# Examination of SNDR and noise in COM

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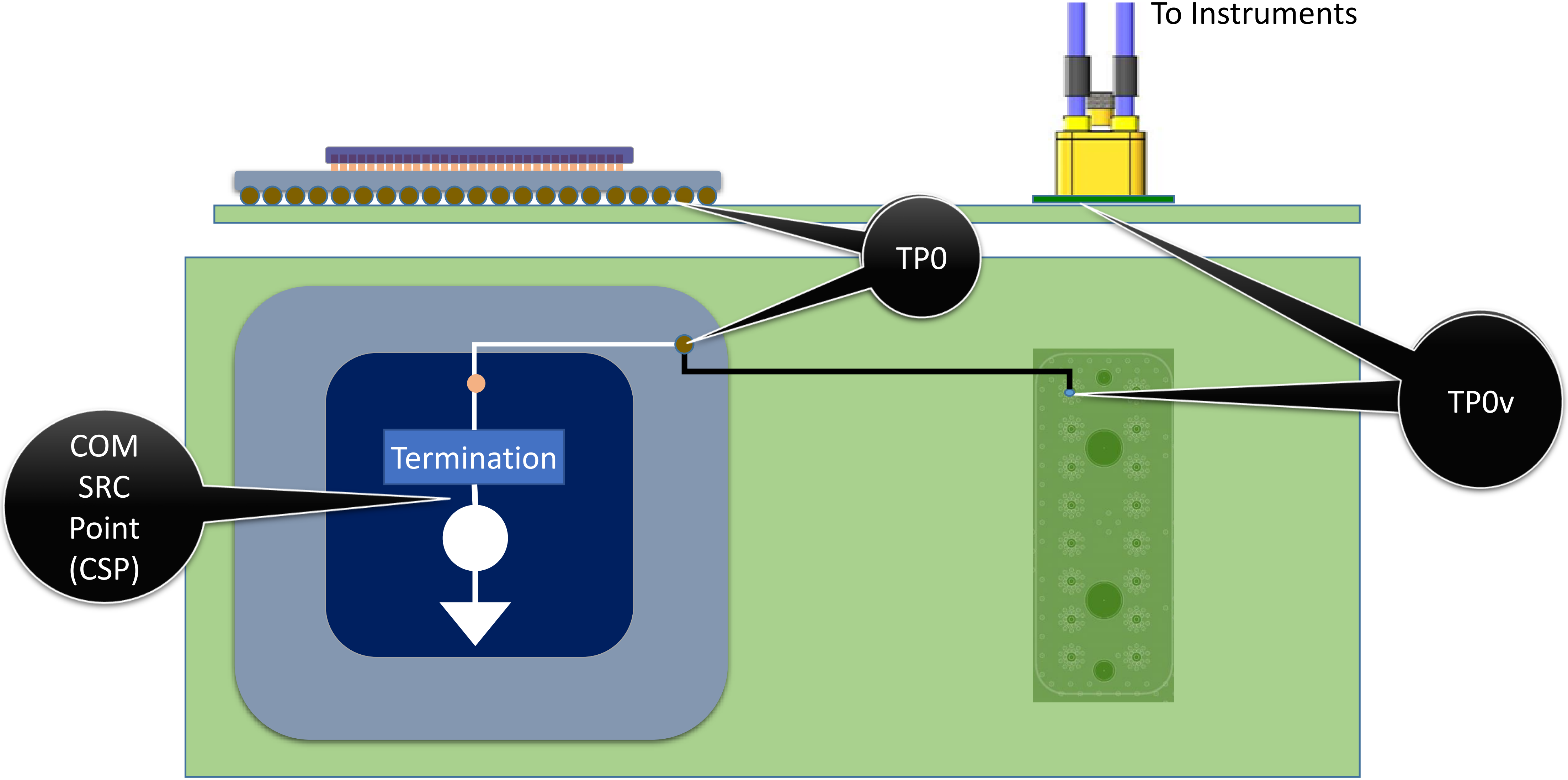
# Purpose

- ❑ SNR_Tx has a strong impact on COM
- ❑ Revisit SNDR and $SNR_{TX}$
- ❑ Examine Assumptions
- ❑ Usage and measurements
- ❑ Summary/Conclusion

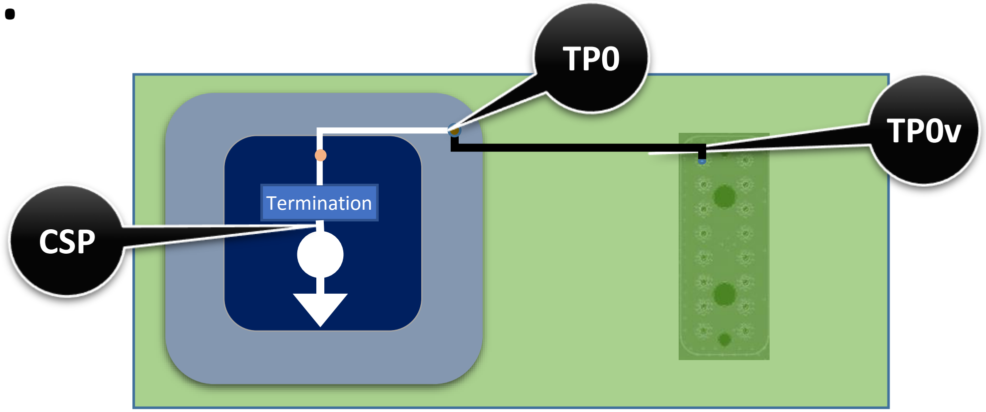
# SNDR and $SNR_{TX}$ Background

- $SNR_{TX}$ is related to the SNDR measurement
- There is some thinking that SNR_Tx is the limit for SNDR minus a small implementation penalty
  - I.e. SNR_Tx = SNDR limit - ½ dB
- $SNR_{TX}$ is used as noise source at the receive "sampler" in COM computations
- SNDR is measured at TP0v
- Now ,SNDR is adjusted to a COM reference package and reference source
- Let's see what this all means

