

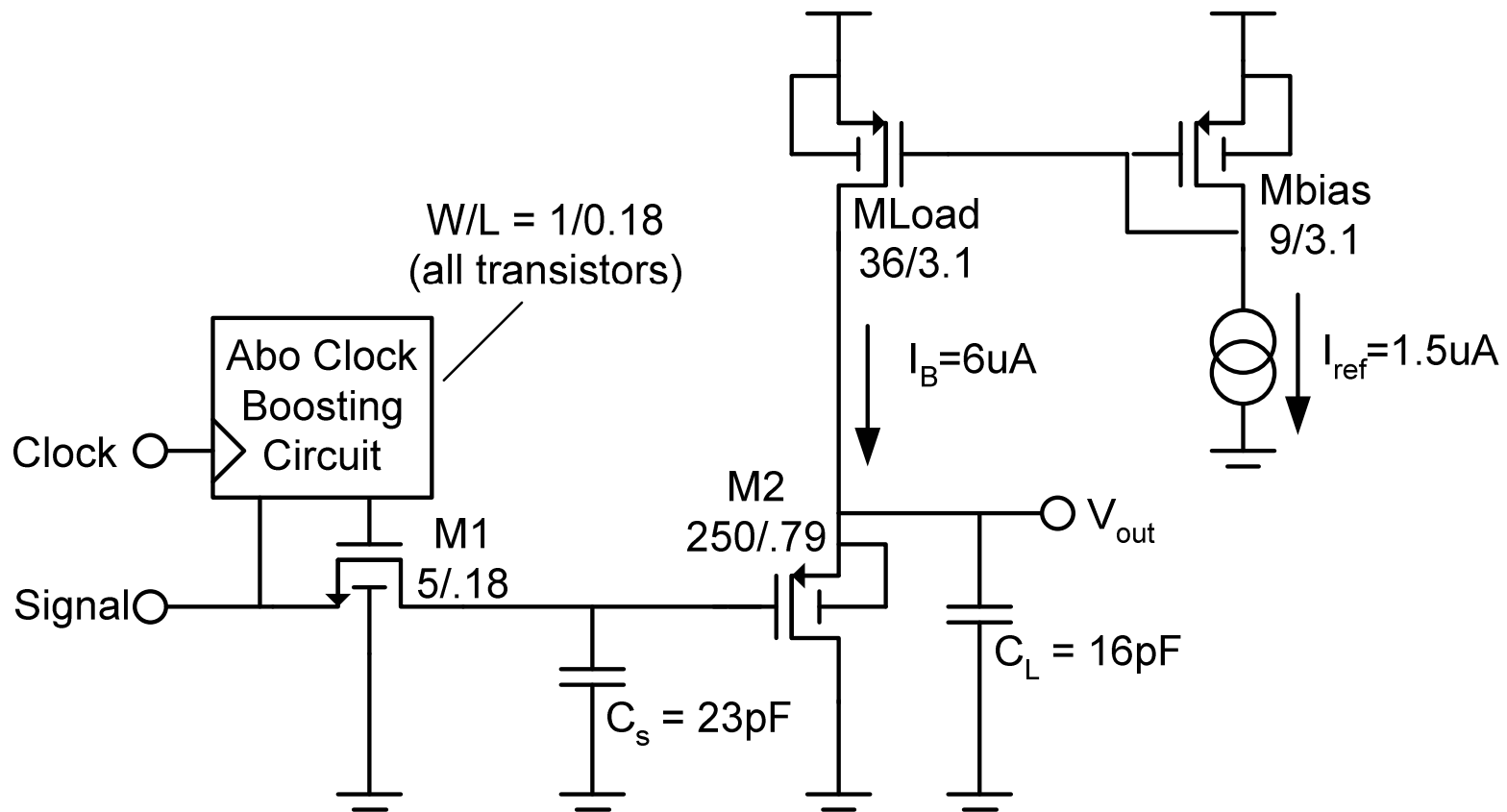
The Slowest Track-and-Hold in the Class

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Performance Summary

	Predicted	Simulated
Sampling Frequency	100 kS/s	100 kS/s
Circuit Power	24 μ W	25 μ W
Drive Power	39 μ W	39 μ W
SFDR	90 dB	92.2 dB
SNDR	84.5 dB	86.1 dB
FOM	4.5×10^{17}	6.4×10^{17}

