Stressed receiver sensitivity setup and calibration
(comment 304)

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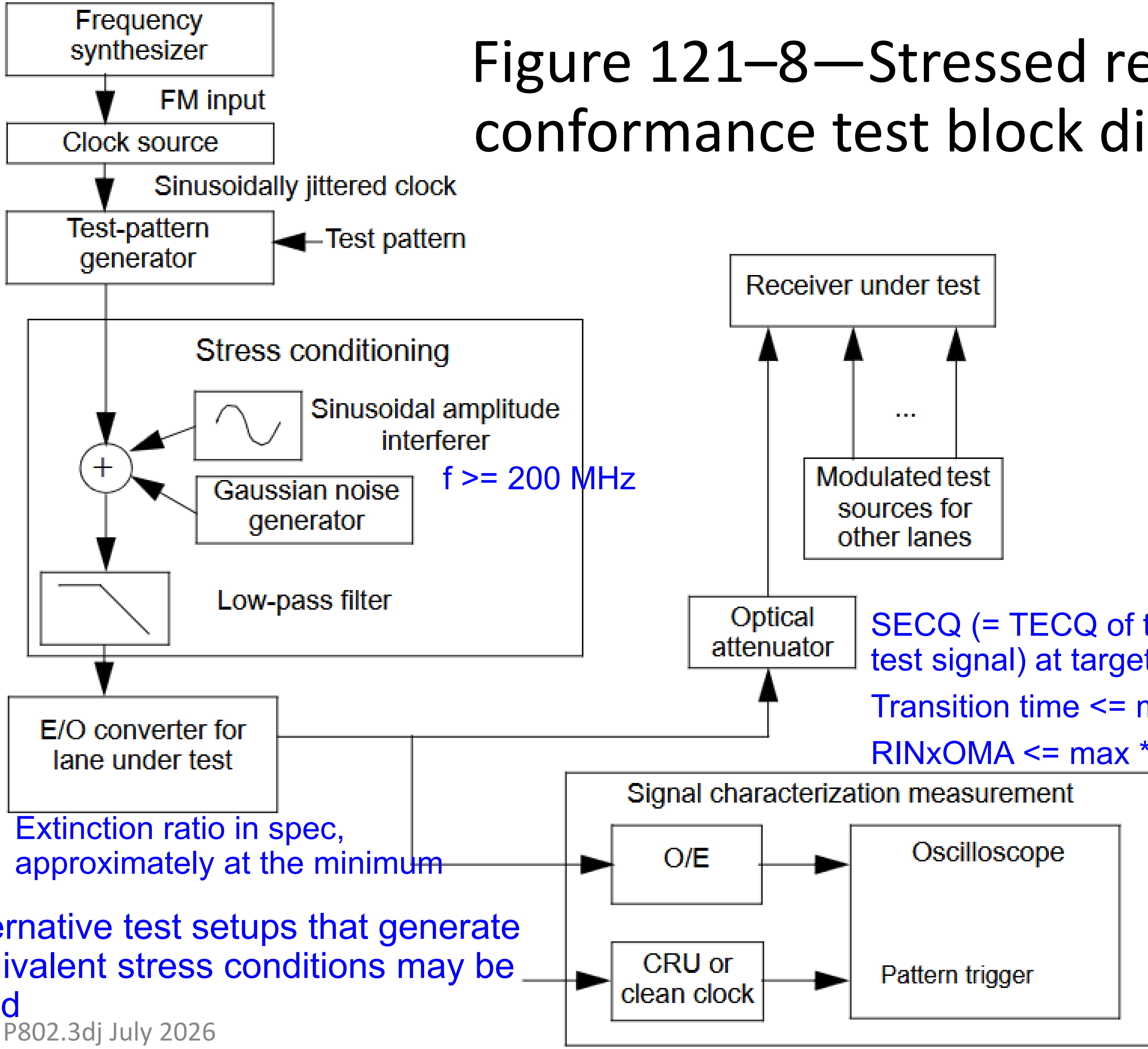
Introduction

