Clause 162 interference tolerance noise calibration

(comment #207)

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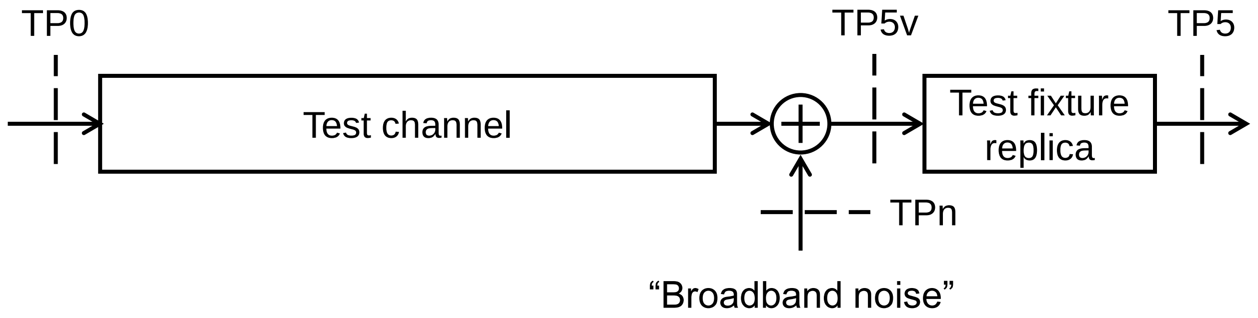
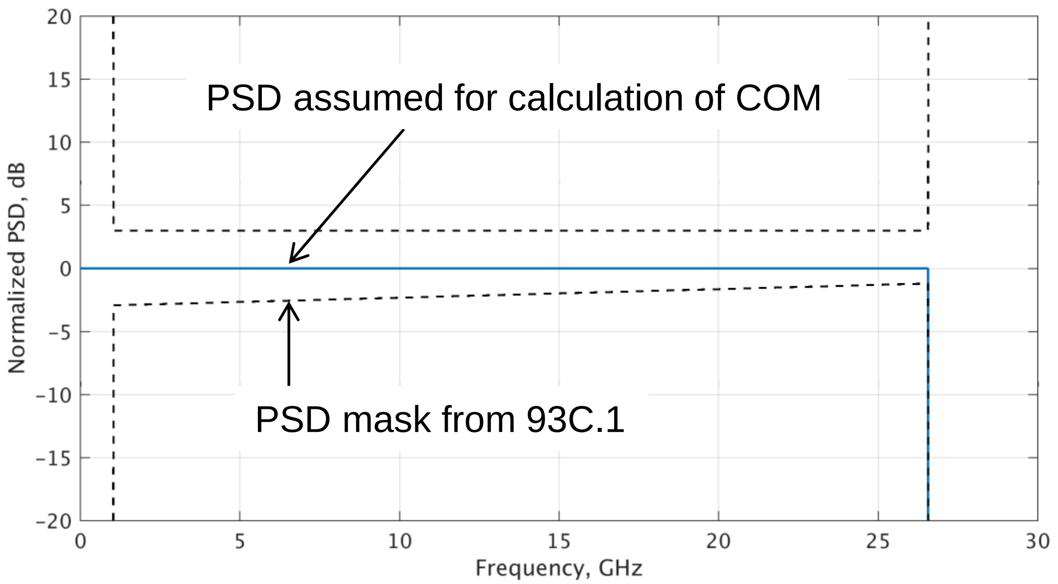
Broadband noise impairment for Clause 163, Annex 120F