Circuit Overview (Half Circuit)



Maximum FOM with Source-Follower Architecture

- Theoretical FOM for a source follower is higher than for an OTA-based design

$$\text{SNR} = \frac{\frac{(2V_{\text{dd}})^2}{2}}{2 \cdot \left(\frac{kT}{C_s} + \frac{kT}{C_L} \right)} = \frac{V_{\text{dd}}^2}{2 \frac{kT}{C}}$$

$$\text{FOM} = \frac{f_s \cdot \text{SNR}}{P_{\text{ckt}} + P_{\text{drive}}} = \frac{1}{2 \cdot kT \cdot (3\pi + 2)} = 1.057 \times 10^{19} \frac{1}{\text{J}}$$

If FOM is independent of F_s , why use a slow source follower?

- Distortion increases at higher F_s (generally not included in first order calculations)
- We chose a slow design in order to not “waste” power trying to control distortion.
- Also allows subthreshold operation
 - Remember from 214: MOSFETs operate like BJT in subthreshold

Noise in subthreshold operation

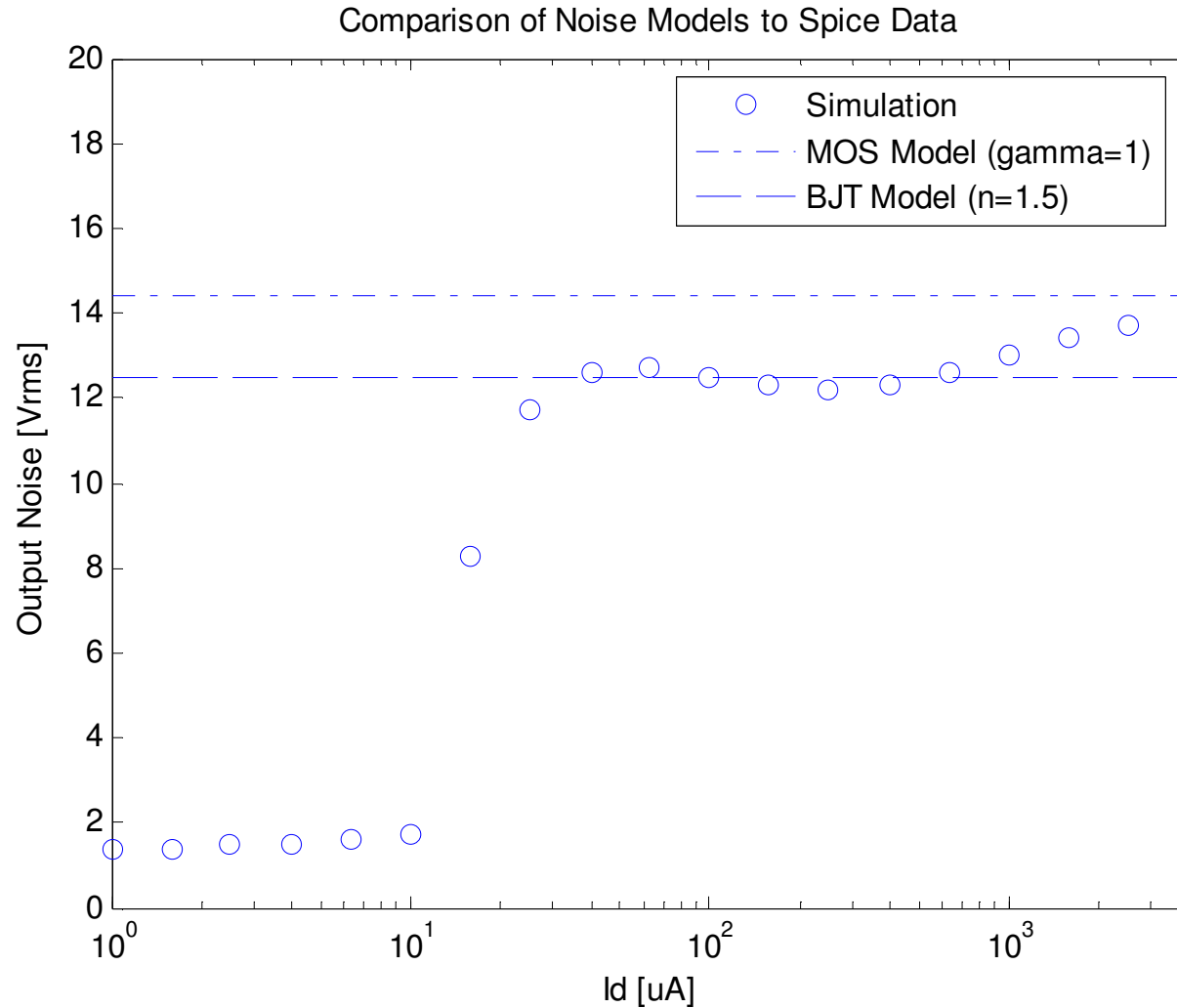
(BJT)