# Different Reference Points

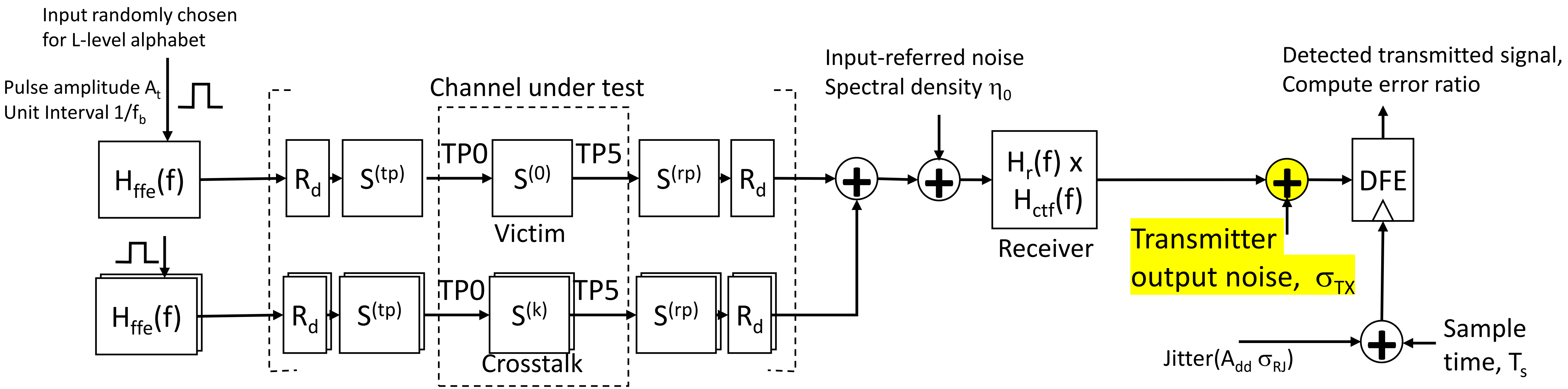


# Clarifying Points of Interest.




- TP0 is transmitter end of a channel
  - Channel s-parameter are measured between Tp0 and Tp5
  - These s-parameters are used in the COM computation
- The COM source point (CSP) is the point where transmitter source are reference to, both of signal and noise.
  - In COM a reference package and termination is cascaded to TP0 (and TP5).
- A transmitter device is measured at TP0v (old TP0a)
- In order to be useful for COM computation measurements and specifications are referenced back to the CSP
  - $A_v$, $A_{fe}$, and $A_{ne}$ are examples

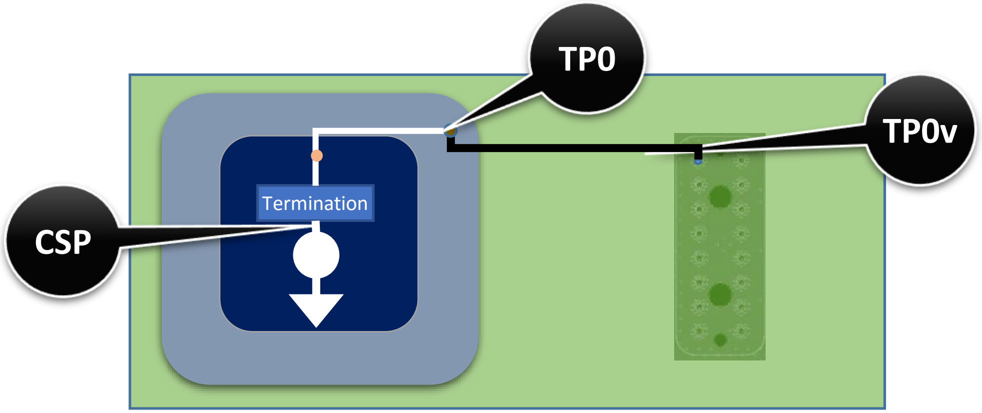
# Review of equation Figure 93A-1 with Eq. 93A-30




- $\sigma_{TX}^2 = \left[h^{(0)}(t_s)\right]^2 10^{-\frac{SNR_{TX}}{10}}$
- $h^{(0)}(t_s)$ is the available signal, $A_s$
- $SNR_{TX}$ is 20*log10( $A_s$/noise)

The idea is that noise scales with $A_s$

# Experiments to understand SNDR measured at TP0v

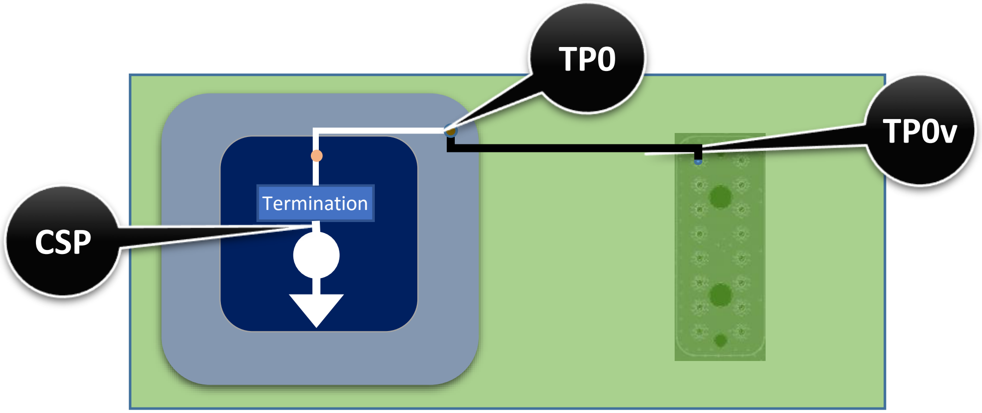


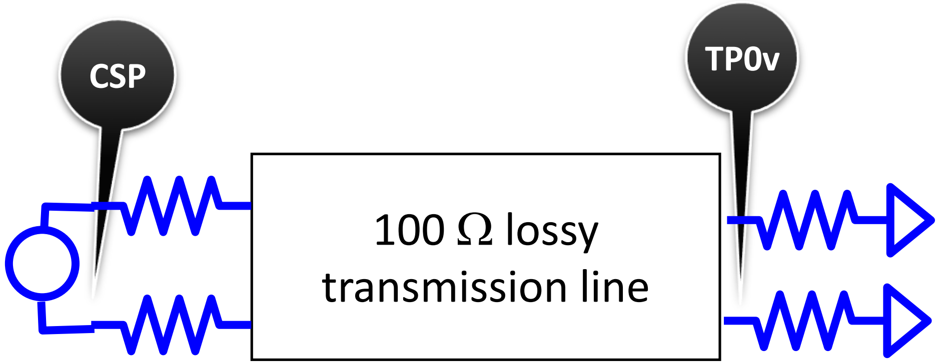

$SNDR = 10log_{10}\left(\frac{p_{max}^2}{\sigma_e^2+\sigma_n^2}\right)$ … equation 92.9

