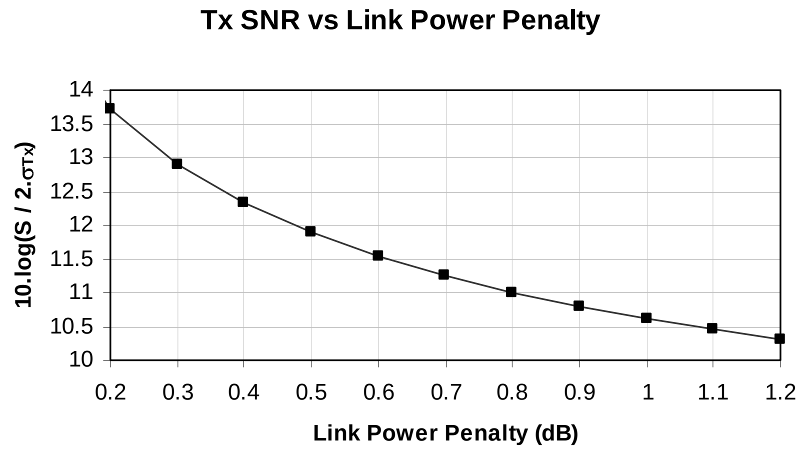
$$SNR_{SL} = S / \sqrt{(\sigma_{Rx}^2 + \sigma_{Tx}^2)} = R, \text{ and}$$

$$S/\sigma_{Rx} = M . R$$

i.e.: **Transmitted SNR =** $\mathbf{S / \sigma_{Tx} = R / \sqrt{(1 - 1/M^2)}}$

This result exactly matches the expression given by Tom in his response to Lew, last week. It does not depend upon the channel transfer function, so applies to non-ISI channels and also to channels with ISI when combined with “perfect” equalizing receivers.

3) The graph shows the relationship between the resulting transmitted SNR and M for the case of R = 14 (i.e. for BER of 10^{-12}). The horizontal axis is l0.log(M), and the vertical 10.log(S / 2.σ_{TX}) - for comparison with the plot in Lew’s presentation.



The curve closely matches Lew’s “without ISI” curves.

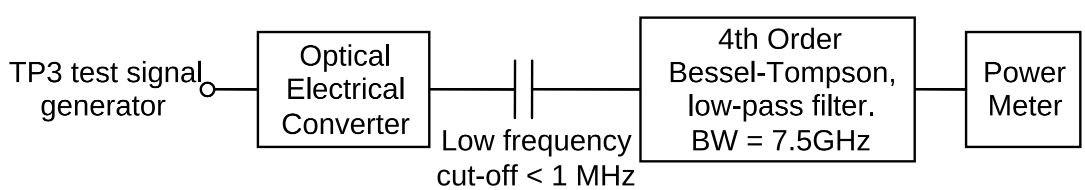
Signal to Noise Ratio for Stressed Receiver Test

Assuming that modal noise may be considered high frequency (with respect to equalizer adaptation rates) and Gaussian, then the combined effect may be may be modelled, for the purpose of the TP3 test, by summing the penalties, and using the above curve to arrive at the transmitted optical SNR. Some adjustment may be needed to cater for the simplification made in the analysis.

Propose that the transmitted SNR calibration be made without ISI generation (i.e. with ISI generator included but acting as identity channel) and with the Bessel-Thompson filter connected as shown in Figure 68-87 of Draft 0.2.

Noise measurement bandwidth: As receiver bandwidths are not expected to exceed 7.5GHz, calibration of the TP3 noise within this bandwidth seems suitable. Therefore, propose that the noise power (and modulation power?) be calibrated using this measurement set-up:

Set-up for TP3 OMA and noise power calibration



Note on Power Penalties needed to account for RIN and Modal Noise

The specified 10GBASE-LR limit on RIN power density is -128dB/Hz. Over the –LR receiver bandwidth (max) of 12.3GHz, this gives a RIN power of -27dBe, -13.5dBo, with respect to the modulation power. On the other hand, from the above we would expect the 0.4dB penalty to correspond to a ratio of -12.3dBo. i.e. There is a 1.2dBo difference between the LR spec and the result of this simplified analysis.

We have not specified a maximum LRM receiver bandwidth. There is an opportunity to reduce the budgeted power penalties by assuming (or specifying) a bandwidth smaller than 12.5GHz. For example, keeping the LR RIN power density, but over 7.5GHz gives a RIN power of -29dBe, -14.5dBo (with respect to the mod power). Allowing the same 1.2dBo adjustment that we found necessary to match the LR case, gives a ratio of -13.3dBo, and the corresponding penalty of 0.25dBo from the above curve. Obviously more rigor is needed here, but this indicates that about 0.15dB penalty saving may be available.

A similar approach may be used to derive modal noise penalty from modal noise power density.