$$v_{n2}^2 = (2 \cdot n \cdot kT \cdot gm) \cdot \left(\frac{1}{gm^2} \right) \cdot \left(\frac{1}{2 \cdot \pi \cdot C_L \cdot \frac{1}{gm}} \cdot \frac{\pi}{2} \right) = \frac{n \cdot kT}{2C_L}$$

(FET)

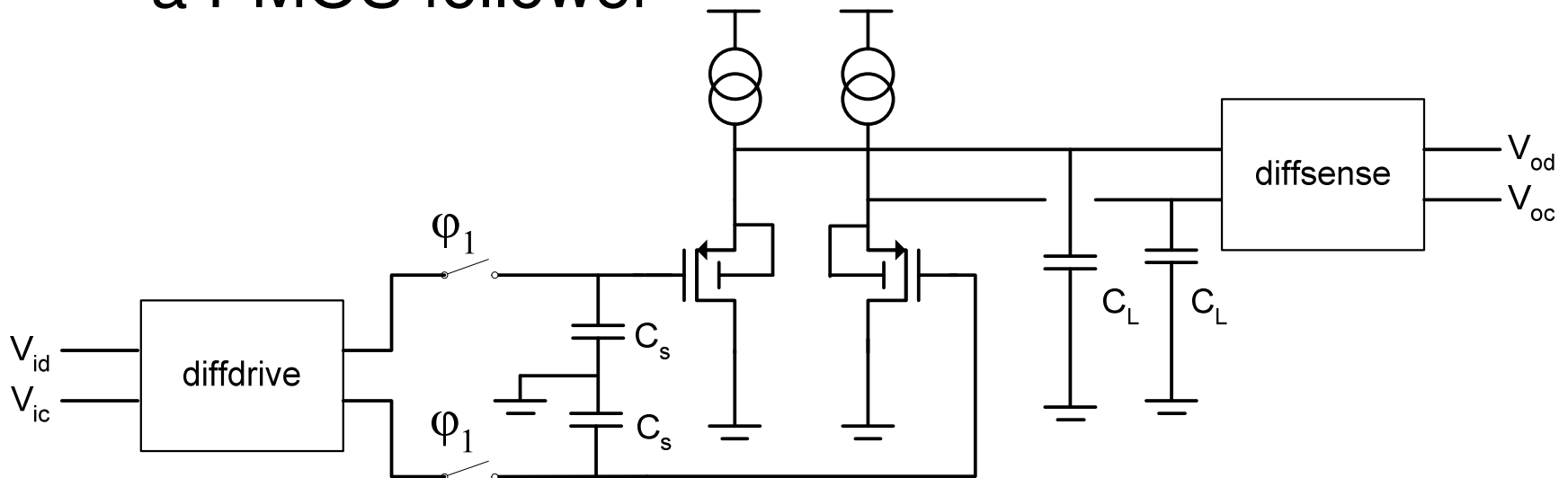
$$v_{n2}^2 = \underbrace{(4 \cdot \gamma \cdot kT \cdot gm)}_{i_{nd}^2 \div \Delta f} \cdot \underbrace{\left(\frac{1}{gm^2} \right)}_{r_o^2} \cdot \underbrace{\left(\frac{1}{2 \cdot \pi \cdot C_L \cdot \frac{1}{gm}} \cdot \frac{\pi}{2} \right)}_{ENBW} = \frac{\gamma \cdot kT}{C_L}$$

