SRS test source calibration: measurement bandwidth (comment r03-9)

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SRS test source calibration measurement bandwidth in D3.2

- Refers back to 121.8.5 - in 121.8.5.1 the calibration bandwidth defined as :
  - “ a fourth-order Bessel-Thompson filter response with a bandwidth of approximately 13.28125 GHz.”
    - There’s no upper frequency limit.
    - Similar descriptions of the SRS test source measurement bandwidth have been used for several preceding optical clauses.
  - Also included in D3.2 is “Compensation may be made for any deviation from an ideal fourth-order Bessel-Thompson response.”

SRS test source calibration measurement bandwidth (in D3.2, D3.3, and preceding drafts)

- A warning is included about excess jitter in the measurement system and the danger of under-stressing the SRS test source (example for 139)

139.7.9.3 Stressed receiver conformance test signal verification

Care should be taken when characterizing the test signal because excessive noise/jitter in the measurement system would result in an input signal that does not fully stress the receiver under test. Running the receiver tolerance test with a signal that is under-stressed may result in the deployment of non-compliant receivers. The noise/jitter introduced by the O/E, filters, and oscilloscope should be negligible or the results should be corrected for its effects. While the details of test equipment are beyond the scope of this standard, it is recommended that the implementer fully characterize the test equipment and apply appropriate guard bands to ensure that the stressed receiver conformance input signal meets the stress and sinusoidal jitter specified in 139.7.9.2 and 121.8.9.4.

Draft 3.3 spec

> The filter response of the combination of the O/E and the oscilloscope used for the SECQ measurement should be a fourth-order Bessel-Thomson filter response with a bandwidth of approximately 13.28125 GHz to at least 0.9 × 26.5625 GHz and at frequencies between 0.9 × 26.5625 GHz and 1.5 × 26.5625 GHz the response should not exceed the Bessel-Thomson response.

- Removes the need to meet a fourth-order Bessel-Thompson response for frequencies above 0.9 x Baud
  - Allows any phase response provided it doesn’t exceed the magnitude response of a BT4 up to 0.9 x Baud
  - No constraints at all beyond 1.5 x Baud
  - This seemingly precise definition makes it even less likely that a casual reader will pay attention to warnings about jitter and noise given, for example, in 139.7.9.3.

What does the D3.3 bandwidth description look like ?

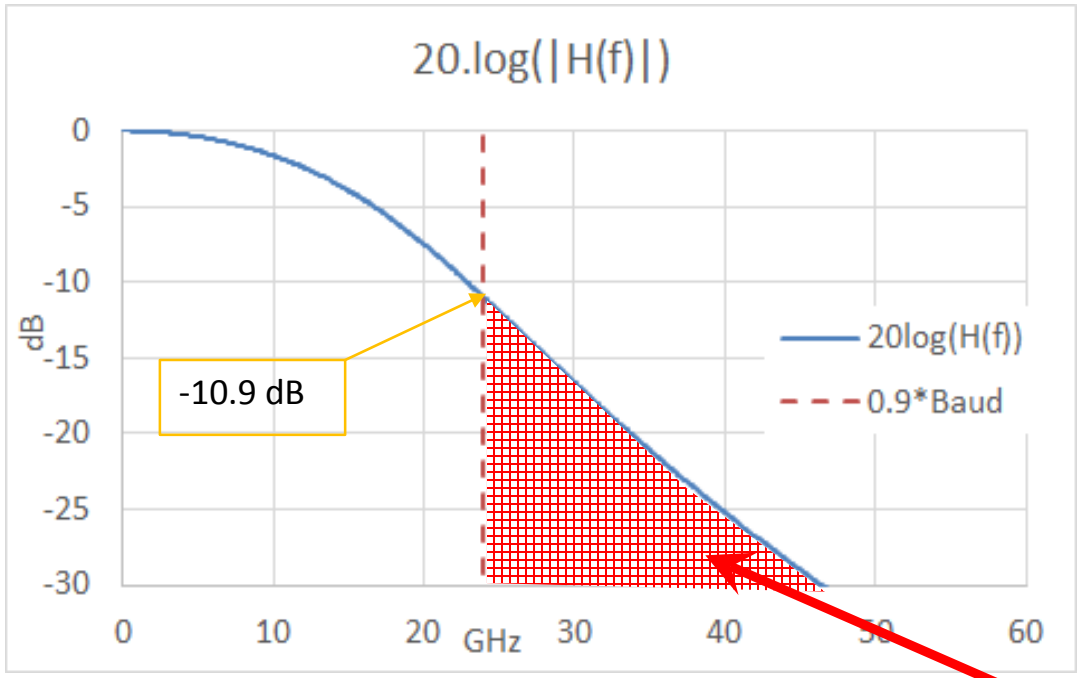
- Fourth-order Bessel-Thompson (e.g. as described in clause 52)

