Exploring System Noise, η_0, for Usage in COM

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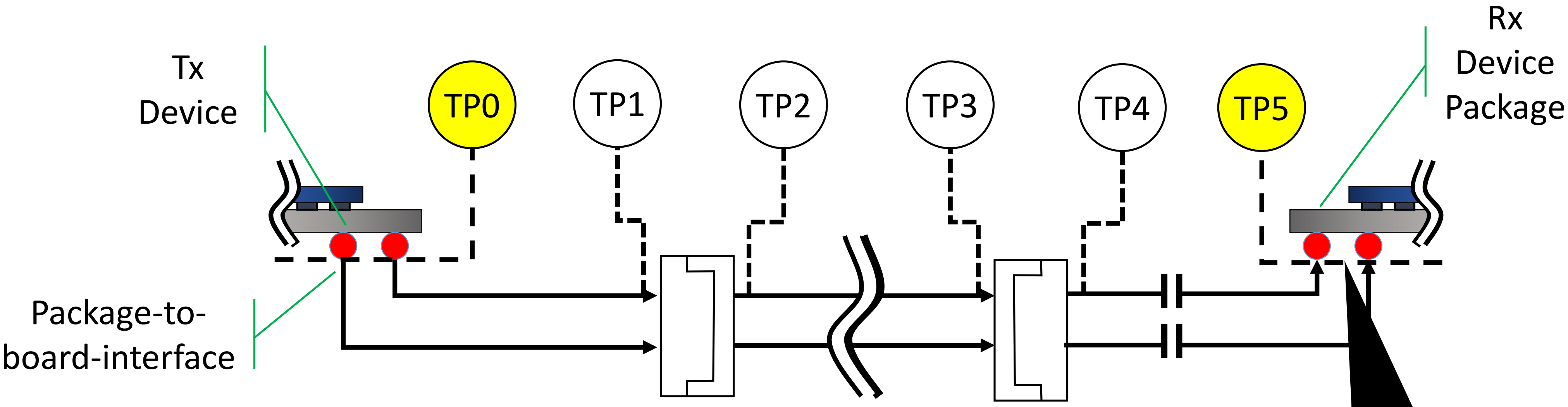
η_0 is defined a the pins of the receiver



It is the system noise not included in the Tx, Rx, or any noise induced by the Rx parent device

η_0 is defined here

Background

- The inclusion of system noise was indicated on slide 7 of the original COM proposal mellitz_01_071, *"Time-Domain Channel Specification: Proposal for Backplane Channel"*
- Characteristic Sections.
  - It was broadband gaussian source called σ_r .
- Measurement was provided in ran_02_0712, *"Considering Alien Noise"*
  - Approximately 1 mV of signal was suggested
  - EMI inducted noise on well design systems was ruled out from proximally inducing highly tuned EMI noise near differential signals
- 1 mv σ_r was first introduced in IEEE P802.3bj™/D1.4, 21st February 2013
- 5.2e-8 V^2 /GHz adopted for η_0 in IEEE P802.3bj™/D2.3, 11th October 2013

How many mV?

$$\sigma = \sqrt{\sum_{0}^{f_b} \eta_{0\,\Delta f}}\,, \qquad Where\ \Delta f\ and\ f_b, the\ baud\ rate, are\ in\ GHz$$

- For IEEE802.3by, .3by, and.3bm
  - Given f_b= 25.781 GHz & η_0=5.2e-8 V^2/GHz σ=1.228 mV
- IEEE802.3cd
  - Given f_b= 26.5625 GHz & η_0=1.64e-8 V^2/GHz σ=.66 mV
- Presently for 100 G IEEE8.3ck
  - Given f_b= 53.125 GHz & η_0=8.2e9 V^2/GHz σ=.66 mV

How is it used in COM

- The system noise is filtered by the Rx and CTF filters to create an broadband AWGN which is convolved with all the other noise sources

$$\sigma_N^2 = \eta_0 \int_0^{\infty} |H_r(f) H_{ctf}(f)|^2 df \qquad (93A\text{–}35)$$

- η_0 at 8.2e-9 V^2/GHz can account for up to 2 dB of COM 100 Gbs PAM-4 in 28 dB channels
- Maybe we should revisit η_0
  - See wu_3ck_adhoc_01_022719.pdf