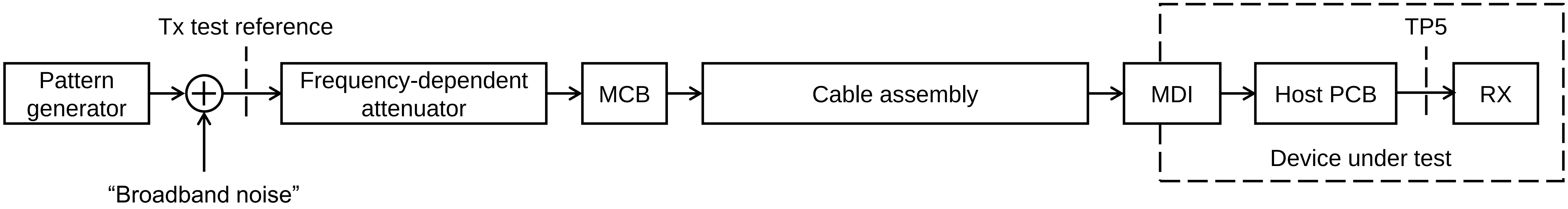
- Normalized power spectral density (PSD) mask defined in 93C.1
- Noise amplitude calibrated using Channel Operating Margin (COM) with supplemental term σ_{bn}
- Broadband noise amplitude at test point TPn set to value of σ_{bn} required to get specified COM value
- COM calculation assumes noise has flat power spectral density to $f_b / 2$





Broadband noise impairment for Clause 162

- Test setup similar to 110.8.4.2.1
- "Broadband noise" added at "Tx test reference" with undefined spectrum
- Noise amplitude calibrated using COM
- Amplitude of SNR_{TX} required to get specified COM value is found
- Noise amplitude is adjusted until SNDR measured at "Tx test reference" agrees with found SNR_{TX} value
- The noise added at the "Tx test reference" is low-pass filtered by the test channel and device under test



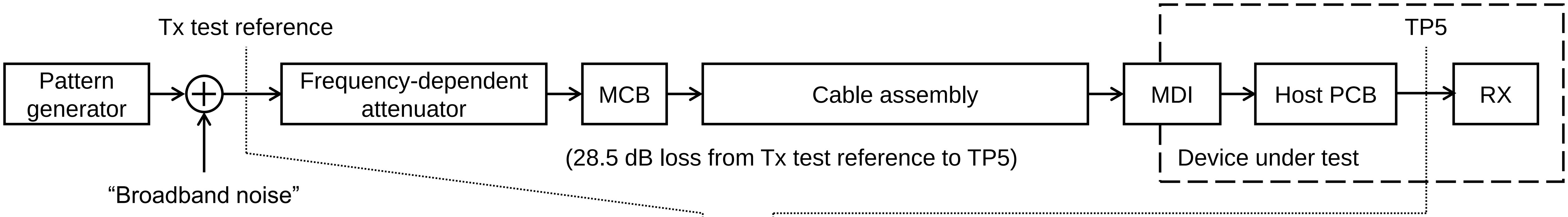
Possible issues with the definition of Clause 162 stress

