Tektronix

802.3ck waveform measurement BW roll-off

Waveform measurement with 4th-order B-T filter have unclear roll-off stop frequency. We are proposing to mandate the minimum roll-off stop frequency.

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Supporters

…

Introduction…

- The measurement within 802.3ck require a waveform acquisition by an oscilloscope system with a 4th order Bessel-Thomson roll off (or Butterworth in a few places; same consideration)
- We show that the results are a function of the 4th order Bessel-Thomson filter's roll-off end-of-compliance (stop) frequency
- We propose that in order to limit the variability of the result between different measurement tools, the Bessel-Thomson roll-off should be mandated up to at least a certain frequency

Specifically: (next page)

… introduction

- The measurements in 802.3ck mandate an frequency response:

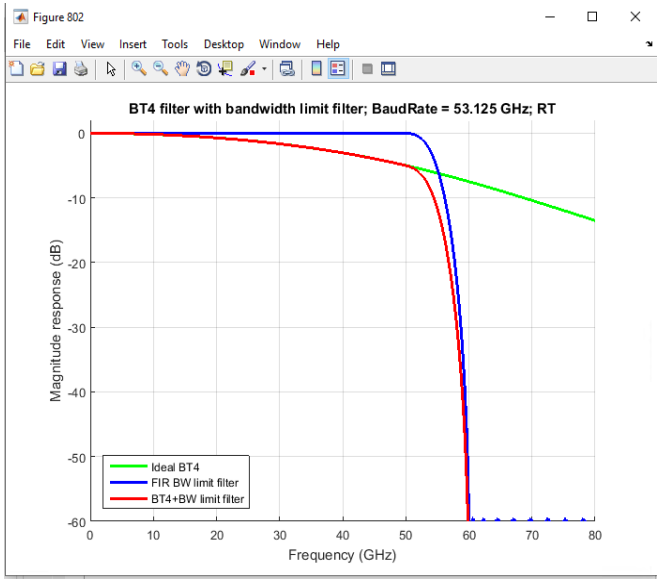
1. “162.9.3 Transmitter characteristics
   The transmitter on each lane shall meet the specifications given in Table 162–10 and detailed in the referenced subclauses. Unless specified otherwise, all transmitter signal measurements are made for each lane separately, at TP2, utilizing the test fixtures specified in Annex 162B, using a test system with a fourth order Bessel-Thomson low-pass response with 40 GHz 3 dB bandwidth.
2. 162.9.4.3.3 Test channel calibration
3. 163.9.2 Transmitter characteristics
4. 163.9.3.5 Receiver interference tolerance
5. Other places

Similarly for “receiver noise filter” (a Butterworth filter):

1. 93A.1.4.1 Receiver noise filter is a noise filter defined by Equation (93A–20).
2. 120G.5.2 Eye opening measurement method
   The eye opening parameters eye height and VEC are measured with the effect of a reference receiver which includes receiver input referred noise, a continuous-time filter as defined in 93A.1.4.3, a receiver noise filter as defined in 93A.1.4.1
3. Other places

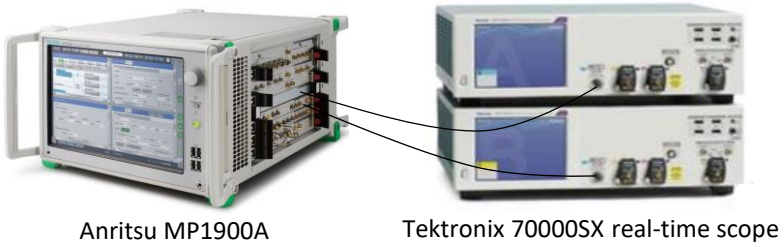
The question to answer: how far does the B-T BW need be valid?

- To how high a frequency does the oscilloscope frequency has to match the 4th-order Bessel-Thomson filter need to comply ?
  - We swept the B-T end-of-compliance frequency by convolving it with a sharp drop filter (so truncating the frequency response of the B-T;
    see the plot on the right: blue curve is the truncating filter, and red is the convolution of B-T with the truncating filter)
    -and we observed the impact on the SNDR and VEC (next pages)