$$H(y) = \frac{105}{105 + 105y + 45y^2 + 10y^3 + y^4} \qquad (52\text{–}2)$$

where:

$$y = 2.114p; \quad p = \frac{j\omega}{\omega_r}; \quad \omega_r = 2\pi f_r; \quad f_r = 7.5\text{GHz} \qquad (52\text{–}3)$$

13.28125 GHz for 53Gb/s PAM4

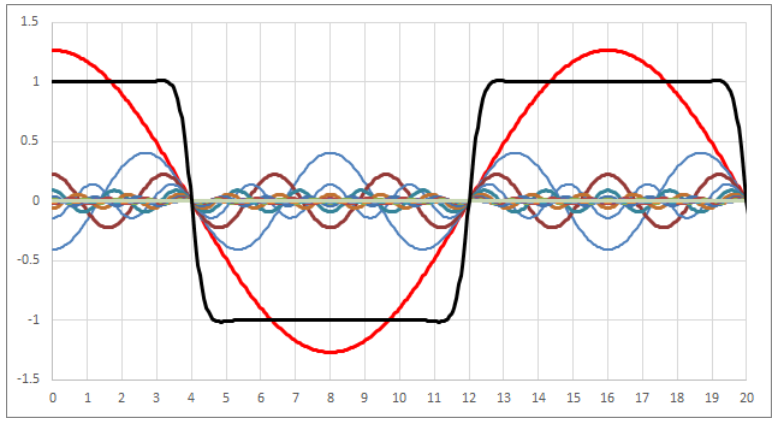


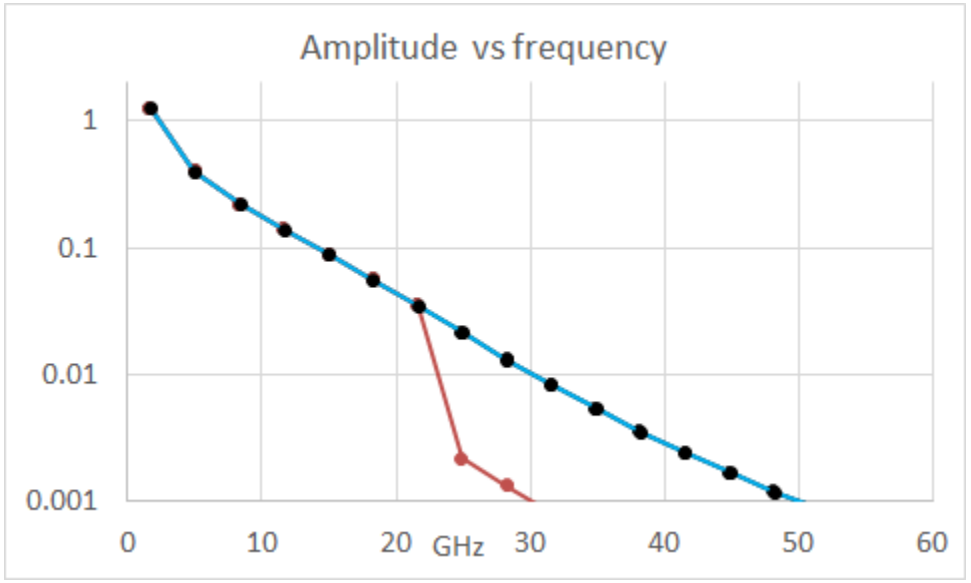
-10.9 dB (electrical) = 28% voltage

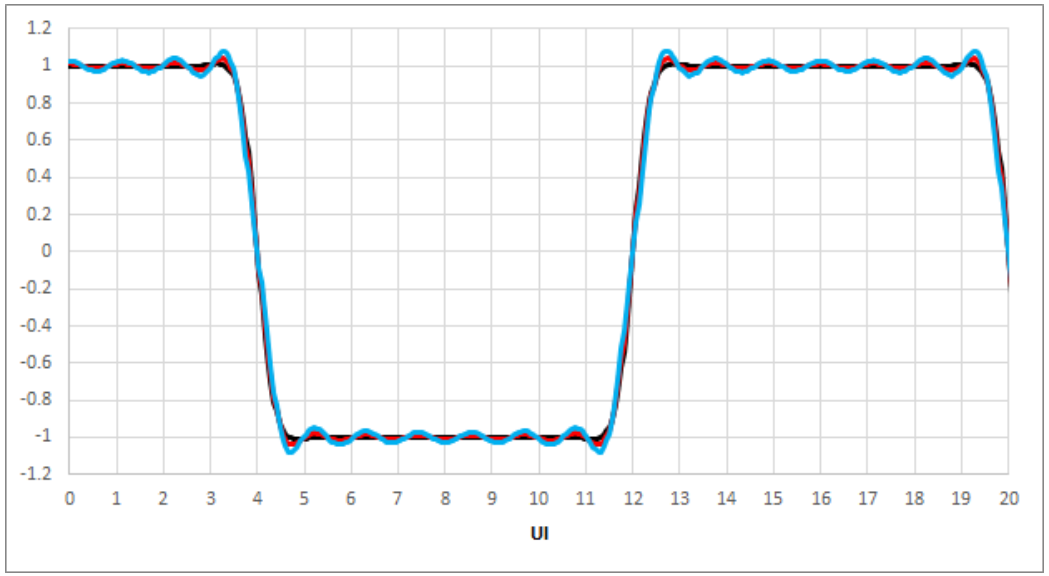
For a BT4 filtered white noise source, area represents 2.8% power

D3.3 SRS bandwidth applied to transition time measurement -1

- Square wave test pattern, 8 threes, 8 zeros
  - 3 conditions:
    - BT4 response per D3.2 (black dots)
    - BT4 with π phase shift at 24GHz (blue line)
    - BT4 with components attenuated by factor of 10 at 0.9xBaud (red)