- The signal for stressed receiver sensitivity is defined in 180.9.15
- Following 121.8.10: a clean signal is degraded with sinusoidal jitter, sinusoidal amplitude interferer (SI), Gaussian noise (GN) and a low-pass filter
- There are some constraints and the implementer has quite a lot of freedom
- Different implementations can give different results, and unrealistic levels and types of stress
- SI and its calibration is a particular problem

Figure 121–8—Stressed receiver conformance test block diagram



f >= 200 MHz

SECQ (= TECQ of the stressful test signal) at target

Transition time <= max

RINxOMA <= max *

Extinction ratio in spec, approximately at the minimum

Alternative test setups that generate equivalent stress conditions may be used

From 121.8.10.1

- The sinusoidal amplitude interferer may be set at any frequency between [200] MHz and 2 GHz, although care should be taken to avoid harmonic relationships between the sinusoidal interferer, the sinusoidal jitter, the signaling rate, and the pattern repetition rate. The Gaussian noise generator, the amplitude of the sinusoidal interferer, and the low-pass filter are adjusted so that the specified SECQ is met.
- For improved visibility for calibration, all elements in the signal path ... should have wide and smooth frequency response, and linear phase response, throughout the spectrum of interest. Baseline wander and overshoot and undershoot should be negligible.

The implementer chooses the mix of filtering, Gaussian noise and SI amplitude. Also the SI frequency

Some choices can give very unrealistic signals

Often the penalty from SI is very large

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- SC 180.9.15 P 493 L 45 TR
- The frequency of the sinusoidal interferer was changed from minimum 100 MHz to minimum 200 MHz, but it's still a single frequency. The sampling scope aliases it to some other frequency and the software FFE will amplify it according to the apparent frequency, not the real one, **causing error**.
- 1. Change from a sine tone to a PRBS generator (not synchronous to the victim) with a high enough signalling rate that wherever the aliasing takes the apparent frequencies to (there are many real frequencies in a PRBS), the overall enhancement will be reasonably consistent. A PAM2 PRBS is more "bounded-like" than a PAM4 one as well as having a uniform spectrum.
- 2. Limit the amount of bounded interference.
- 3. In 121.8.10.1, we say "care should be taken to avoid harmonic relationships between the sinusoidal interferer, the sinusoidal jitter, the signaling rate, and the pattern repetition rate".   After taking advice from scope experts: add the sampling rate of the scope to that list.

… causing error 1/2

- In general we expect that a signal-borne impairment such as distortion or the effects of reflections has a spectrum related to the "victim". The relatively low SI frequency is unrealistic.
- The aliased frequency can be anything: from DC to signalling rate × oversampling rate / 2
  - The aliasing takes place after the scope front-end filter, so the software FFE can amplify it
  - Not what happens in a real receiver
- The strong single-tone nature of the SI at up to 2 GHz could confuse some repetitive process in a DSP
- By comparison, the Gaussian noise spectrum can be flat up to Nyquist

… causing error 2/2

- A sinusoidal interferer is almost "dual-Dirac"
- Because it is strong, the way people build stressed signals today, the resulting PAM4 histograms are two-moded
- This is unrealistic

Side note: the SI maximum frequency is very old: it was set at signaling rate / 5 before equalizers were expected:

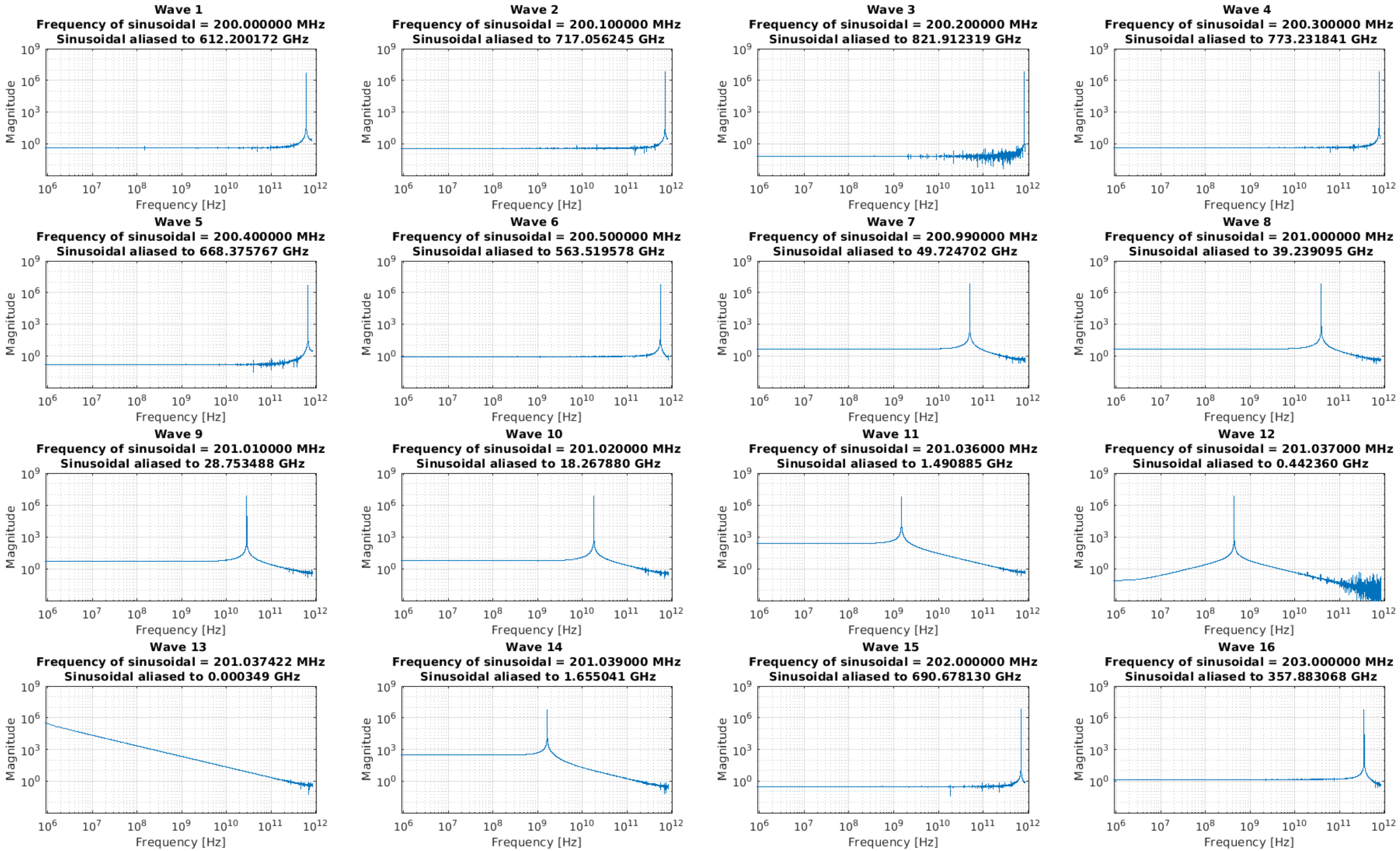
52.9.9.1 Stressed receiver conformance test block diagram

The frequency of the sinusoidal interference may be set at any frequency between 100 MHz and 2 GHz, although be careful to avoid a harmonic relationship between the sinusoidal interference, the sinusoidal jitter, the data rate and the pattern repetition rate.

The Bessel-Thomson filter and the E/O converter should have the appropriate frequency response to result in the appropriate level of initial ISI eye closure before the sinusoidal terms are added.

