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Measuring Amplifier Large Signal Noise Figure via Phase Noise

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Presentation Outline

- Noise Figure (NF) – What is it?
- Y-Factor NF Measurement
- Additive (Residual) Phase Noise Measurement
- Noise Figure Relating to Phase Noise
- Amplifiers in High Compression
- Large Signal NF and Oscillator Design
- Summary

Noise Figure

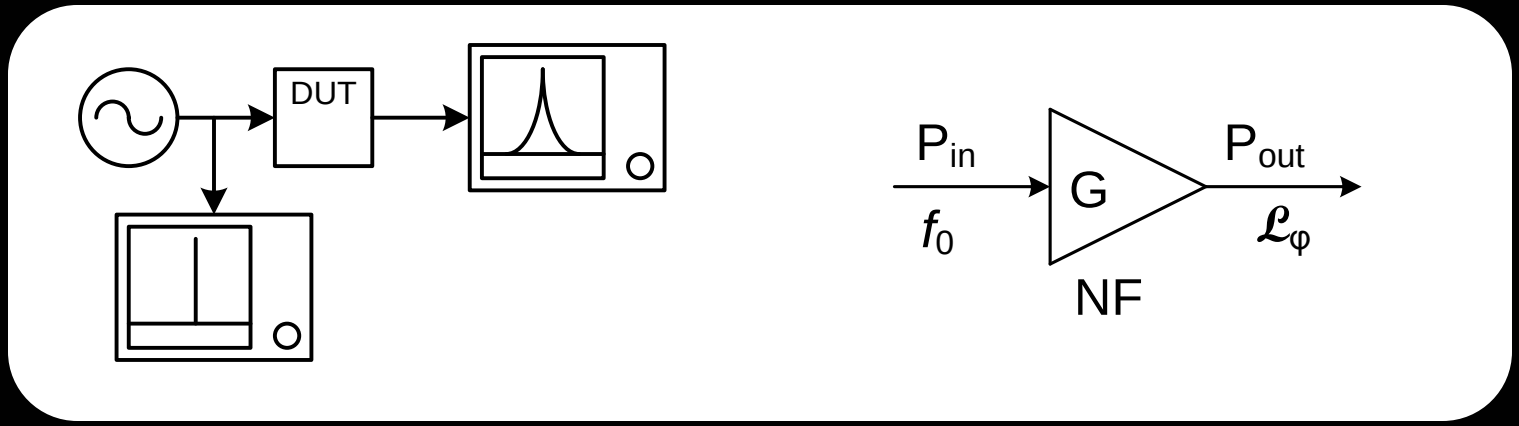
$$NF = SNR_{IN} - SNR_{OUT}$$

Y-Factor (Hot, Cold)

- Y-Factor measures in true small signal and mimics a receiver
- Easy Measurement, well accepted in industry.

- Y-Factor has no meaning in large signal!
- Only valid for class-A or AB type amplifiers with appropriate bias.
- High-Efficiency amplifiers CANNOT be measured.
- Y-Factor is a 4MHz AVERAGE of noise and gives no information close to the carrier.

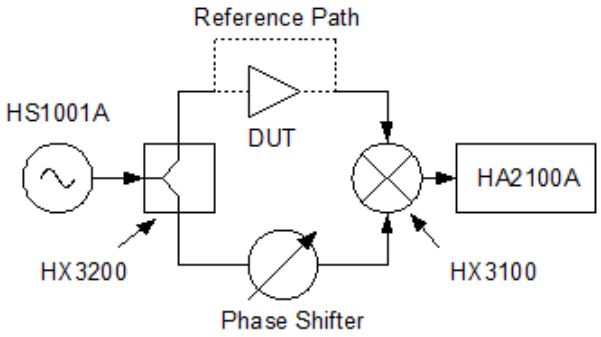
Additive Phase Noise with an '*Ideal*' Spectrum Analyzer