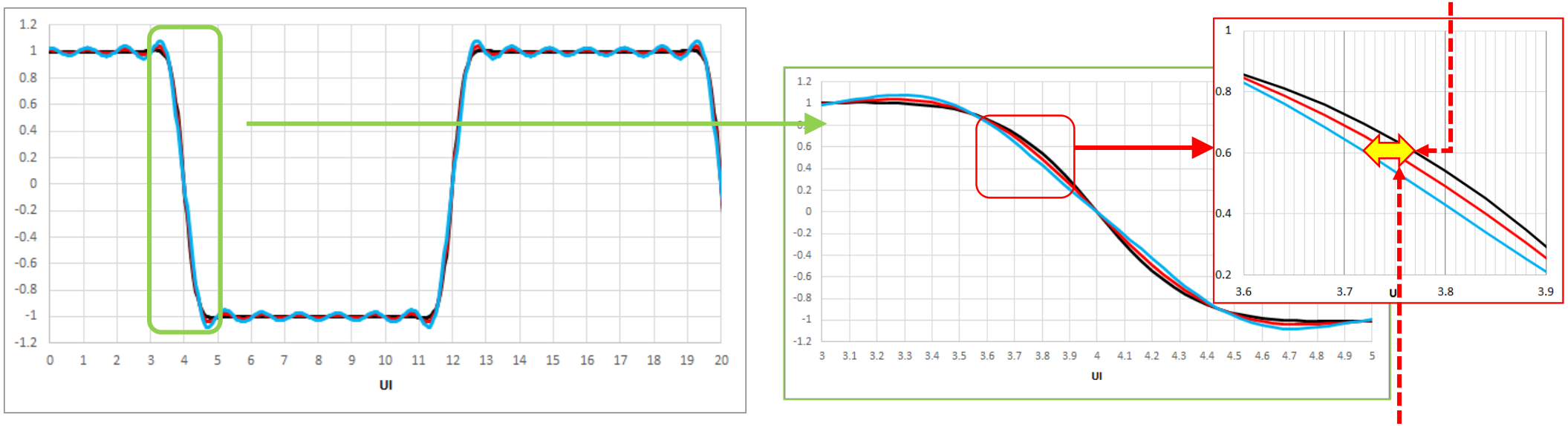






D3.3 SRS bandwidth applied to transition time measurement -1

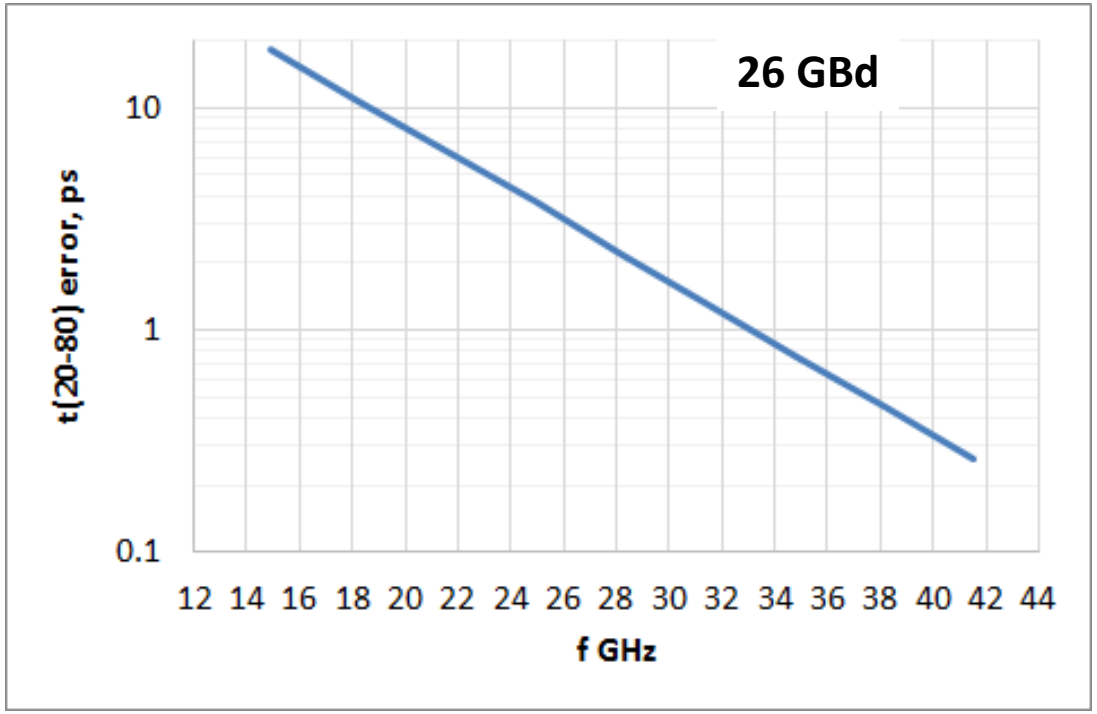
- Square wave test pattern, 3 conditions:
  - BT4 response per D3.2, one answer
  - BT4 with components attenuated by factor of 10 at 0.9xBaud,
  - BT4 with π phase shift at 24GHz