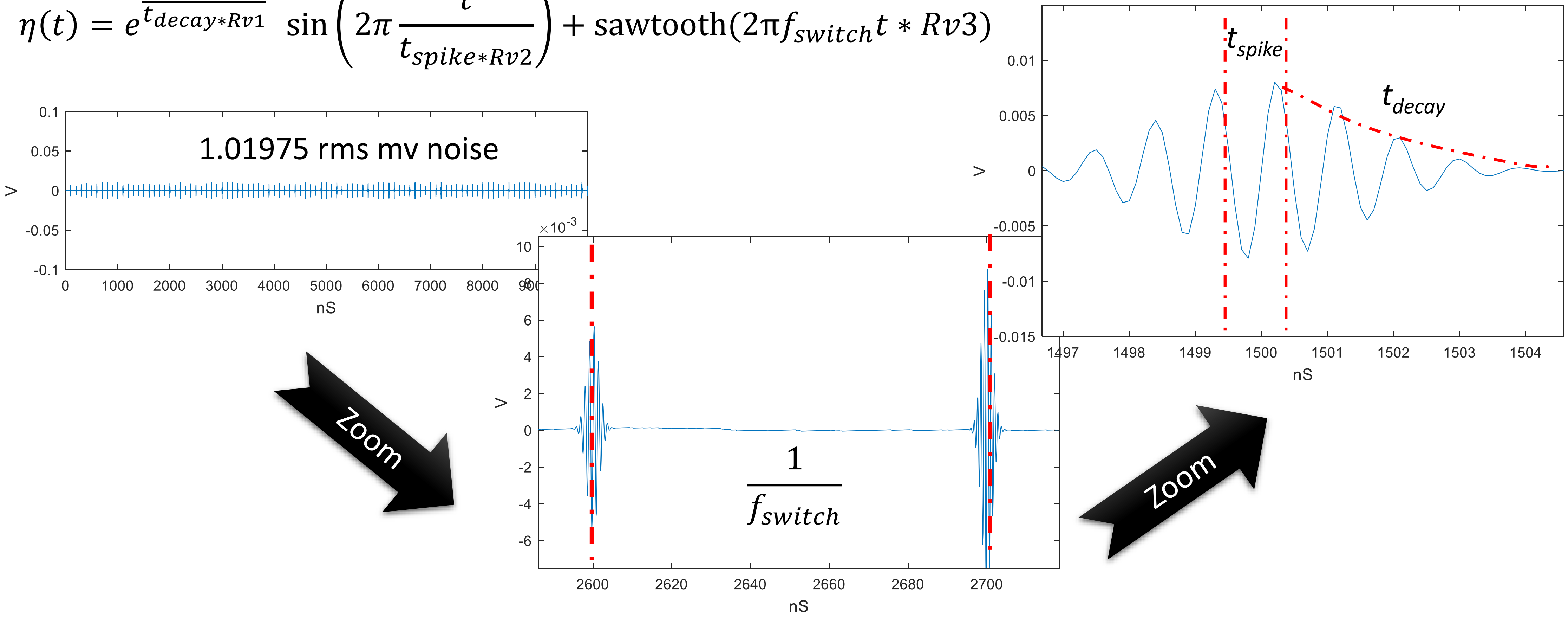
System noise

- Power supply noise on a differential line can be modeled as
  - A low frequency sawtooth wave and
  - A higher frequency sine wave enveloped with decaying exponentials at the sawtooth transitions
- The higher frequency proportion is likely caused by random nature of system di/dt loading at the inductor switching transistor in a power supply.
- Tact
  - Experiment to recreate the 1 mv RMS
  - Propose a waveform which might be represented of a mV RMS system noise
  - Determine the power spectral density
  - Propose a filter added to equation 93A-35 for the system noise power spectral density, *He(f)*

Simple noise model

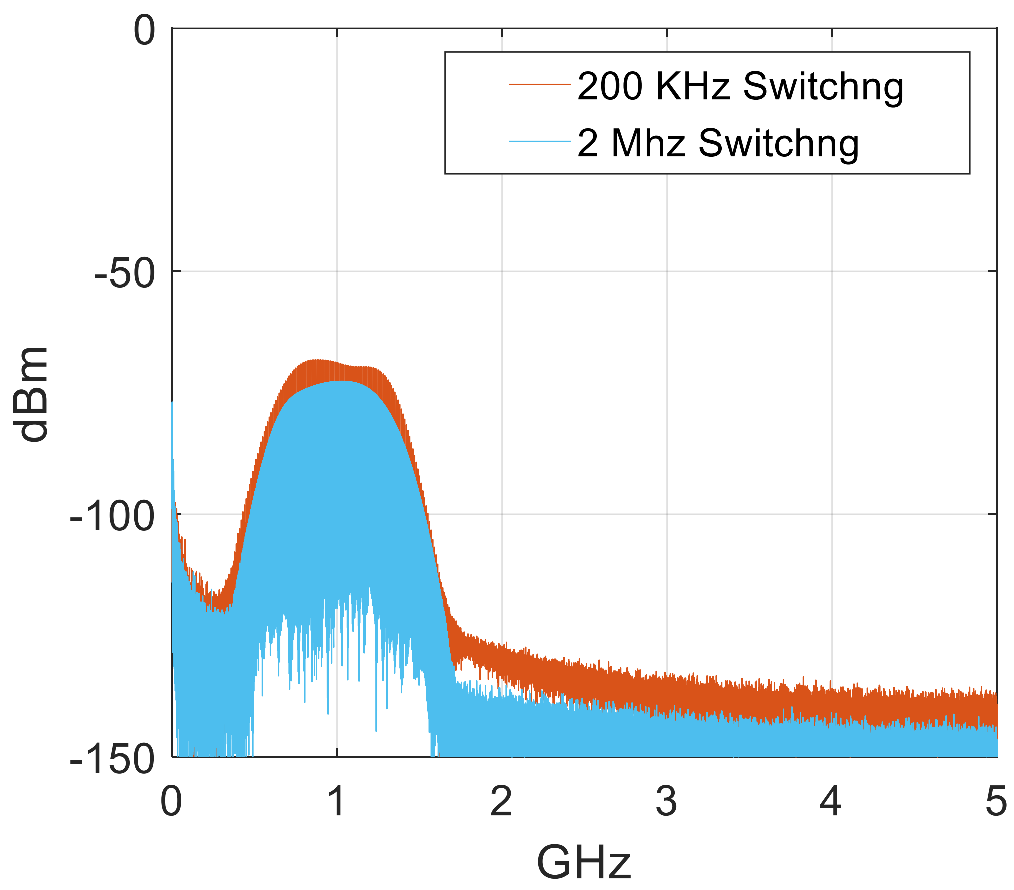
Each switch cycle has this form where Rv1, Rv2, and Rv3 are randomizing variables modeling load variations