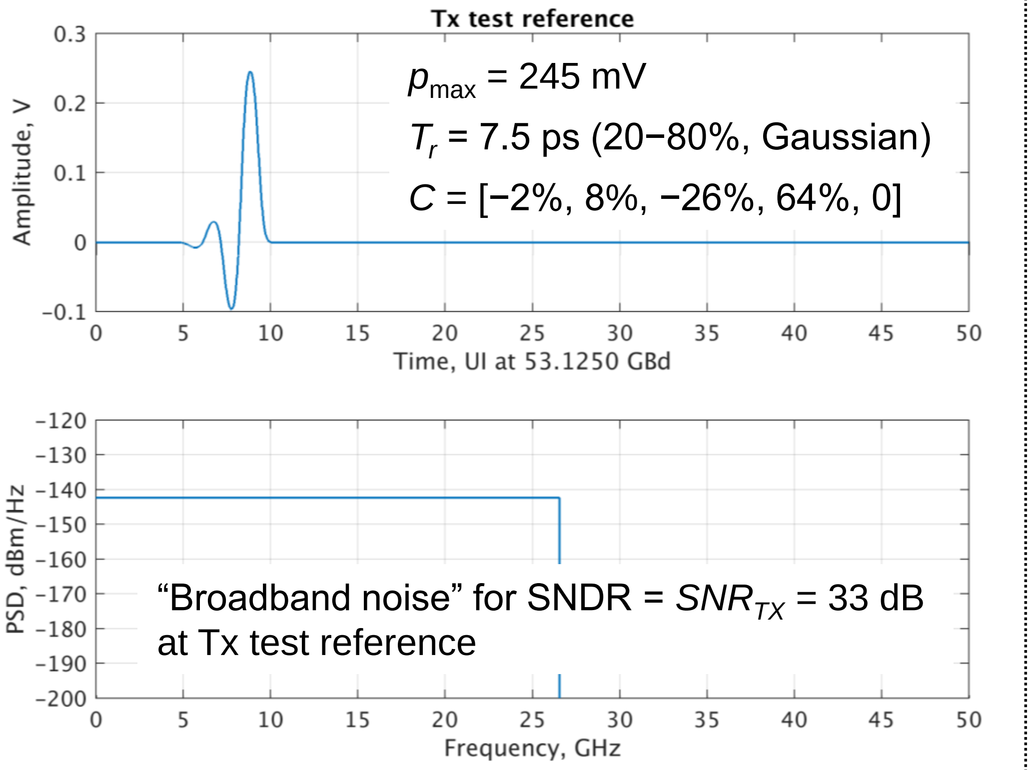
1. COM assumes the noise amplitude scales with the sampled amplitude of the signal pulse
   - Injected noise may not scale this way
   - Difference between expected and actual noise amplitude at Rx input

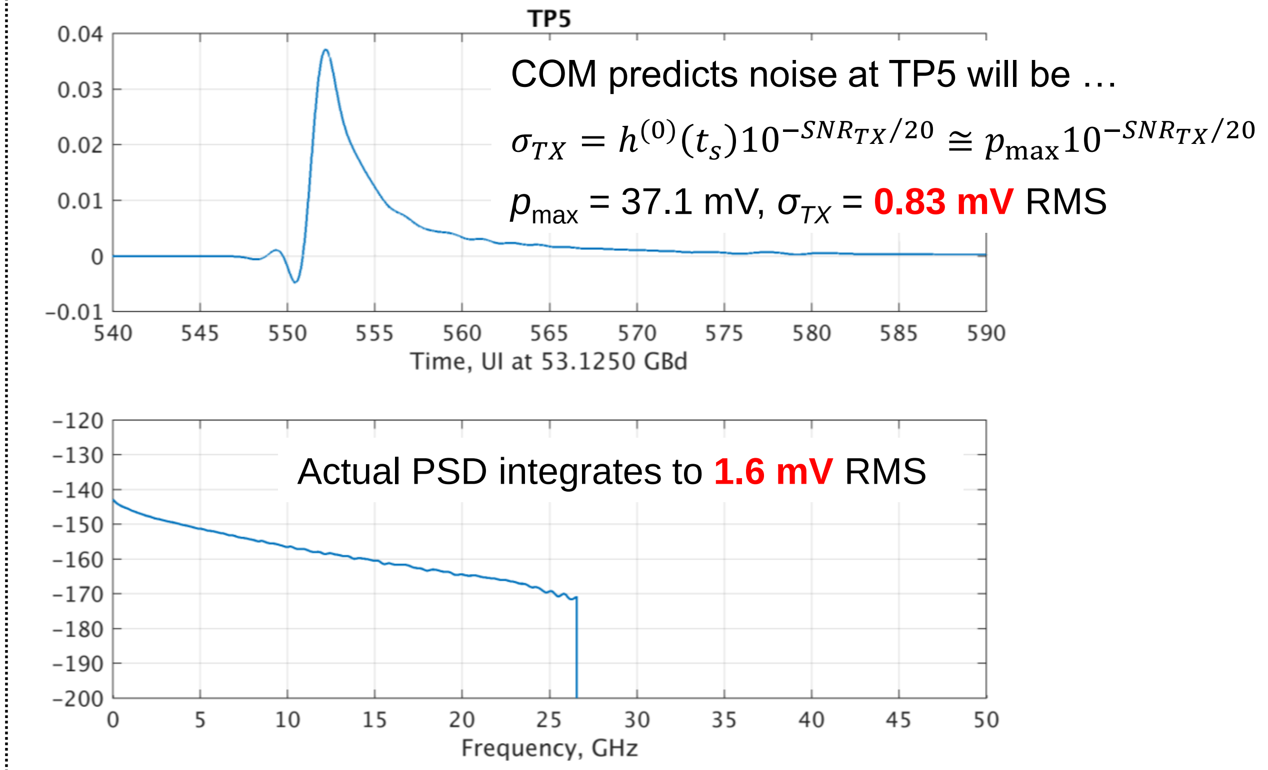
2. Inconsistent stress applied for Clause 162 and Clause 163 tests
   - Intention is that same receiver can be used for both