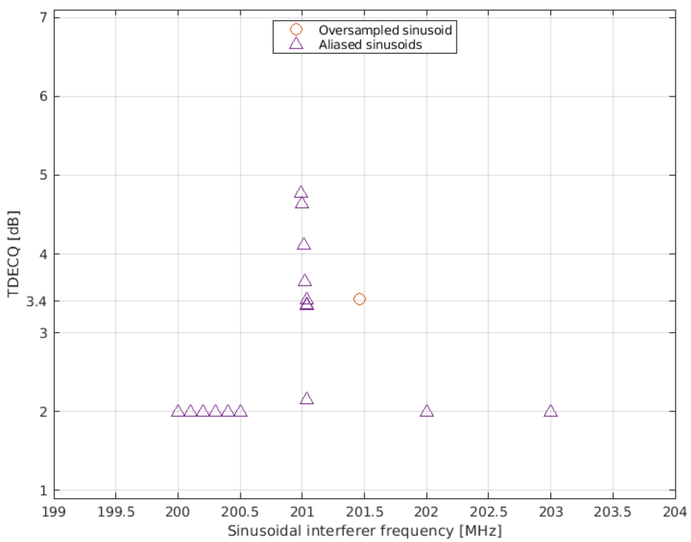
58.7.11.2 Stressed receiver conformance test signal characteristics and calibration

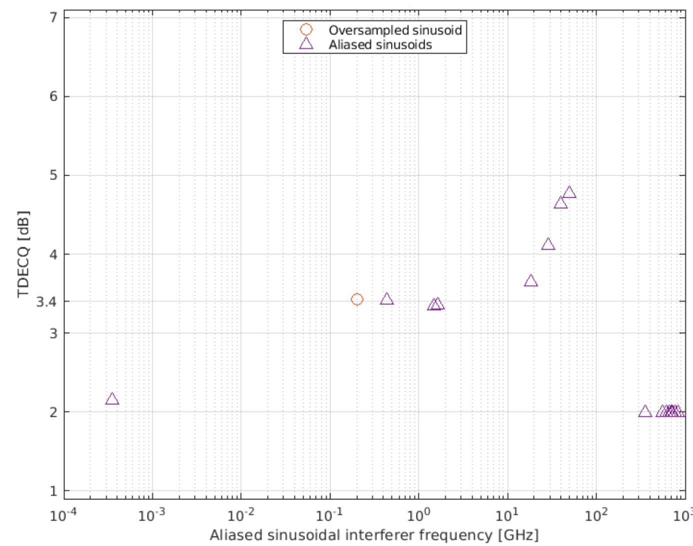
The frequency of the sinusoidal interference may be set at any frequency between B / 100 and B / 5 where B is the signaling speed, although care should be taken to avoid a harmonic relationship between the sinusoidal interference, the sinusoidal jitter, the signaling speed and the pattern repetition rate.



- A difference of 100 kHz in sinusoidal frequency can move the aliased frequency by 100 GHz

SECQ variability





- Simulations with the same SI amplitude at different frequencies give very different (apparent) SECQ
- In calibration, the SI amplitude would be adjusted to make the apparent SECQ to the target, giving very different real stress

Way forward

- With a PRBS interferer, there are many frequencies. They are aliased too, but to many frequencies which are noise-enhanced differently, leading to better consistency
- To avoid the 2-moded histogram problem, a PAM4 PRBS may be preferable to a PAM2 PRBS
- The amount of bounded interferer (SI or PRBS) should be limited, and more use made of the Gaussian noise generator
- The GN should represent some of the distortion in a bad signal, and be definitely more than the RIN limit
- We should say that with bounded interferer off and other impairments on, the SECQ should be within 0.5 dB of the target SECQ with all impairments on
  - This leaves the implementer with enough freedom to set the mix

Harmonic relationships

- We use QPRBS aggressors in many places in the standard
  - Using a different-length sequence (to the victim) is seen as acceptable for making a co-propagating aggressor uncorrelated
  - Using the same rate as the victim is convenient, (whether they are locked together or not)
  - A longer pattern such as PRBS31Q contains many tones, as desired. Probably PRBS15Q would work, maybe PRBS13Q if it has a practical advantage
- Care should be taken to avoid harmonic relationships between the sinusoidal interferer, the sinusoidal jitter, the signaling rate, the pattern repetition rate, and the oscilloscope sampling rate