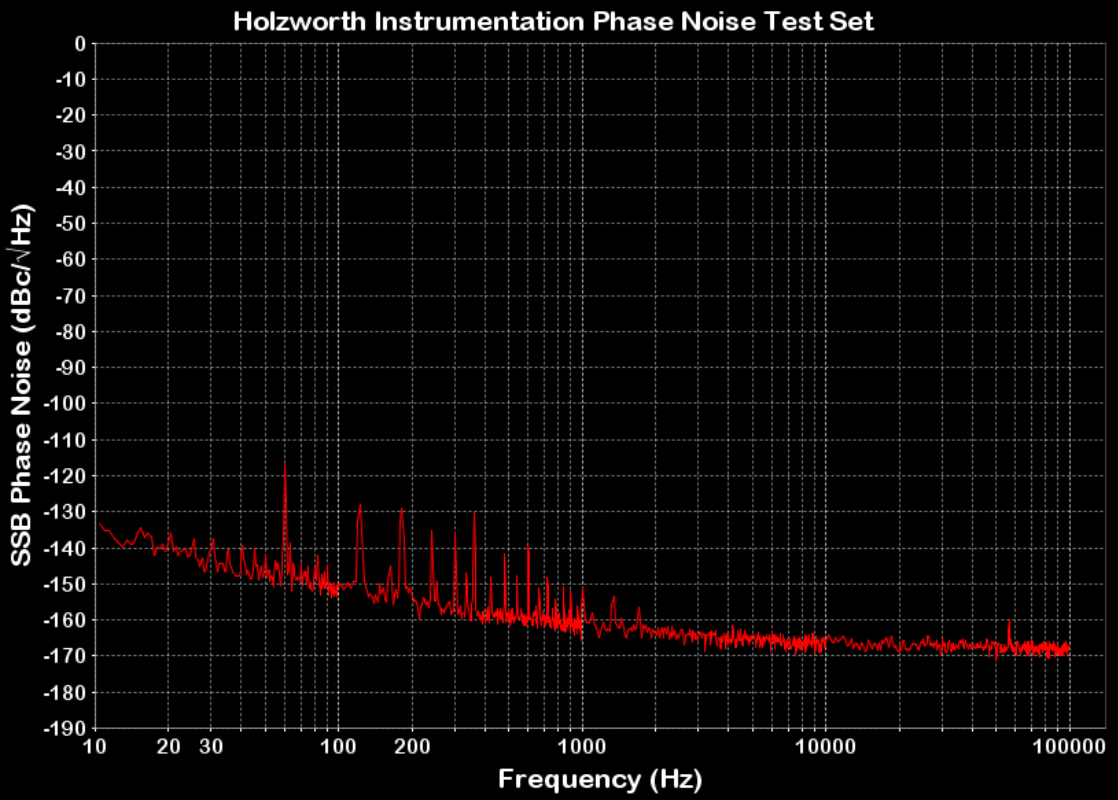
Ideal Spectrum Analyzers Don't Exist!

How do we measure Noise?

Additive Phase Noise Measurement (Discriminator)