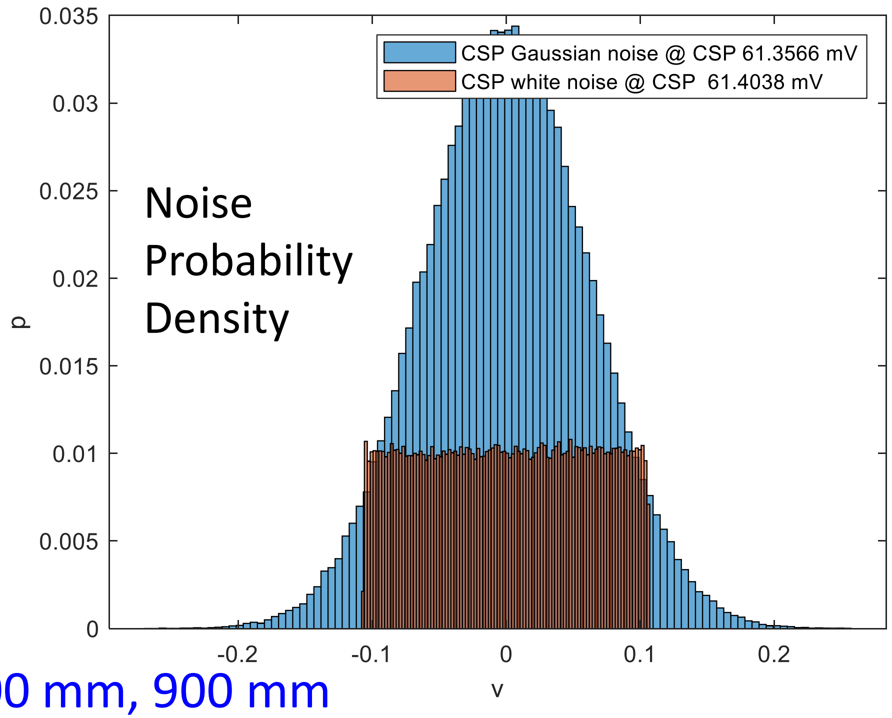
- ❑ Pmax is equivalent to pulse height at TP0v
- ❑ Signal distortion in equivalent to $\sigma_e$
  - Could be correlated noise source
- ❑ Other noise sources are equivalent to $\sigma_n$
  - Could be uncorrelated

- ❑ The experiment will use a uncorrelated noise source which is $\sigma$
- ❑ So that $SNDR = 10log_{10}\left(\frac{p_{max}^2}{\sigma^2}\right)$