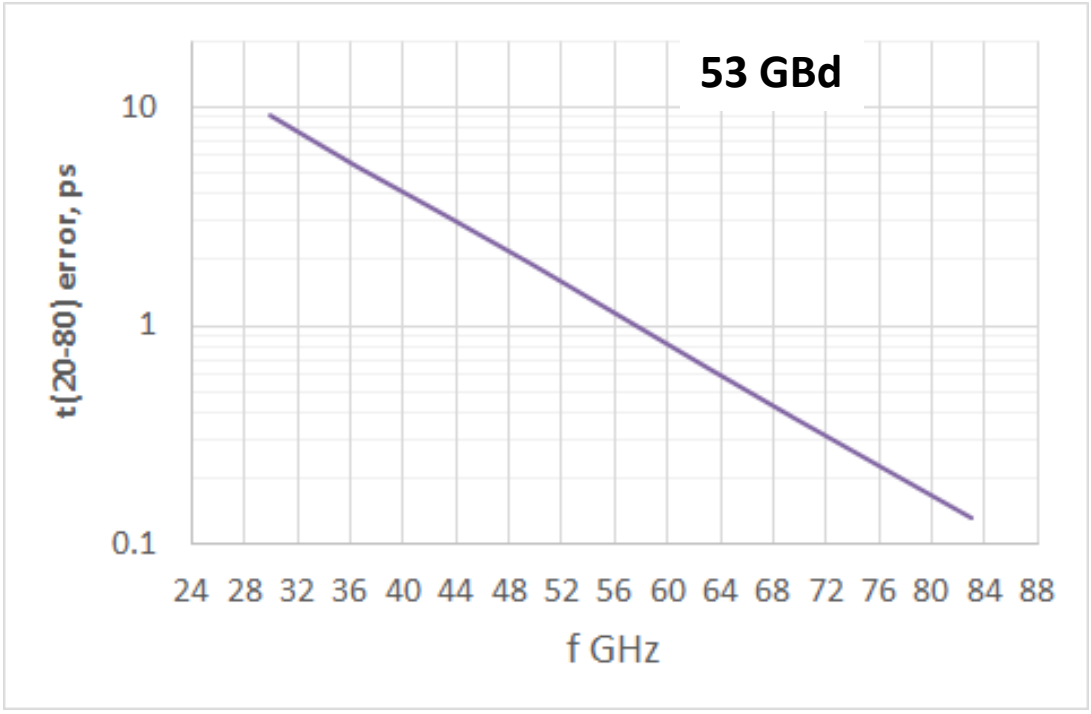


- ~20% variation in transition time measurement

Transition time error vs HF spec -1