$$\mathcal{L}_{\phi}[dBc/Hz]$$



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Phase Noise to Noise Figure

$$\mathcal{L}_{\phi}[dBc/Hz] = SNR_{OUT}(dBc)$$

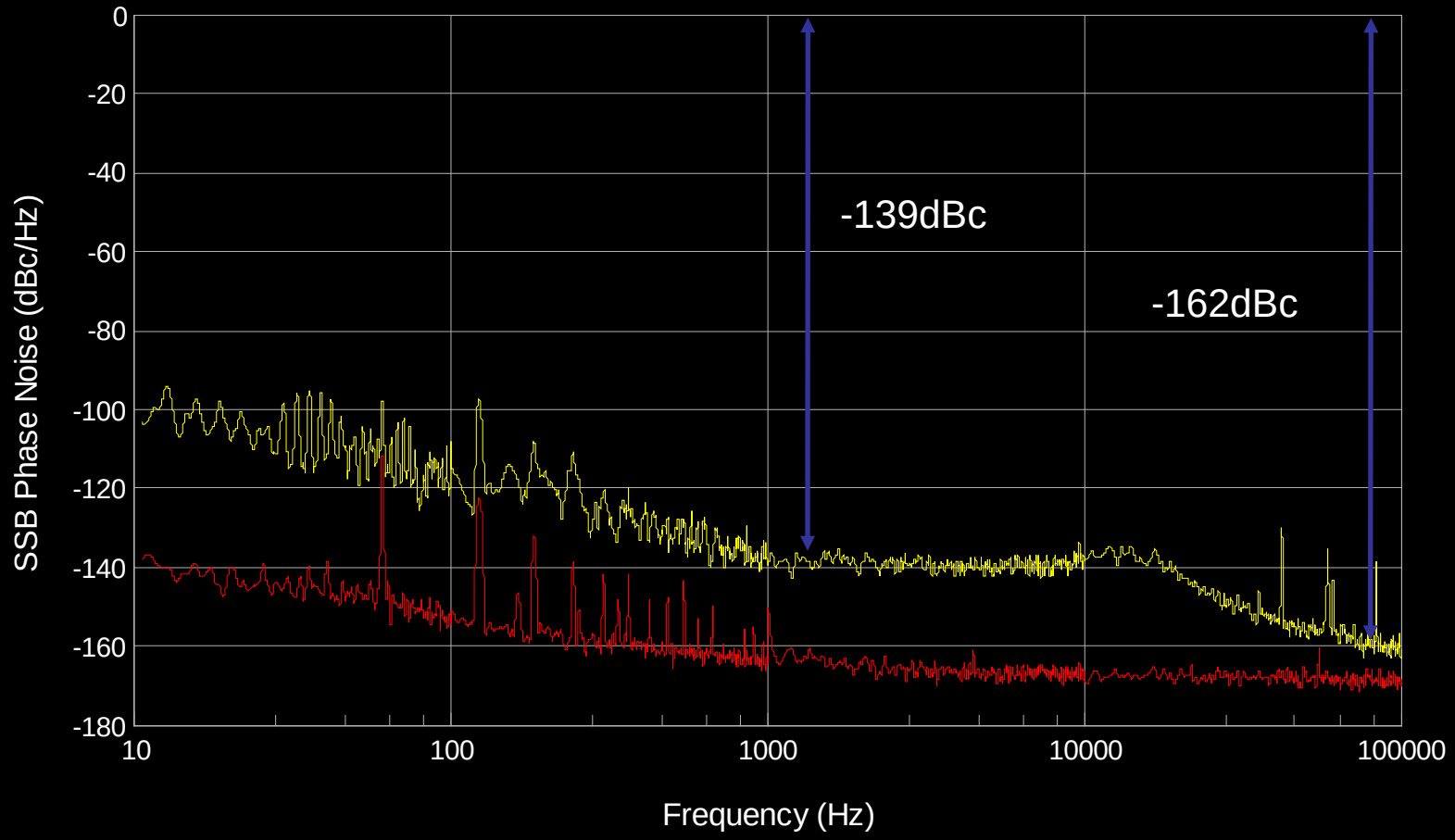
$$SNR_{OUT}(dBc) = \underbrace{-177dBm - P_{IN}(dBm)}_{SNR_{IN}(dBc)} + NF_{DUT}(dB)$$

$$NF_{DUT} = SNR_{OUT} - SNR_{IN}$$

Large Signal NF Measurements

Pin = 26dBm

NF(1k) = 64dB = -139dBc-(-177dBm-26dBm)
NF(100k) = 41dB = -162dBc-(-177dBm-26dBm)