# Set Up the Circuit

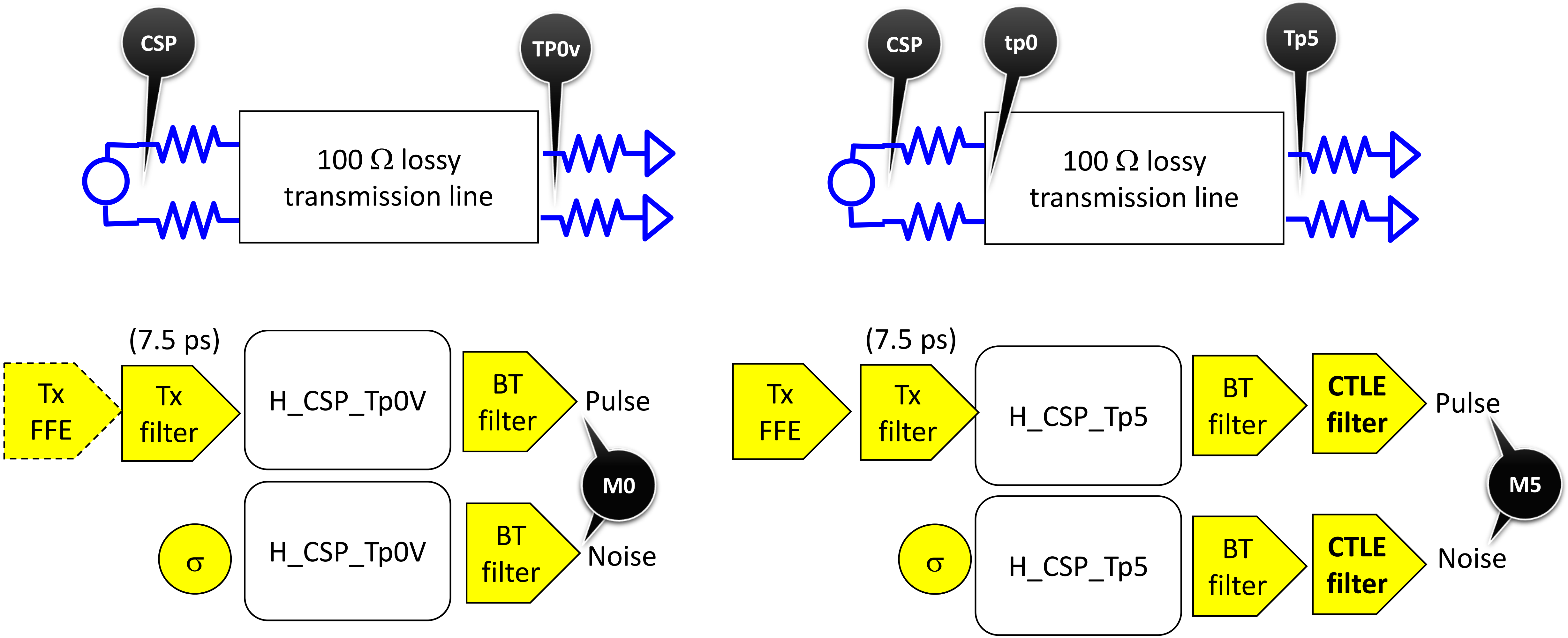


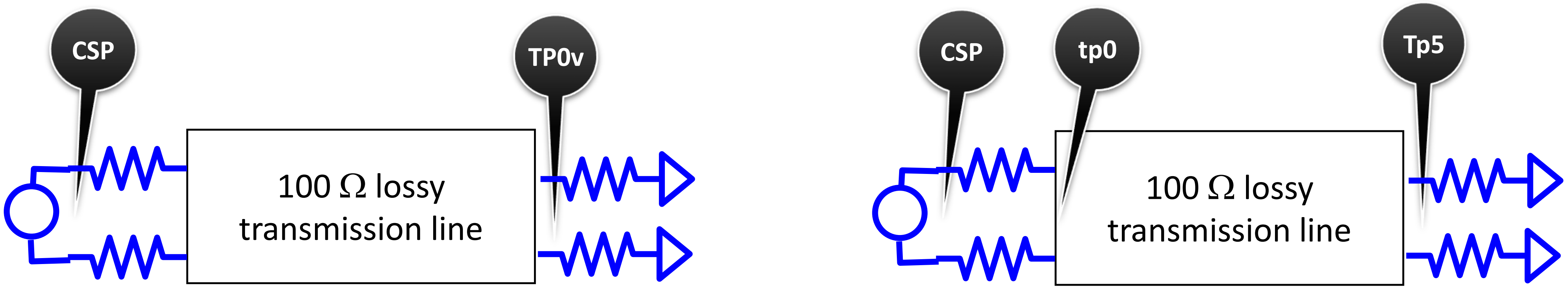



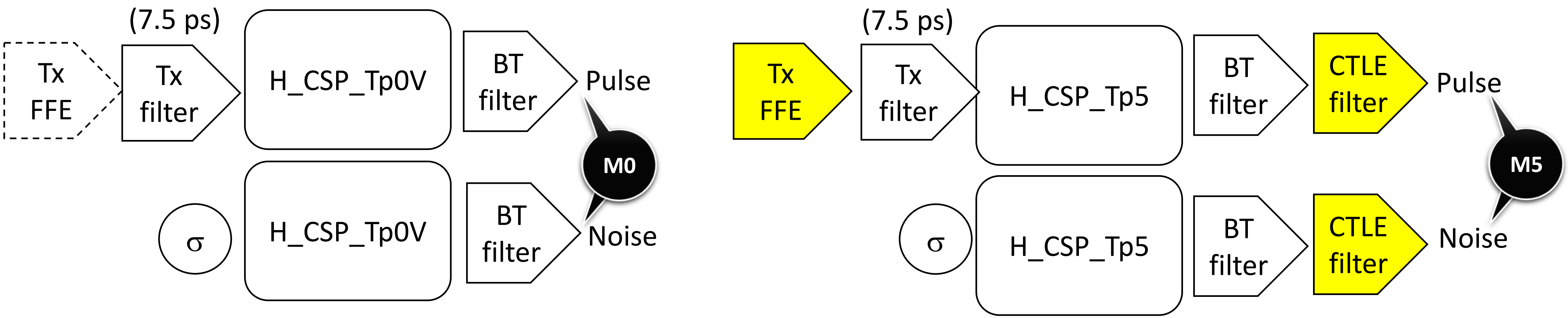

- 2 sources
  1) Unity pulse source (pulse height at CSP = 1)
  2) Two type of noise source with same RMS
     1) Uniform
     2) Gaussian
- Selection to transmission line length (losses)
  - 0 mm, 1mm, 60 mm, 30 mm pkg, 150 mm, 300 mm, 600 mm, 900 mm
    - Fb for following example is 53.125 GHz
    - Listed loss will be at 26.56 GHz
  - Except for the package, all lines are 100 ohms and similar to lines used in table 162-19

# CTLE filter is included at M5 but not at M0

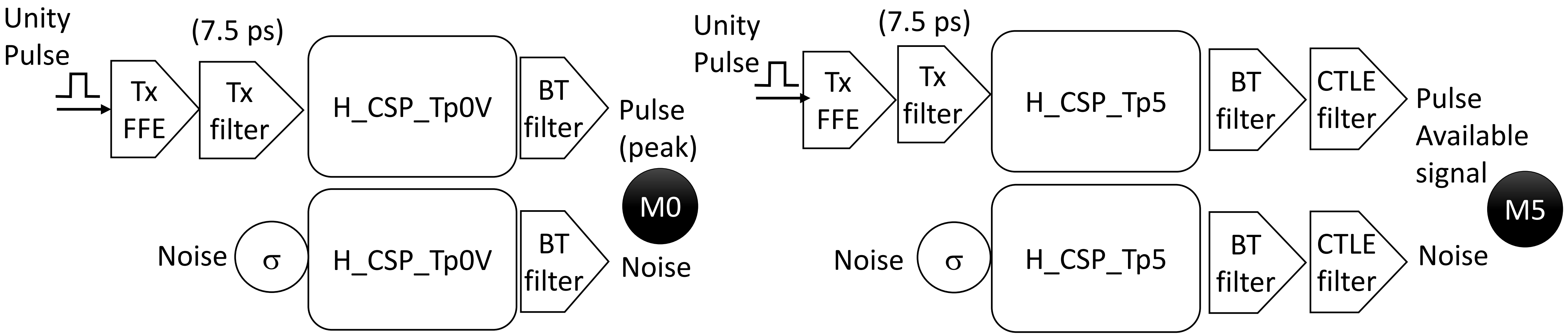


# For SNR$_{TX}$, Do filters matter?



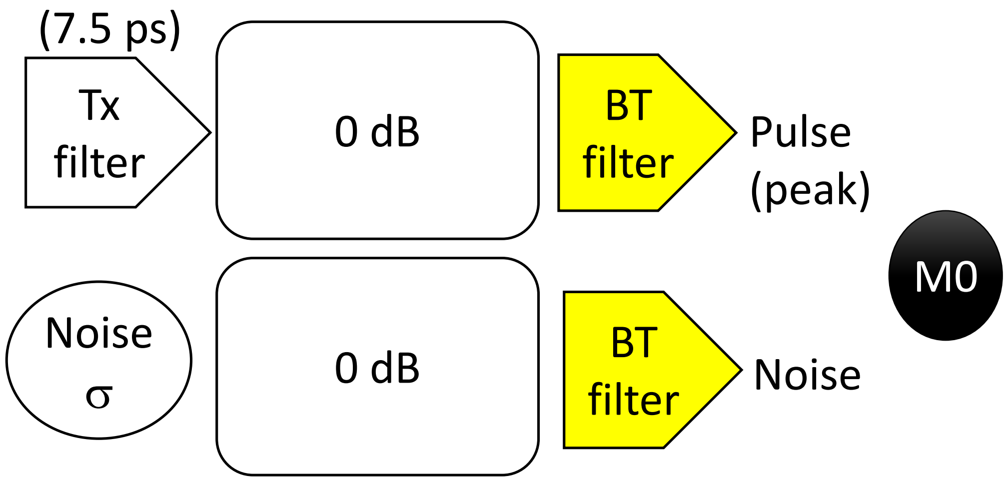



# Compare SNR at M0 and M5 (same channel)



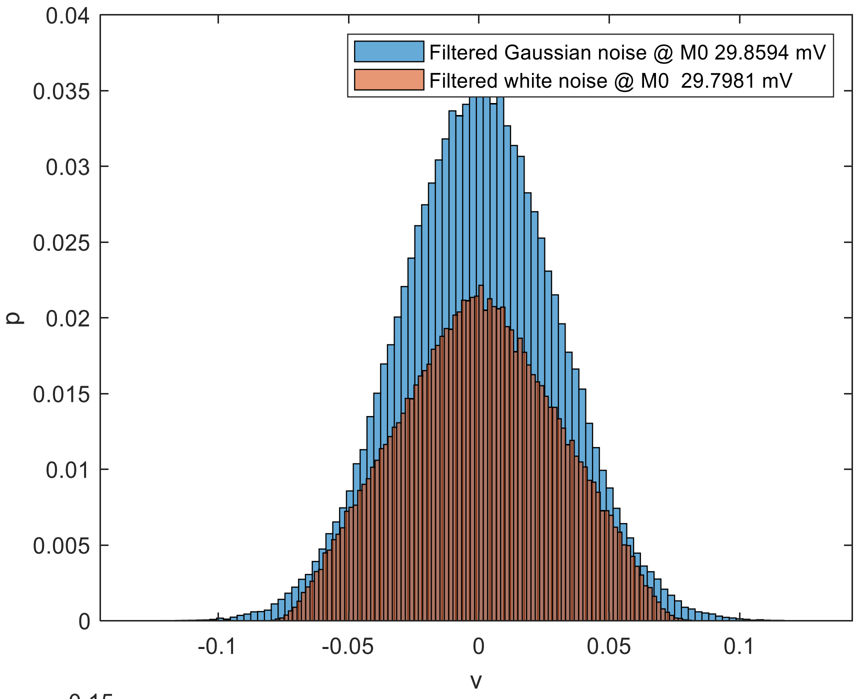

- 2 sources
  - Unity Pulse
  - Noise
- Txffe and CTLE settings are determined using COM algorithms
- No Jitter or other noise sources