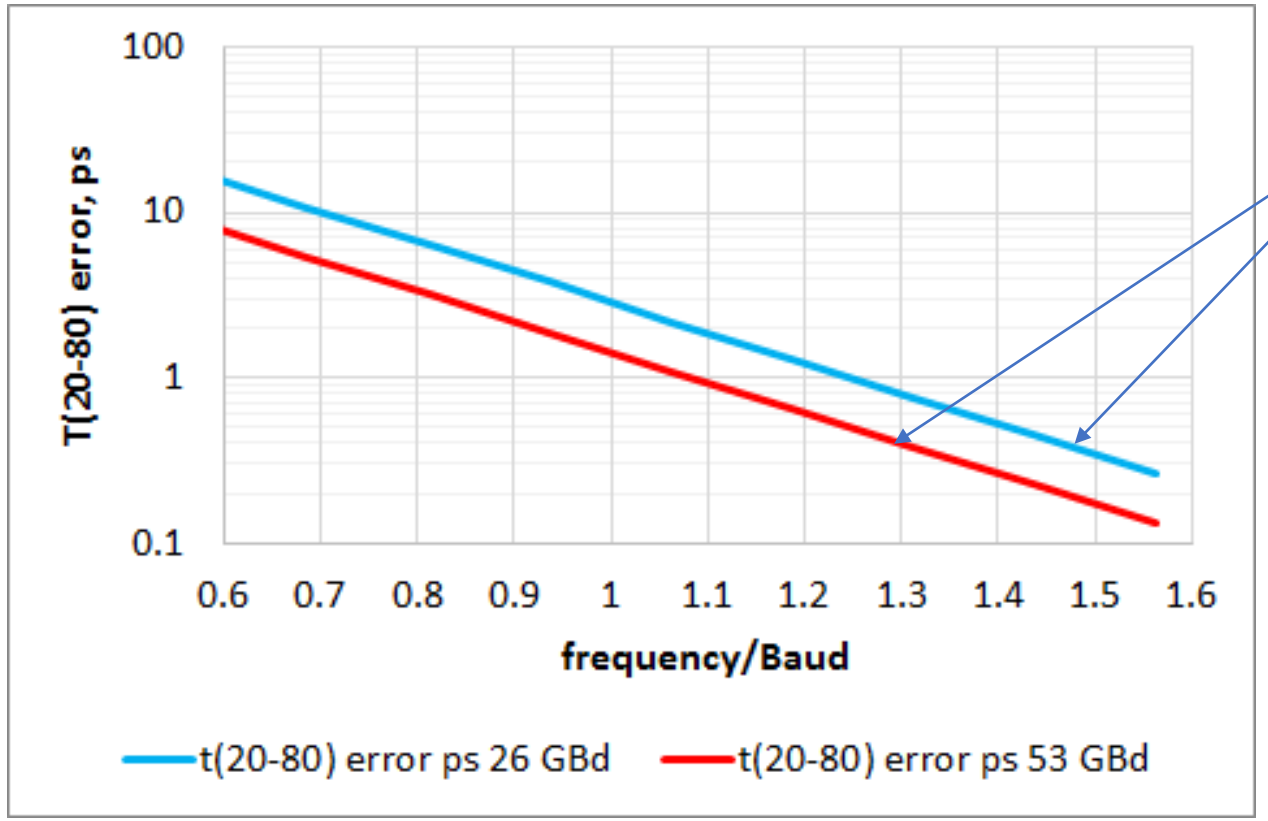
- Transition time variation (ps) vs frequency (GHz) up to which BT4 response is required