3. Clause 162 stress may not be a good proxy for “real-world” impairments seen by the receiver
   - Difference between performance under test and performance in actual application

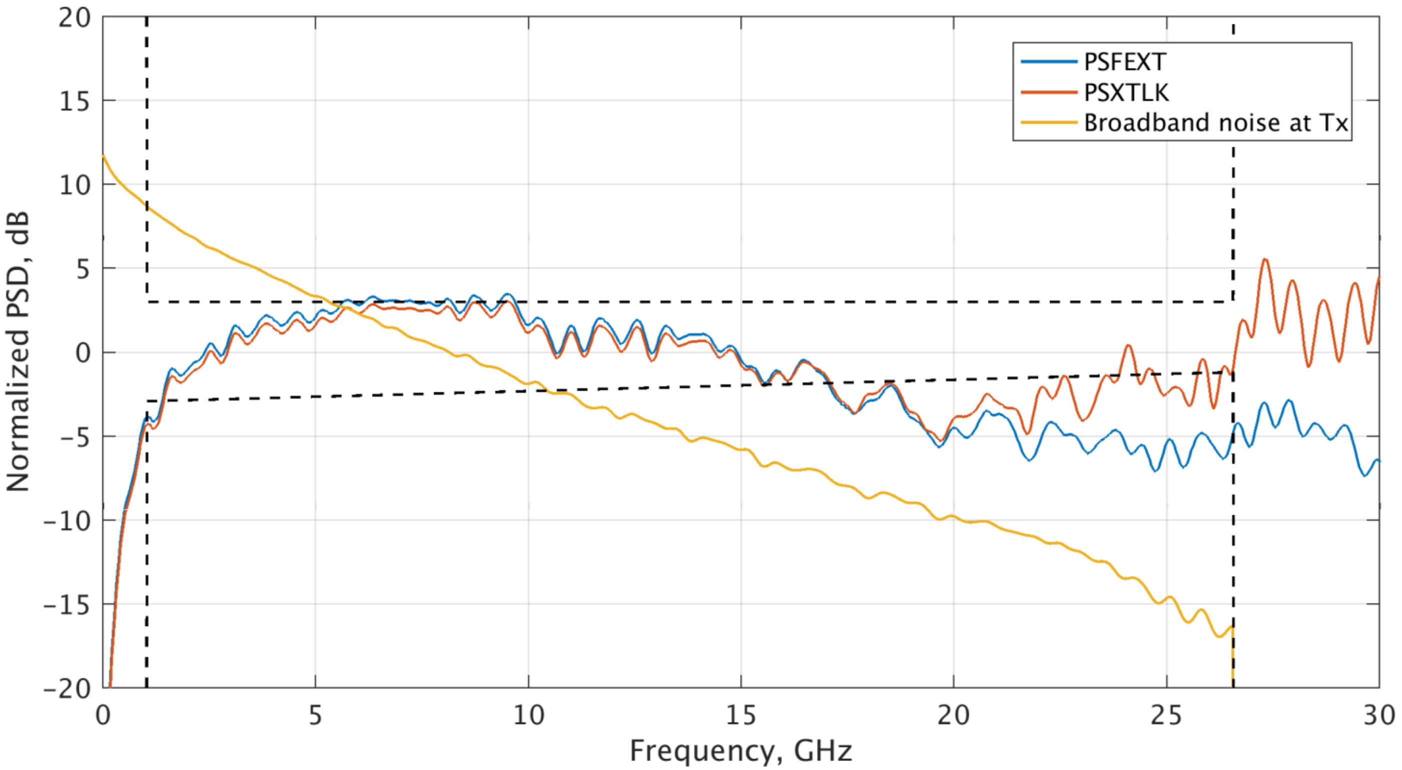
Noise calibration error





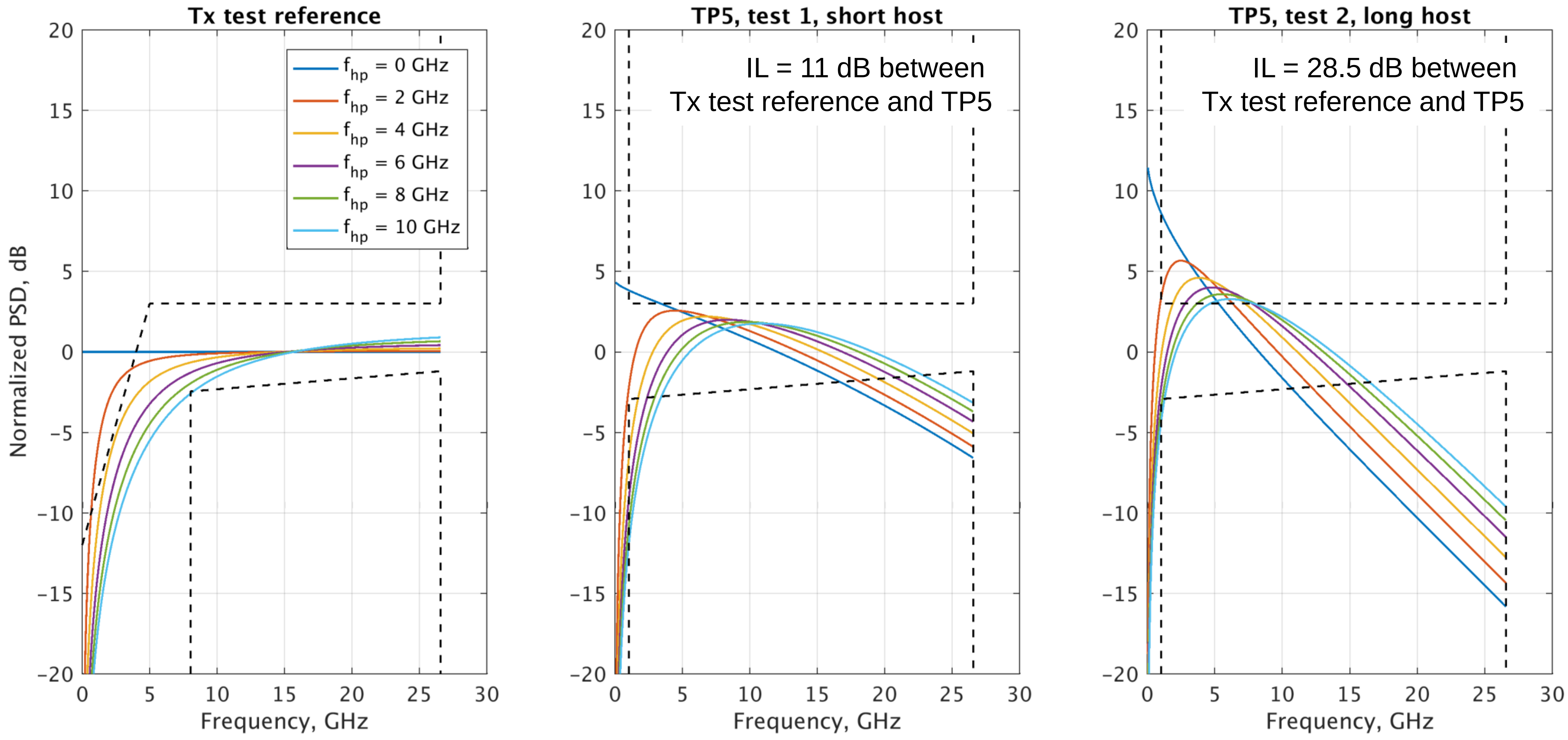


Resemblance to actual channel impairments at TP5



- Broadband noise at TPn (near TP5v) better emulates channel crosstalk

“Broadband” noise spectral densities with high-pass filter



Concept recommended for test setup

- Require pattern generator to exceed minimum SNDR when added noise is disabled
- Specify normalized PSD mask for noise added at Tx test reference
- Specify that the noise is high-pass (via PSD mask) to avoid excessive low-frequency weighting to the receiver input noise

$$NSD_{avg} = \frac{1}{(f_b/2 - f_1)} \int_{f_1}^{f_b/2} NSD(f)df$$

$$10\log_{10}\left(NSD(f)/NSD_{avg}\right) \geq -3 + 3.6(f/f_b) \qquad f_1 \leq f \leq f_b/2$$