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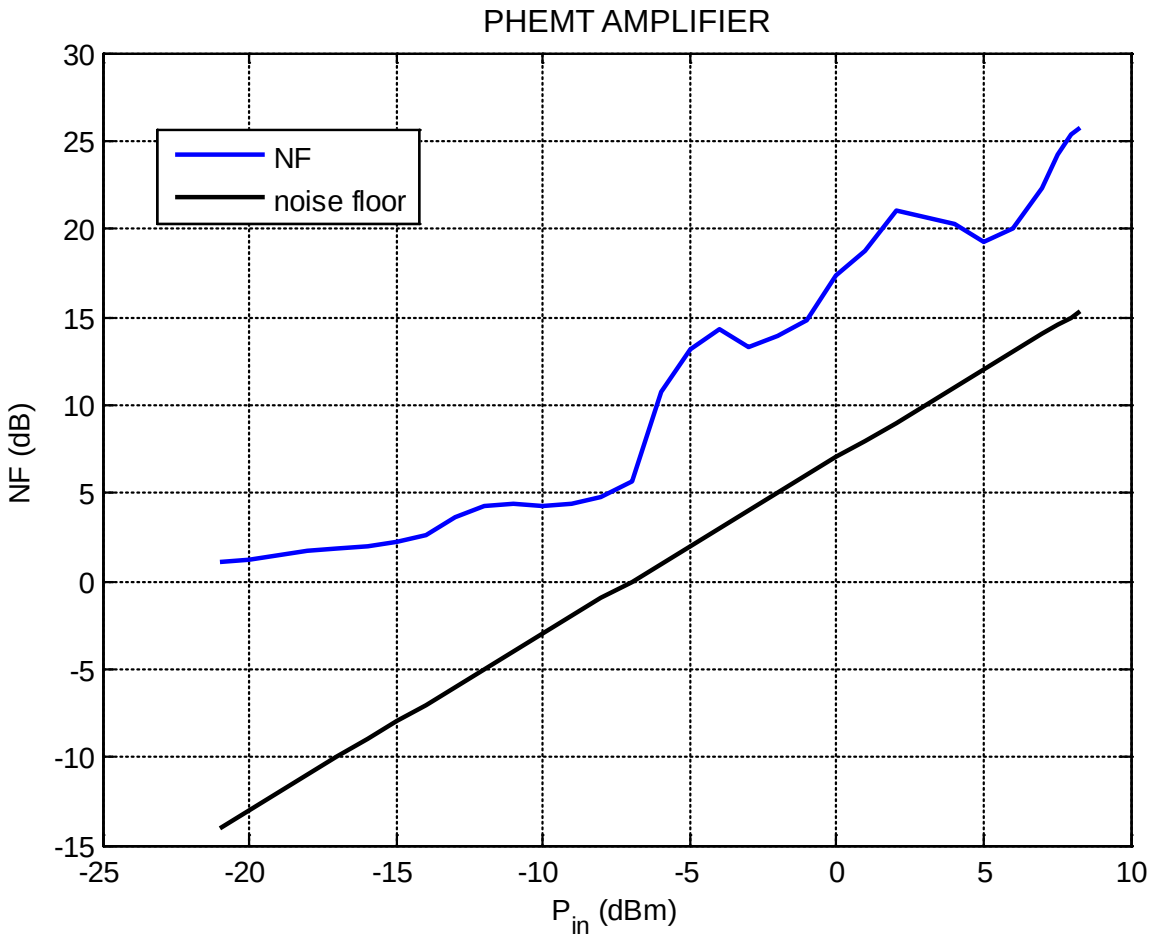
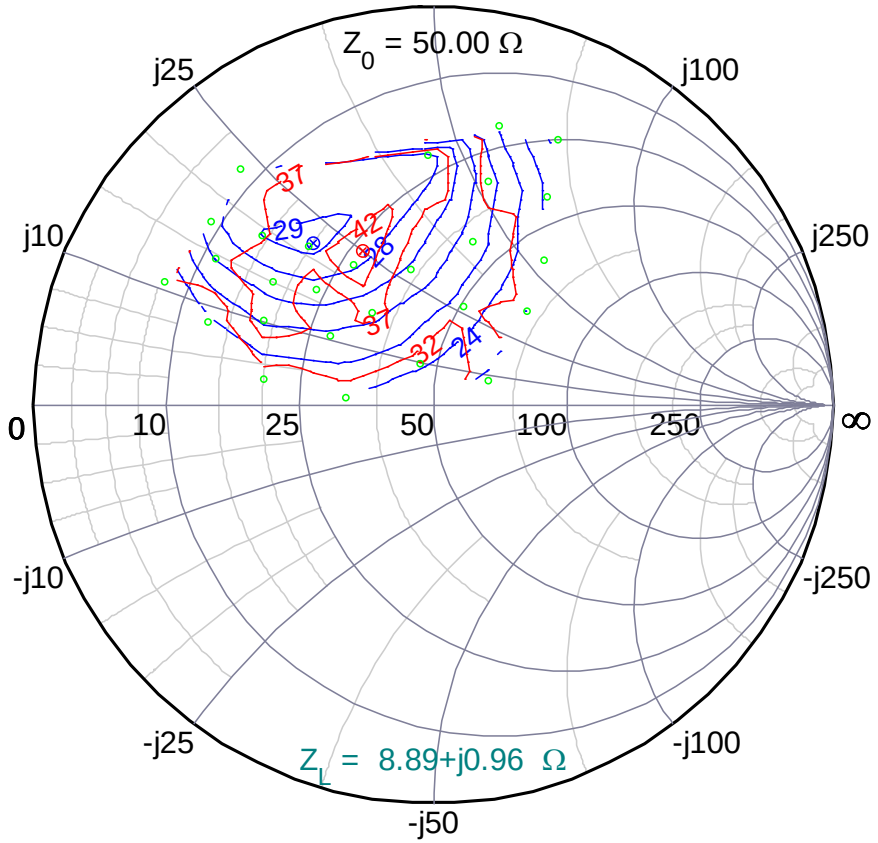
Noise Figure vs. Power Input