Experiment: setup

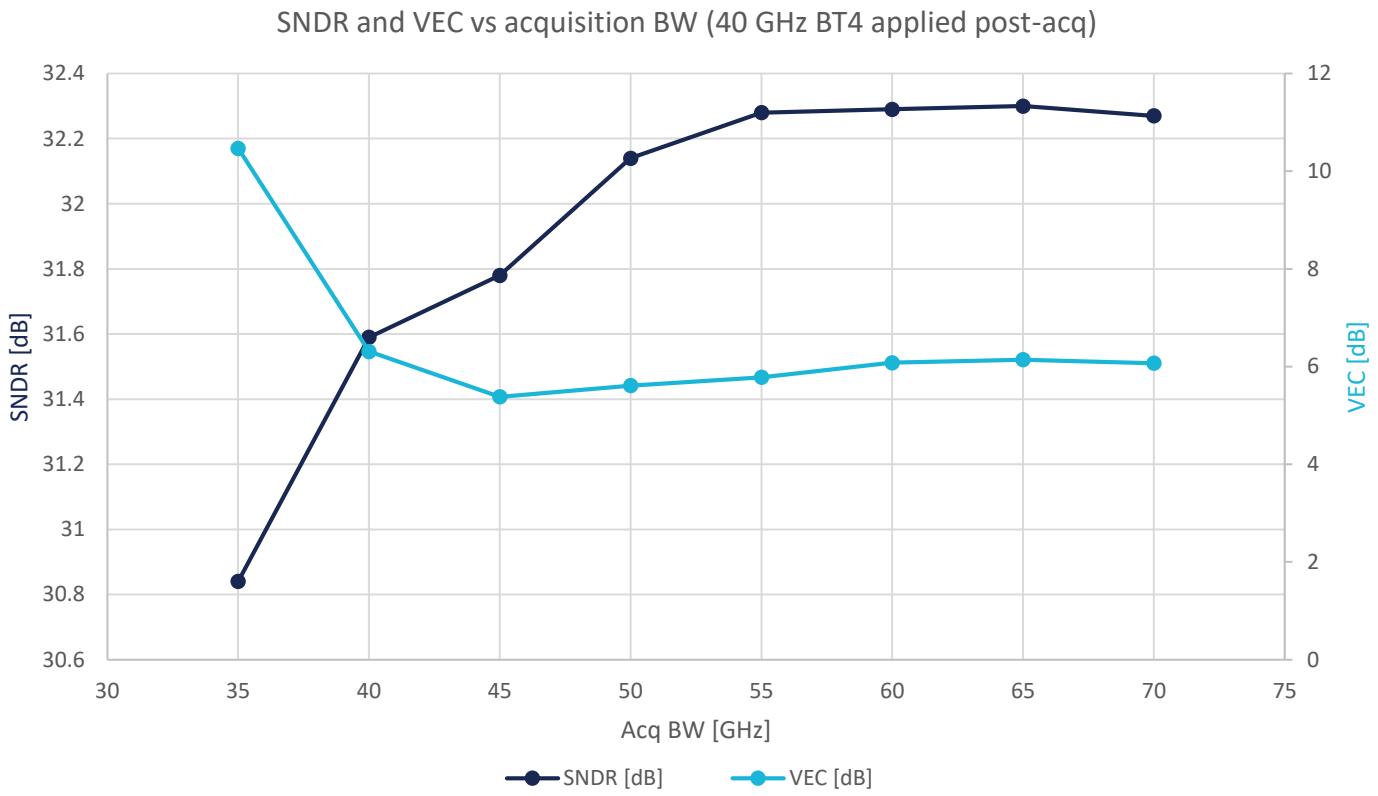
Setup



- PAM4 PPG transmitter as signal source
- Signal bandwidth higher than typical DUT (using high speed edges of the Anritsu MP1900, with short cables supplied)
- Oscilloscope controllable bandwidth swept from 30 GHz to 70 GHz

Experiment: results

results



Proposal

- From our experiments (see the graph on previous page) it is apparent that increasing oscilloscope roll-off (drop from B-T) frequency past 55 GHz there is almost no dependency of SNDR and VEC result on the Bessel-Thompson filter roll-off
- Based on the following we propose that the B-T should be guaranteed to f = 55 GHz and rolled off with a non-rising function afterwards
- The same requirement for the noise receiver filter. Data not given here since that filter is slower yet (than B-T4) hence same BW roll-off suffices.

Conclusion

- We’ve analyzed a known concern (of BW roll-off) with the SNDR result.
- We identified the sensitivity of the SNDR, VEC results to oscilloscope end-of-roll-off
- We suggest a constraint that can be adopted by 802.3ck and will make the results obtained on different oscilloscopes consistent

Thank you

Pavel Zivny, Tek