$$10\log_{10}\left(NSD(f)/NSD_{avg}\right) \leq \begin{cases} -12 + 15(f/f_2) & 0 \leq f < f_2 \\ 3 & f_2 \leq f \leq f_b/2 \end{cases}$$

f_1 = 8 GHz
f_2 = 5 GHz

Concept recommended for calibration using COM

- Use measured pattern generator SNDR (with noise disabled) as the value for SNR_{TX}
- Add a term to σ_{TX} specifically for Clause 162 interference tolerance noise calibration (similar to term added to σ_G for Clause 163 and Annex 120F)

$$\sigma_{TX}^2 = \left[h^{(0)}(t_s)\right]^2 10^{-SNR_{TX}/10} + \sigma_{ne}^2 \qquad \sigma_{ne}^2 = \frac{\sigma_{bn}^2}{(f_b/2)} \int_0^{f_b/2} \left|H_{hp}(f) H_{21}^{(0)}(f) H_r(f) H_{ctf}(f)\right|^2 df$$

$$H_{hp}(f) = \frac{jf}{f_{hp} + jf} \qquad \sigma_{hp}^2 = \frac{\sigma_{bn}^2}{(f_b/2)} \int_0^{f_b/2} \left|H_{hp}(f)\right|^2 df$$

- $H_{hp}(f)$ represents the high-pass spectral shaping of the noise, f_{hp} = 6 GHz
- Find value of σ_{bn} required to get specified COM