Noise Figure vs. Load Pull



Pout (dBm)

Large Signal NF

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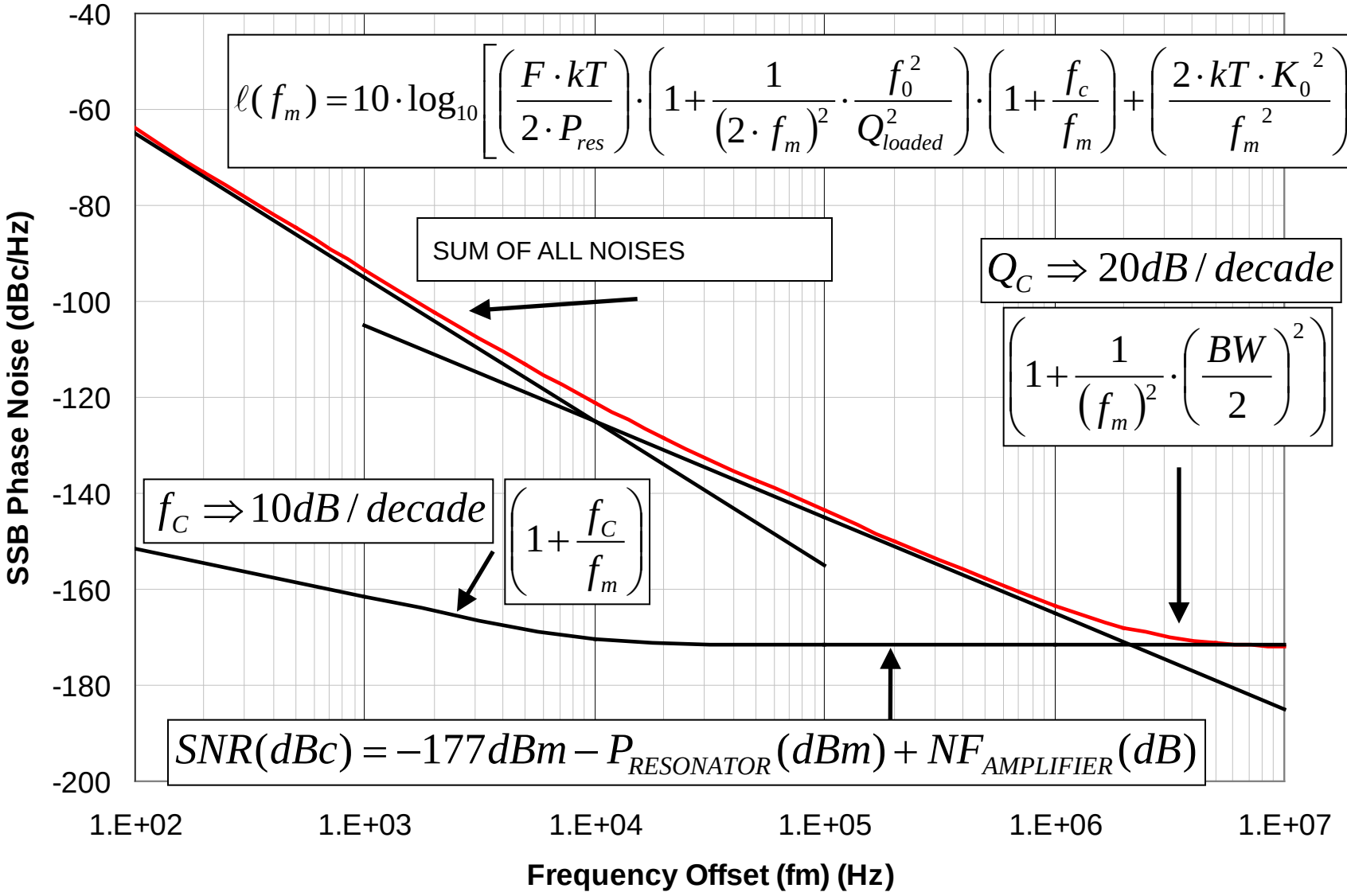
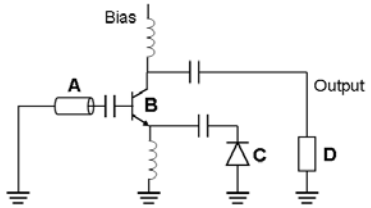
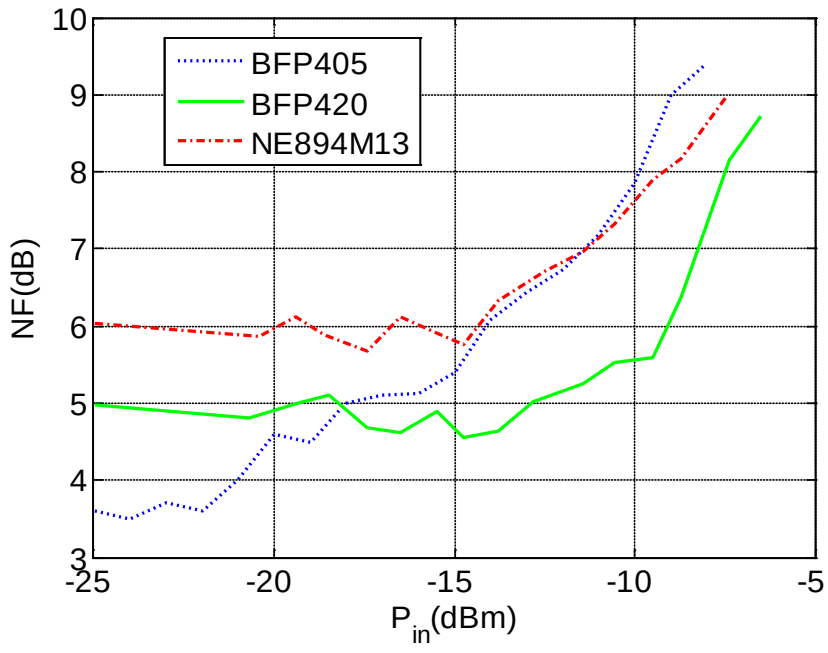