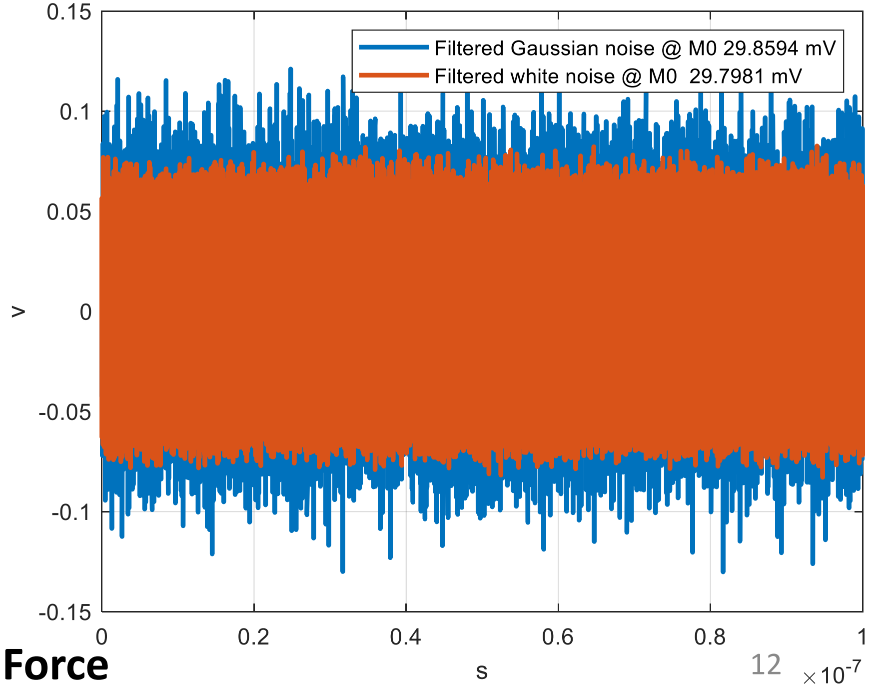
# The **0 dB** loss channel with the transition time filter and a Bessel-Thomson filter yields ~ 30 mV RMS noise



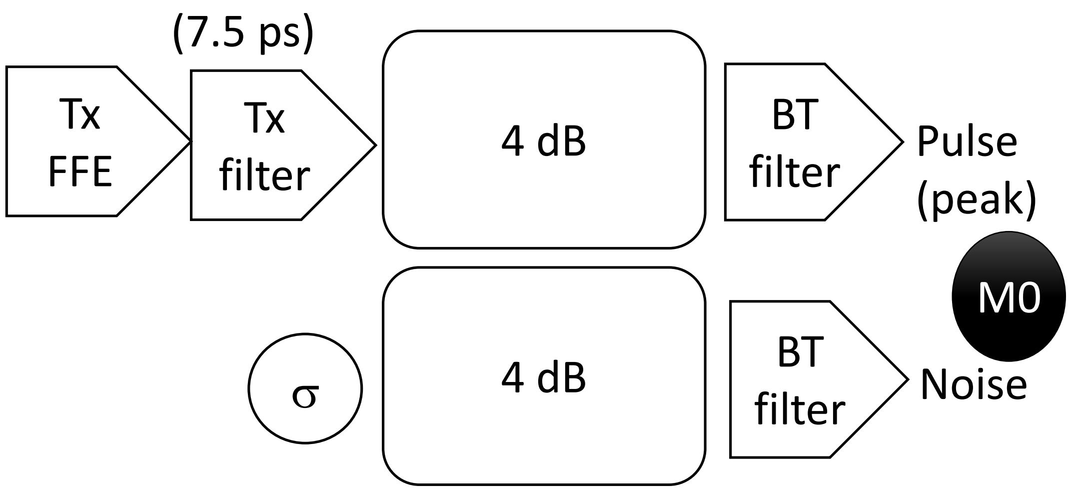

SNDR ~= 29.5 dB

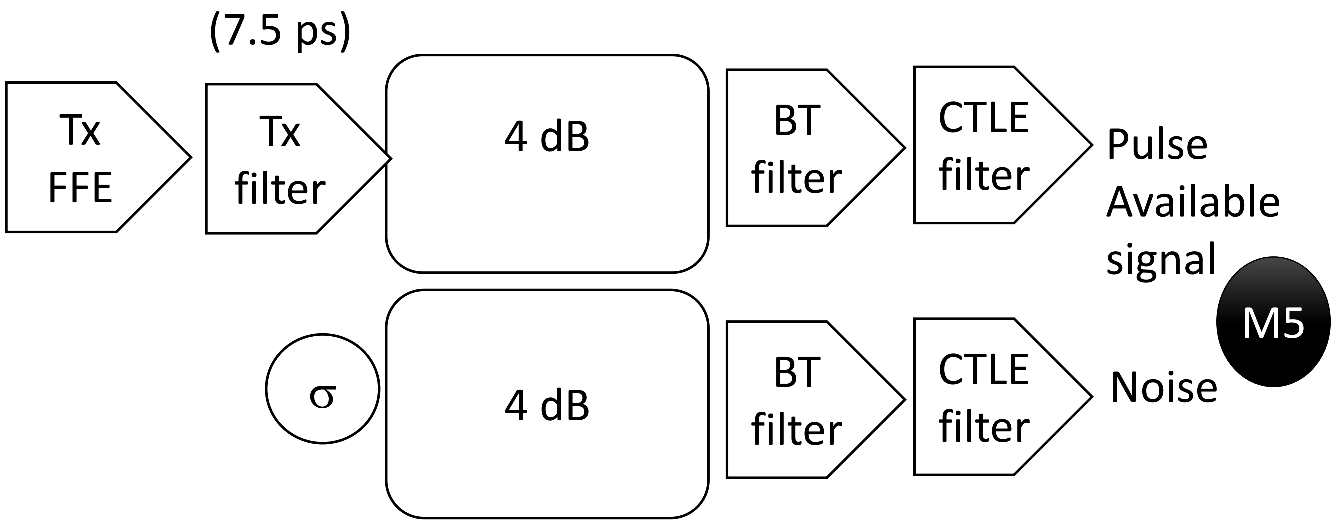
- 20*log10(Pmax/rms(noise))
- How much signal and noise make it to the receive sampler