- Set RMS amplitude of noise added at Tx test reference to σ_{hp} (integration of noise spectrum, weighted by $|H_{hp}(f)|^2$, from 0 to f_b / 2)

Summary of “broadband noise” specifications

Specification component	Clause 163 and Annex 120F	Clause 162 (current)	Clause 162 (proposed)
Noise spectral density mask	Equation 93C–1	None	Defined (See slide 8)
Calibrated noise term	σ_{bn}	SNR_{TX}	σ_{hp}
Shape of noise spectral density assumed for calibration	Uniform from 0 to $f_b/2$ (i.e., integrate from 0 to $f_b/2$)	Undefined (assumed to scale with pulse amplitude)	$\left\|H_{hp}(f)\right\|^2$ from 0 to $f_b/2$ (i.e., integrate from 0 to $f_b/2$)
Noise filter assumed for calibration (up to TP5)	$S^{(nc)}$ (measured response from TPn to TP5)	Undefined (assumed to scale with pulse amplitude)	$S^{(0)}$ (measured / simulated response from Tx test reference to TP5)
Filter applied to measurement of broadband noise amplitude	Brick-wall at $f_b/2$ (i.e., integrate from 0 to $f_b/2$)	None	Apply $H_{hp}(f)$ and integrate from 0 to $f_b/2$