Spice yields unreasonable noise results in deep subthreshold

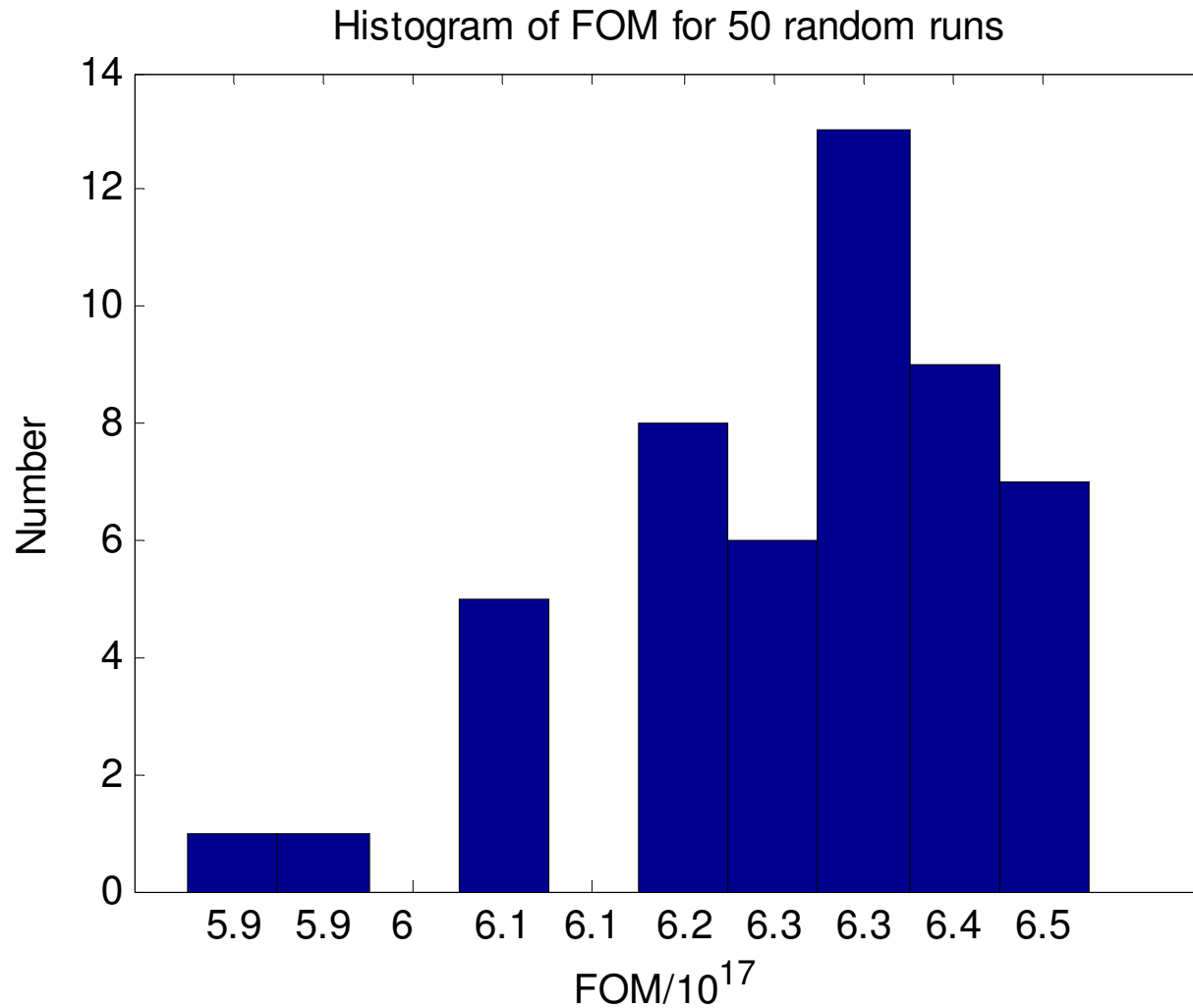


Distortion

- Even order should cancel due to the differential topology
 - What if there are mismatches?
- Odd order depends on circuit parameters
 - No contribution from body effect since we use a PMOS follower