# Channel with ~4 dB loss i.e. 30 mm .3ck package Show differ SNR at M0 vs. M5

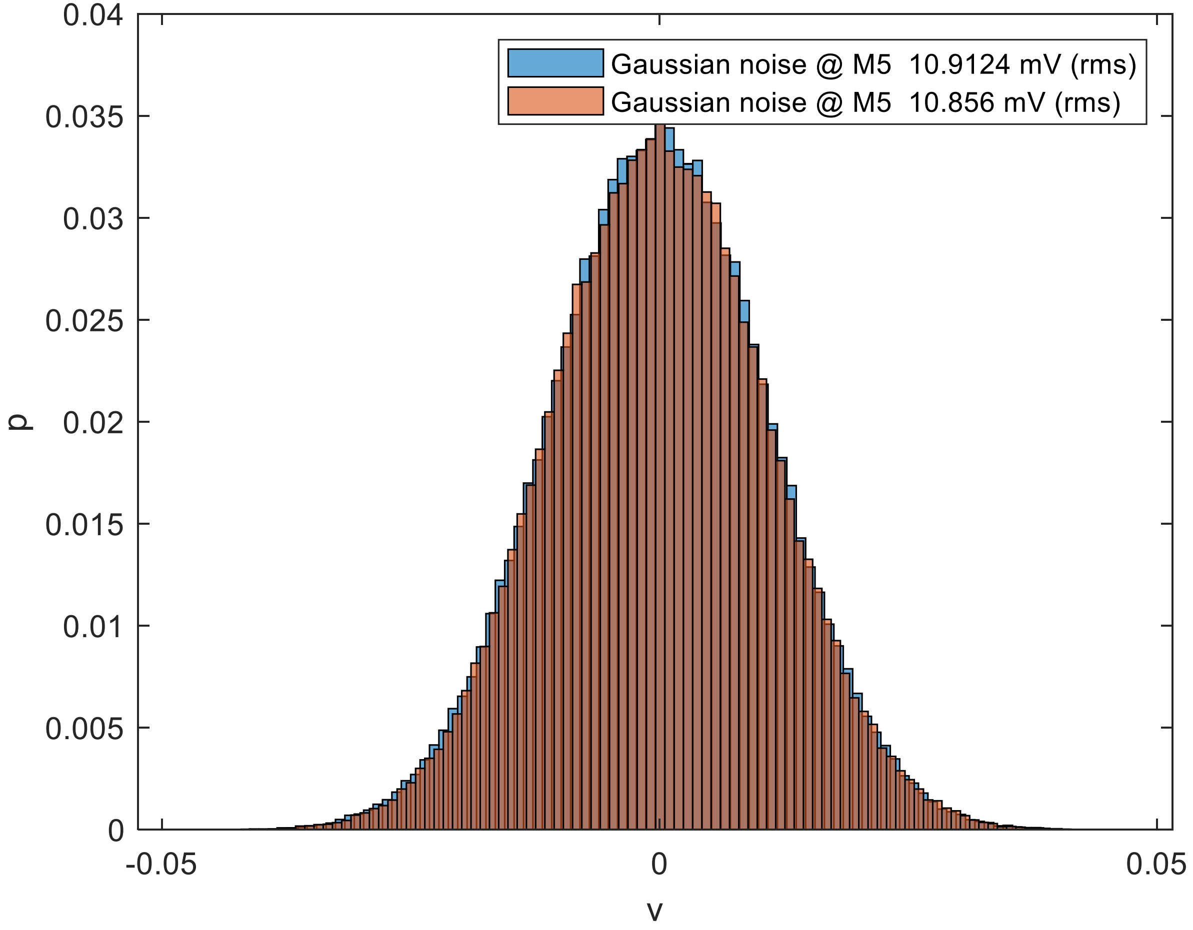



- For noise use an AWGN with rms(noise) at M0 is 10 mV
- SNR @M0 ~= 21.3 dB
- SNR @M5 ~ = 32.7 dB
- This suggest that noise from $SNR_{TX}$ used in COM might be overestimated
- Next: same experiment with different losses

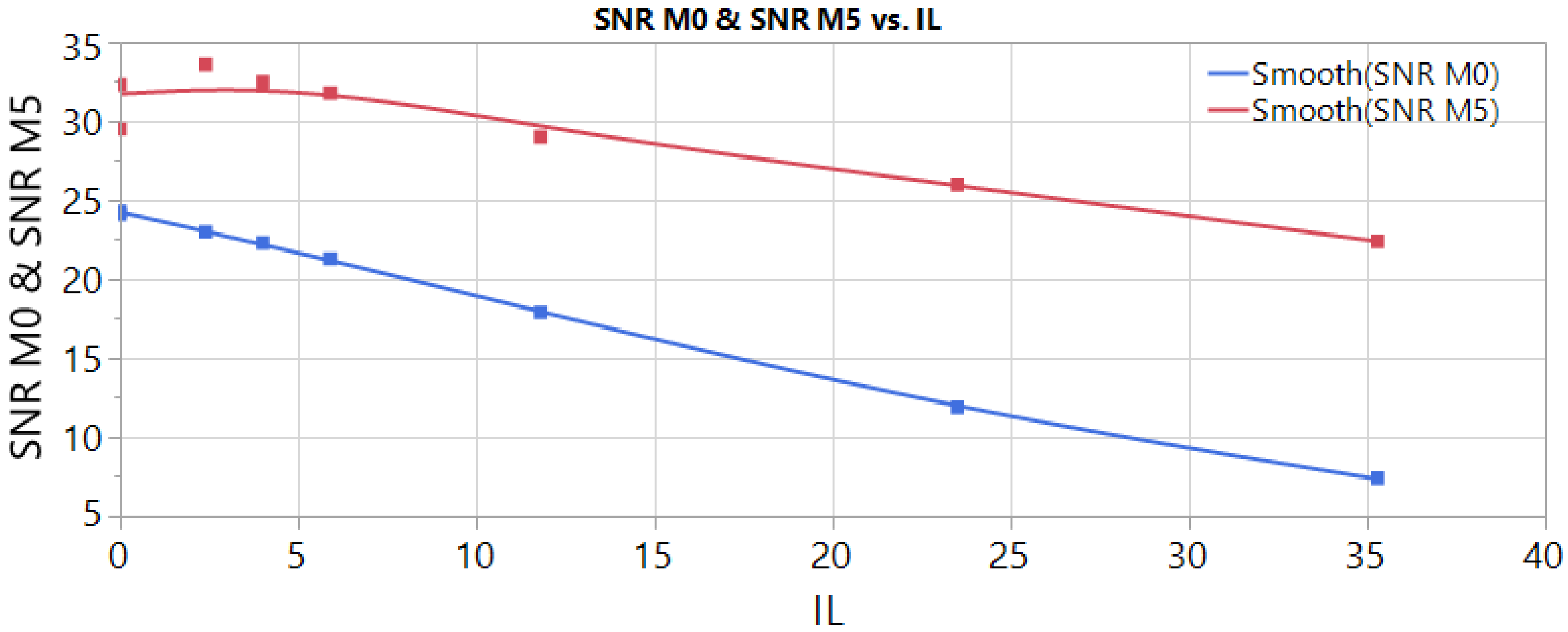
# Interesting Observation

- Noise PDF's measured at the end of a lossy channel (M5) seems to be somewhat independent of the PDF of the source noise