$$\eta(t) = e^{\frac{t}{t_{decay*Rv1}}^{2}} \sin\left(2\pi \frac{t}{t_{spike*Rv2}}\right) + \mathrm{sawtooth}(2\pi f_{switch} t * Rv3)$$



Power Spectral Density (PSD) results

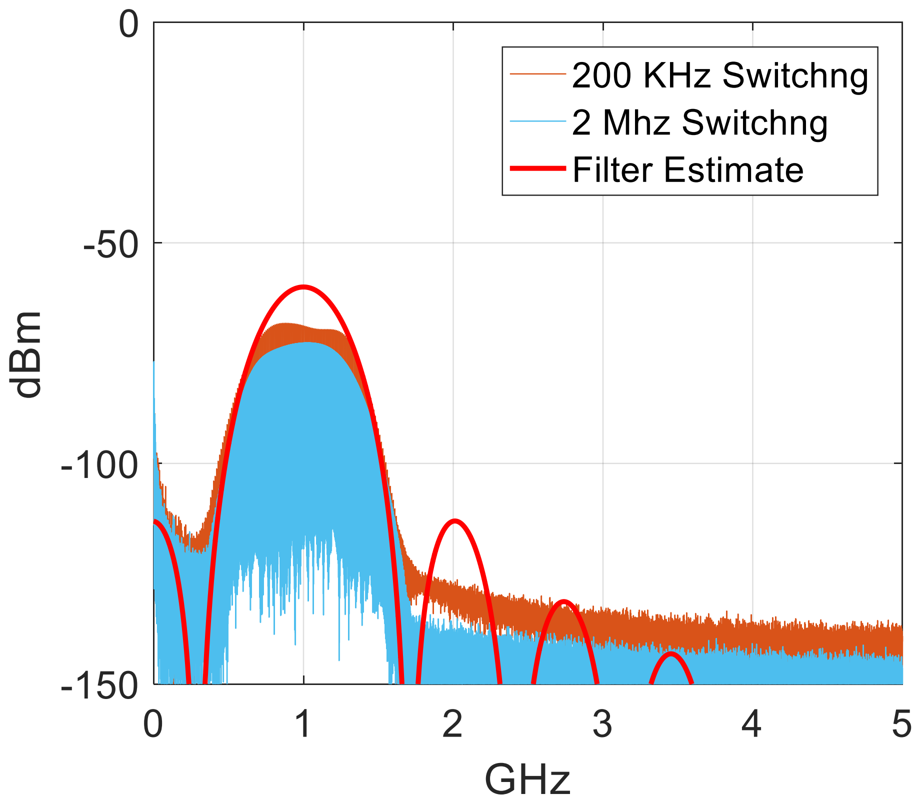
- ❑ For
- ❑ t_{switch} = 200 KHz and 2 MHz
- ❑ t_{spike} = 1 ns
- ❑ t_{delay} = 2 ns



Now we add to the plot:
an η_0 PSD filter estimate
(adjusted for 1 mV RMS of the original signal)

Filter estimate by comparing to PSD of the noise

$$H_e(f) = sinc\left(\frac{f - f_{spike}}{f_{spike}}\sqrt{2}\right)^2$$



Recommendation

Go back to the original, η_0=5.2e-8 V^2/GHz

But add system noise filter, *$H_e(f)$,* to equation (93A-35)

$$H_e(f) = sinc\left(\frac{f - f_{spike}}{f_{spike}}\sqrt{2}\right)^2$$, where f_{spike}=1 GHz

$H_e(f)$

$$\sigma_N^2 = \eta_0 \int_0^\infty |H_r(f) H_{ctf}(f)|^2 df \qquad (93A\text{–}35)$$

Moving Forward

- ❑ Use the $H_e(f)$ recommendation as a starting point
- ❑ Power spectral density measurement of system noise would be useful
- ❑ The not a trivial measurement!
  - Instrument ground common mode noise can be an error term
  - Self-device noise is an error term which need to be removed
    - This noise is already included in SNDR and RIT
  - Sufficient loading activity in the reset of system is required