Transition time error vs HF spec -2

- Transition time variation (ps) vs frequency/Baud up to which a BT4 response is required



~0.4 ps
max transition
time error

Concluding remarks

- The SRS test source calibration measurement bandwidth in D3.3 leaves significant portions of the measurement frequency substantially undefined. It should not be applied to transition time measurements or TDECQ as is.
- If a consistent bandwidth definition for TDECQ, transition time and SRS test source calibration is desired, some options are:
  1) Revert to draft 3.2 definition, but change this sentence: "Compensation ~~may~~ should be made for any deviation from an ideal fourth-order Bessel-Thompson response."
  2) Add a sentence to the D3.3 or D3.2 SRS test bandwidth definition to draw attention to the need for well behaved test measurement bandwidths, for example: "Deviation from an ideal fourth-order Bessel-Thompson response may cause excess jitter and amplitude variation which will make measurements inaccurate, see 139.7.9.3."
  3) Change the D3.3 SRS test source measurement bandwidth definition for 26GBd lanes to "…to at least 1.5 × 26.5625 GHz and at frequencies above 1.5 × 26.5625 GHz the response should not exceed the Bessel-Thomson response."

     and

     "…to at least 1.3 × 53.25 GHz and at frequencies above 1.3 × 53.25 GHz the response should not exceed the Bessel-Thomson response."

Note: Limits transition time variation to <0.4 ps and TDECQ variation to less than ~0.1 dB (TBC)

Back up

History

- SRS test sources are calibrated with an ideal BT4 response for many preceding optical clauses. There is no undefined frequency range.
- Clause 52:
  - “The vertical and horizontal eye closures to be used for receiver conformance testing are verified using an optical reference receiver with a 7.5 GHz fourth order ideal Bessel-Thomson response. Use of G.691 tolerance filters may significantly degrade this calibration.”
  - Similarly for clauses 86, 87, 88
- Clause 95:
  - “The SEC of the stressed receiver conformance test signal is measured according to 95.8.5, except that the combination of the O/E and the oscilloscope used to measure the waveform has a fourth-order Bessel-Thomson filter response with a bandwidth of 19.34 GHz”
- Clause 112 also refers to clause 95

Fourth-order Bessel-Thompson

- For example, as defined in Clause 52

$$H(y) = \frac{105}{105 + 105y + 45y^2 + 10y^3 + y^4} \qquad (52\text{–}2)$$

where:

$$y = 2.114p\ ; \quad p = \frac{j\omega}{\omega_r}\ ; \quad \omega_r = 2\pi f_r\ ; \quad f_r = 7.5\text{GHz} \qquad (52\text{–}3)$$