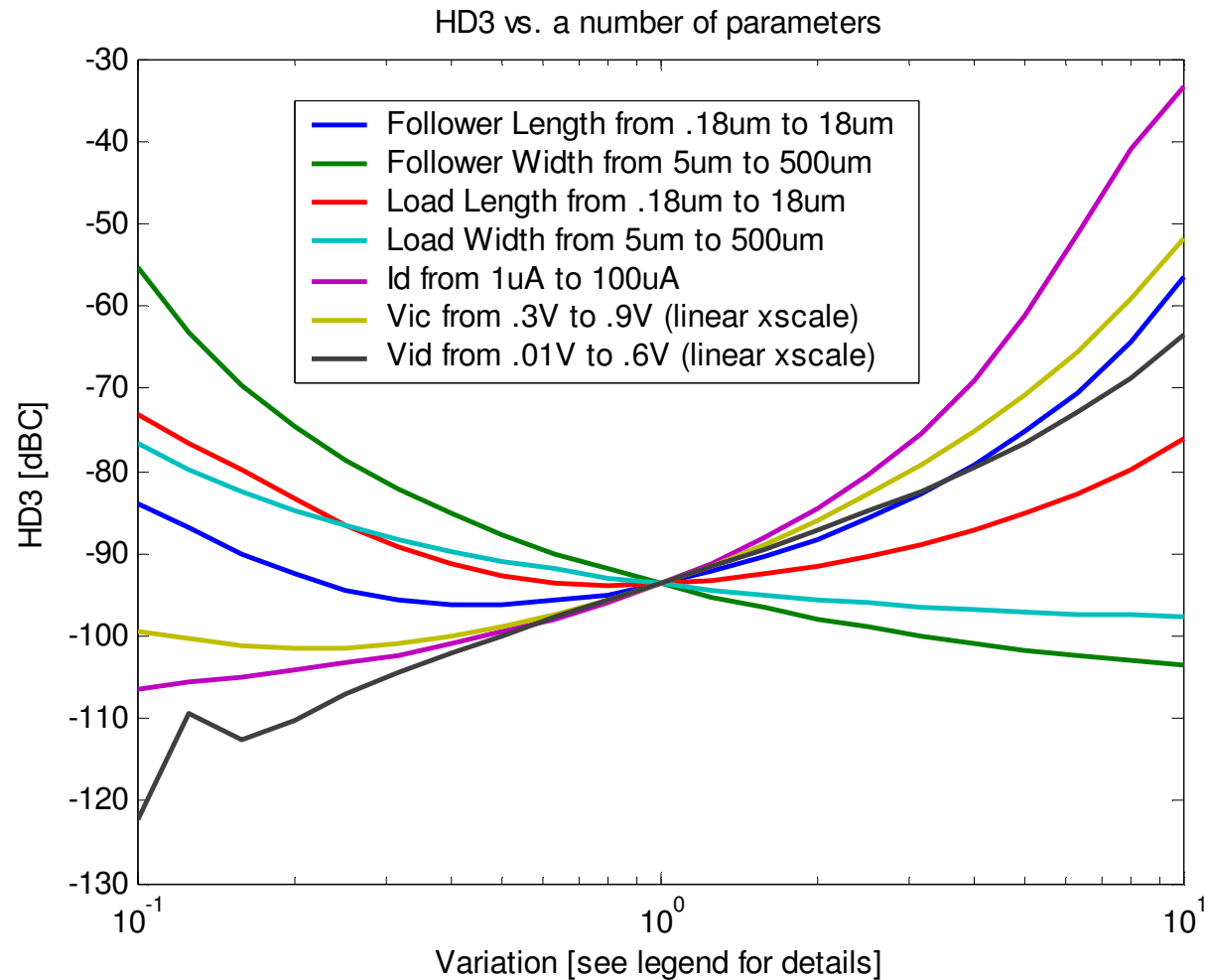


Effect of mismatch on even-order distortion cancellation