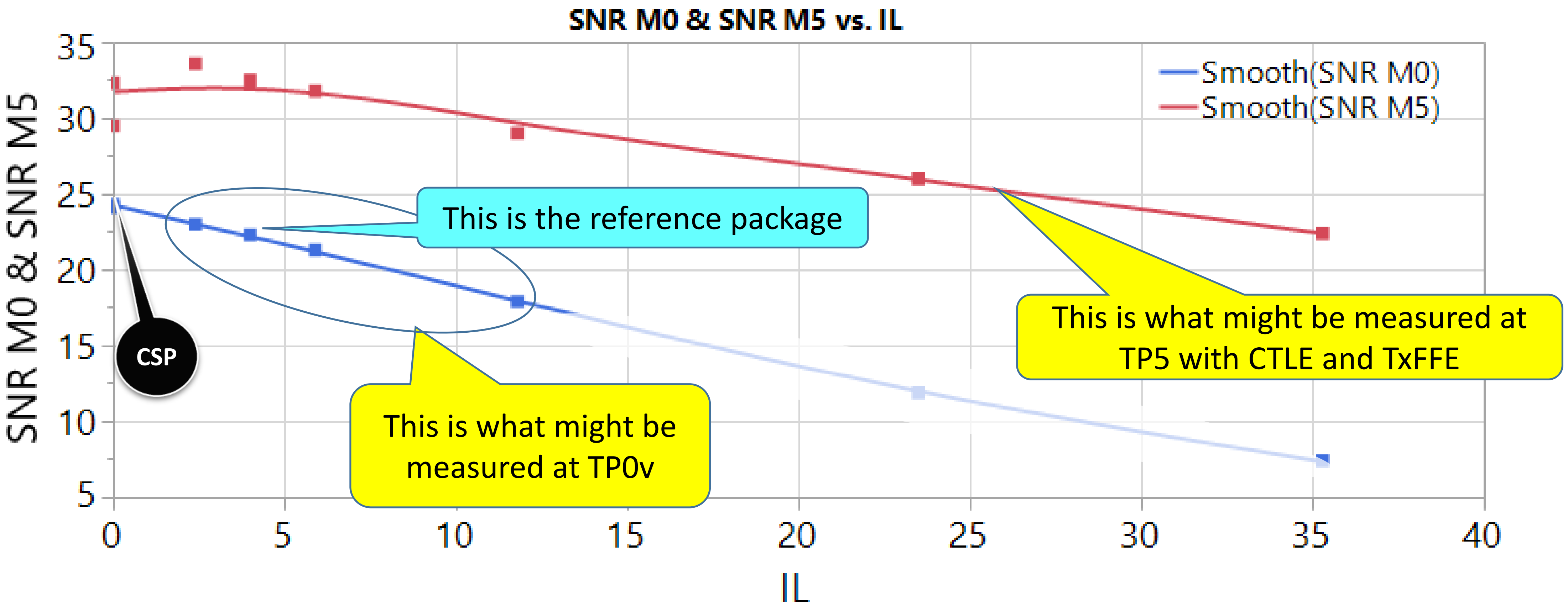


# Losses range from 0 d to 35.3 dB (@26.56 GHz)

| | - | 1mm | 60 mm | 30 mm pkg | 150 mm | 300 mm | 600 mm | 900 mm |
|---|---|---|---|---|---|---|---|---|
| IL (db) | 0.0 | ~0.0 | 2.4 | 4.0 | 5.9 | 11.8 | 23.5 | 35.3 |
| SNR (db) @M0 | 24.1 | 24.3 | 23.0 | 22.3 | 21.3 | 17.9 | 11.9 | 7.4 |
| SNR (db) @M5 | 29.5 | 32.3 | 33.6 | 32.5 | 31.8 | 29.0 | 26.0 | 22.4 |