BJTs for 3.4GHz Low Power Oscillator

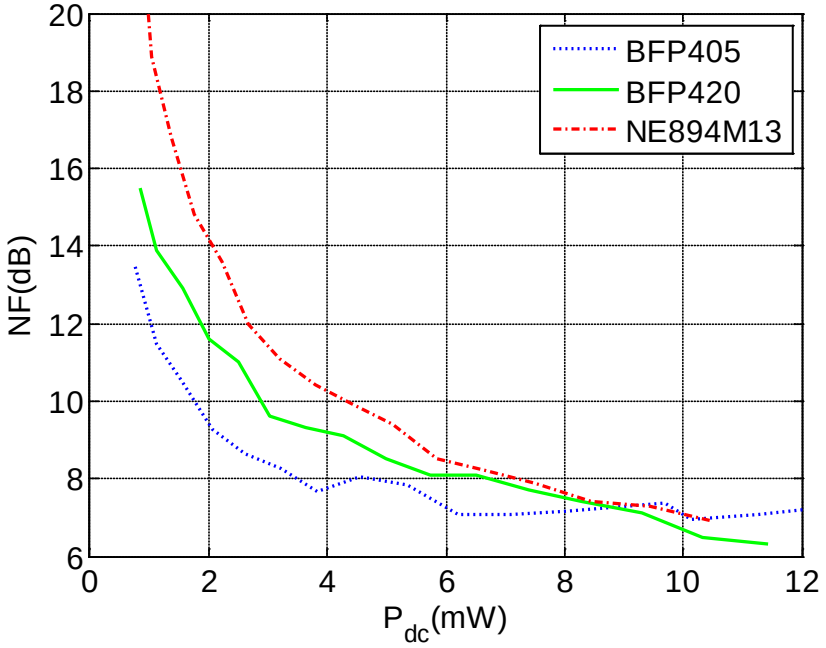
Data Sheet Noise Figure:
-BFP 405: 1.2 dB
-BFP 420: 1.15dB
-NE894M13: 1.4 dB



Standard Bias



3dB Compression



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Noise Figure Measurement Summary

- Y-Factor Method only for Class-A Amplifiers
- Low Noise Figure does NOT Equal Low Phase Noise
- Large Signal Noise Figure is the NF for Leeson's Equation
- NF is a function of Offset Frequency

THANK YOU

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