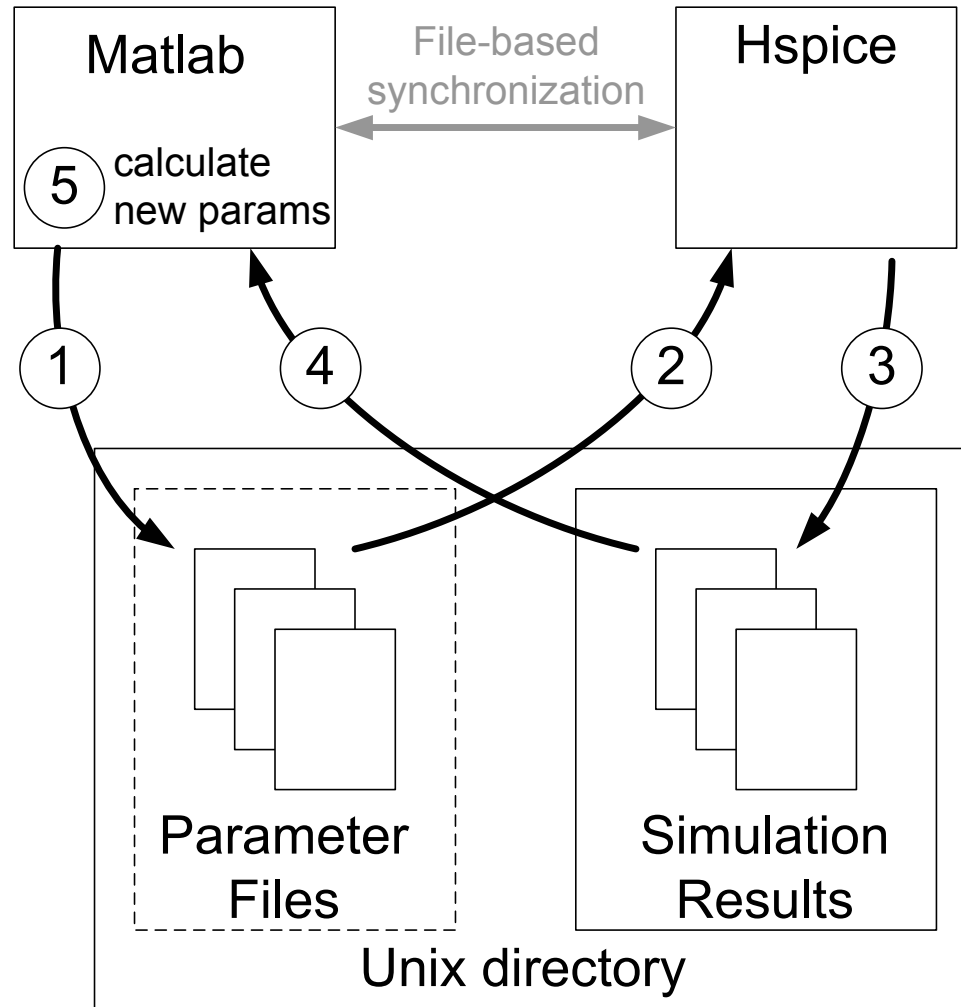


Effect of Circuit Parameters on Odd Order Distortion

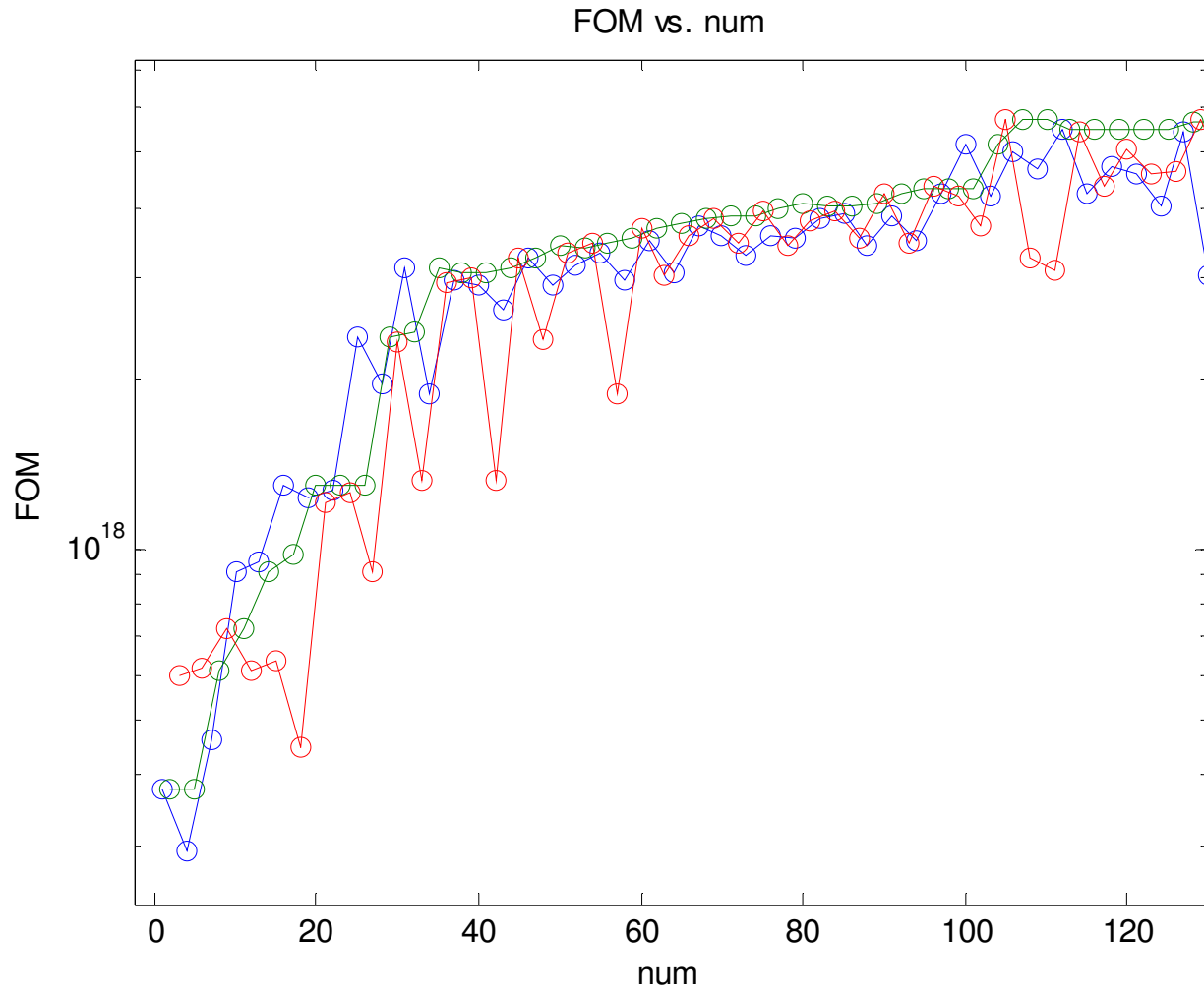
$$HD3 = \frac{c_3 \cdot V_i^2}{4c_1}$$



FOM Optimization in Matlab/Hspice



FOM Optimization in Matlab/Hspice



Thanks