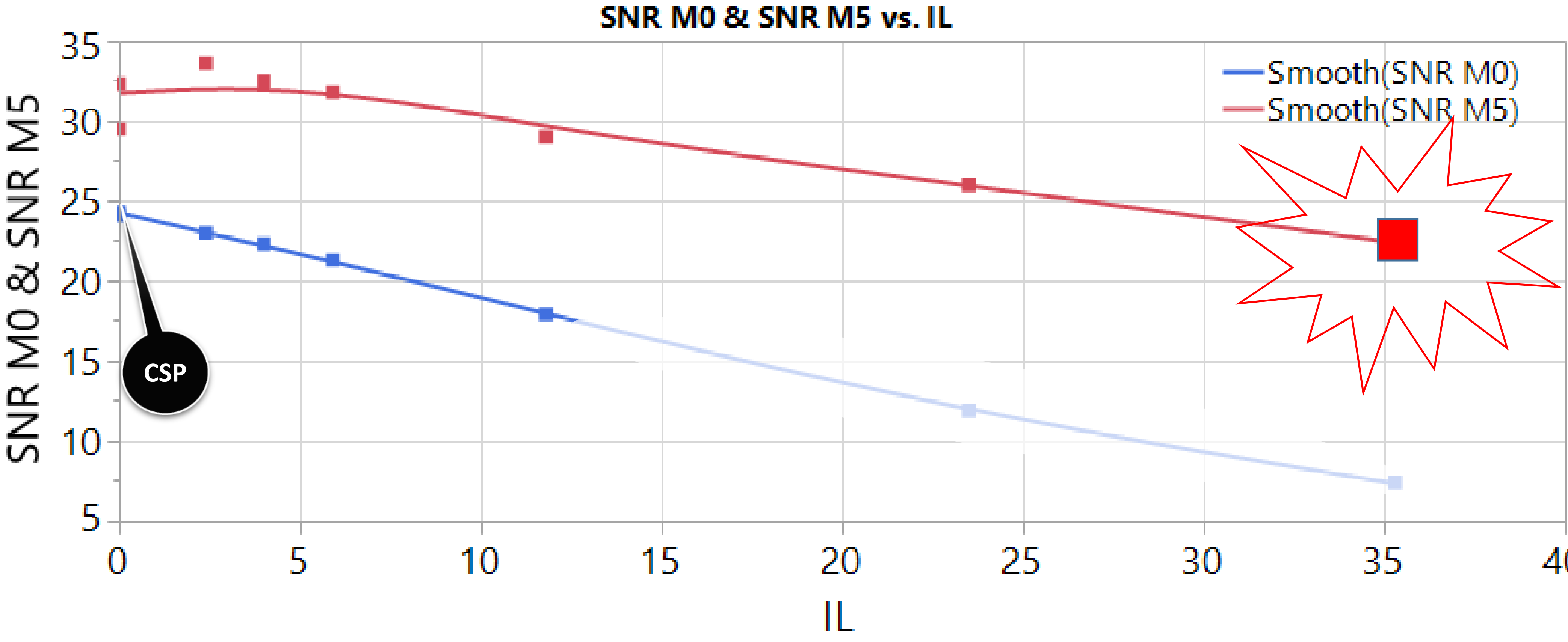


# Thoughts on measuring at TP0v and TP5 for COM



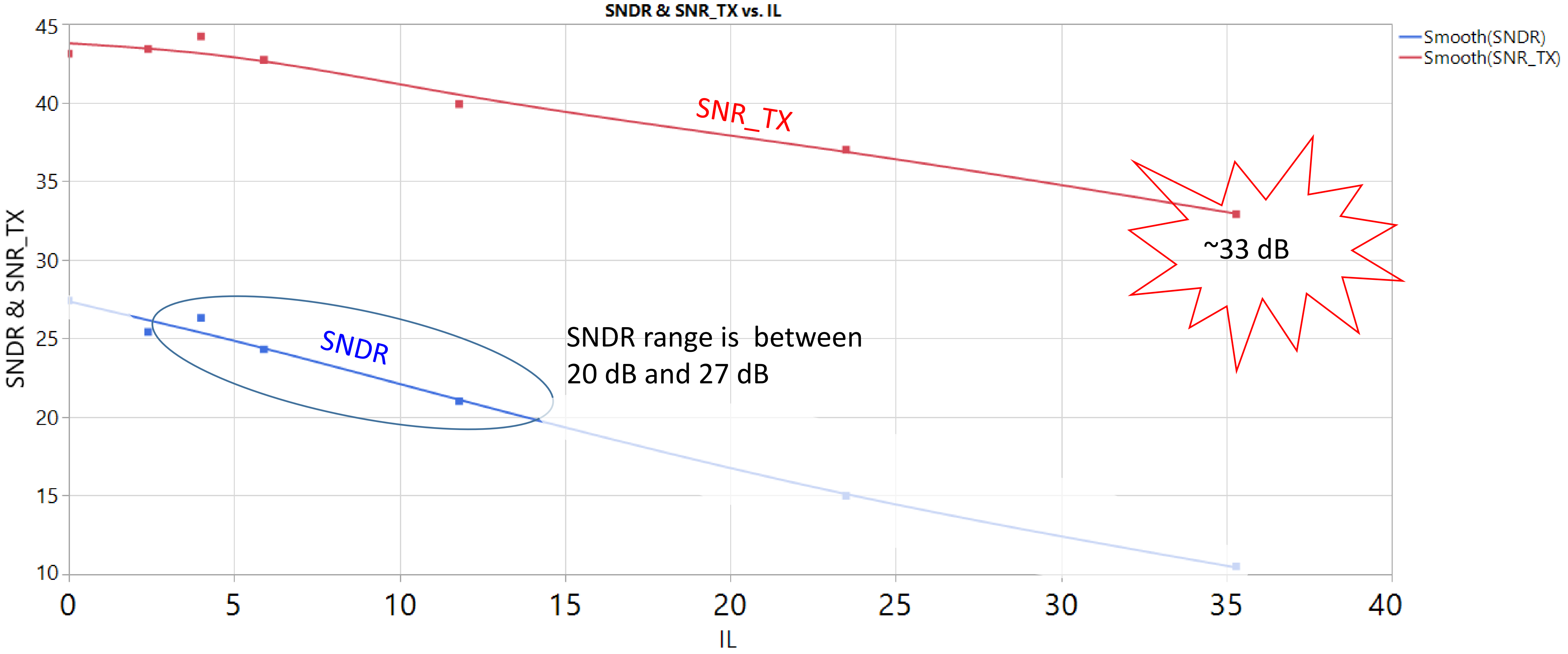

**It seem that evaluation of SNDR measured at TP0v extrapolated back to point CPS will need to adjust for the actual response H(f)**

# Let's say we need SNR_Tx to be 33 dB for 36 dB loss channel




33 dB SNR_Tx would back compute and adjusted to 413 mV Av the RMS unfiltered noise at CSP would be 7.354 mV

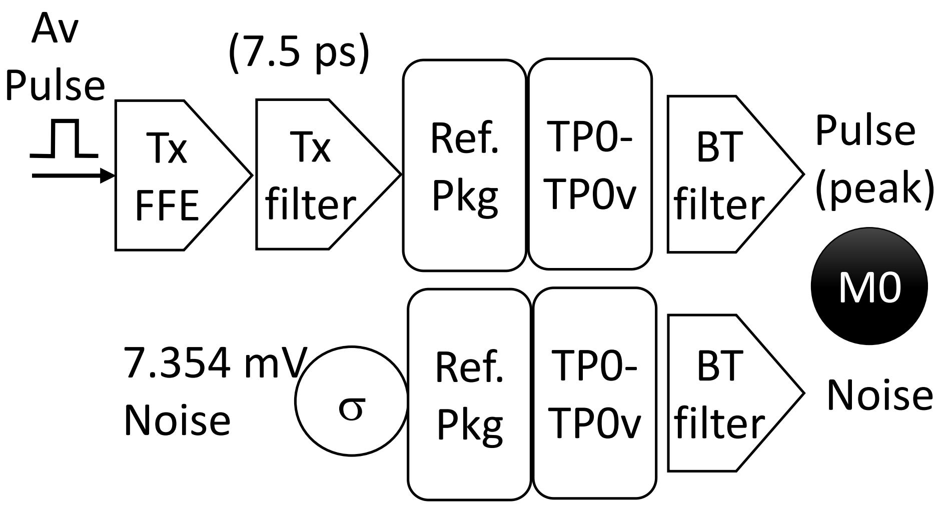
# Expected SNDR and SNR_Tx

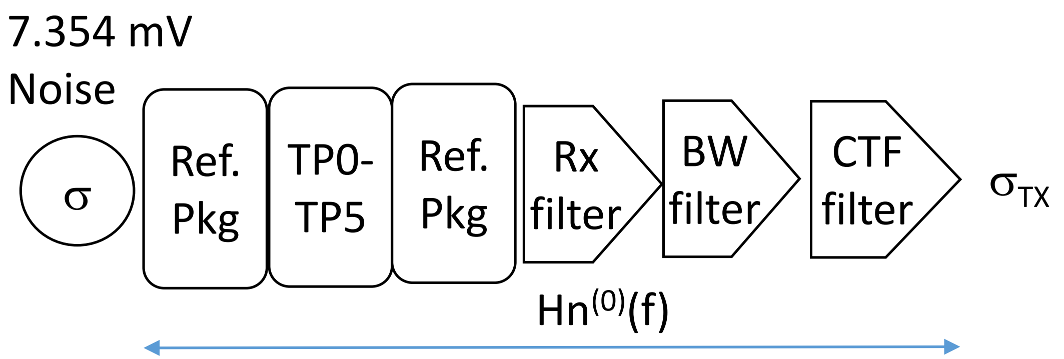



SNDR range is between 20 dB and 27 dB

# Usage

M5




Finding SNDR limit

- ❑ Use Av minimum as in standard
- ❑ Apply specified filters
- ❑ Use AWGN noise w/RMS of 7.354 mV
- ❑ SNDR limit becomes SNR at M0

Using $\sigma_{TX}$

- ❑ Reduces to use the raw $\sigma$ at CSP
- ❑ Compute $\sigma_{TX}$ using integration of $Hn^{(0)}(f)$ (Eq.93A=19, w/o Tx filters) and the raw AWGN

# Conclusion

- ❑ SNDR at the TP0v can utilize a raw AWGN (at CSP) of a specified RMS
- ❑ Transmitter noise at the receiver ($\sigma_{TX}$)should be computed from the specified AWGN at CSP times the integration of the channel response.