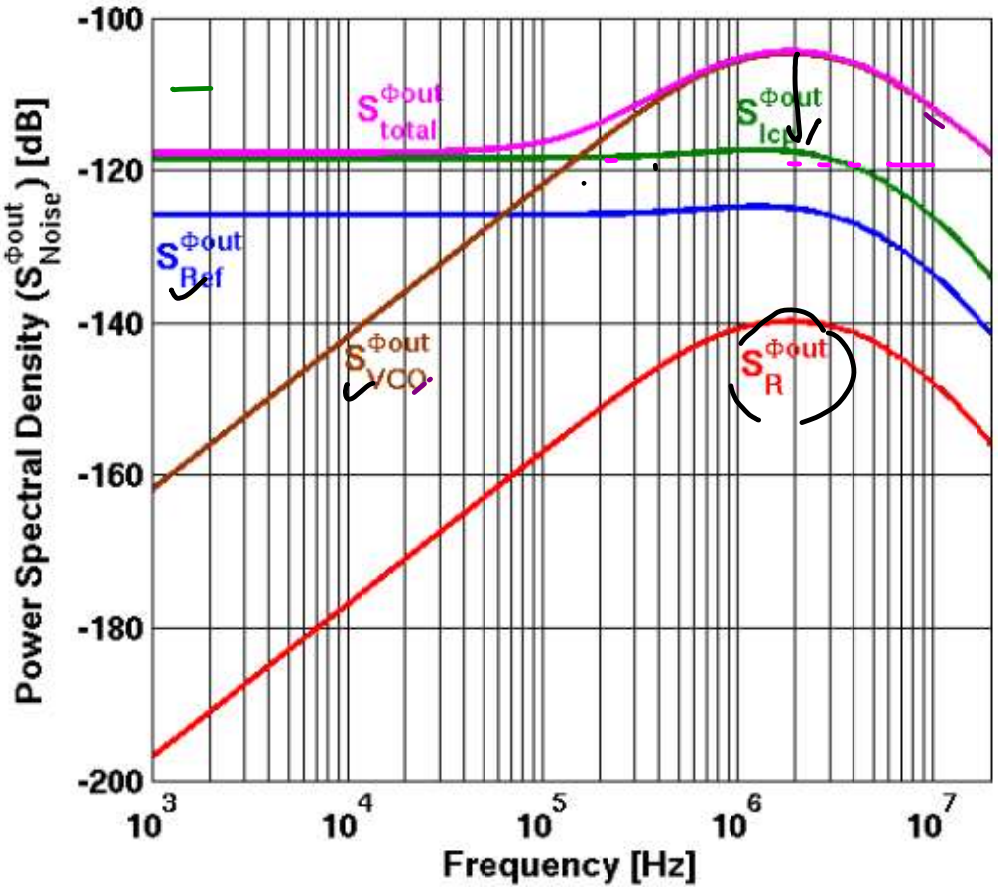
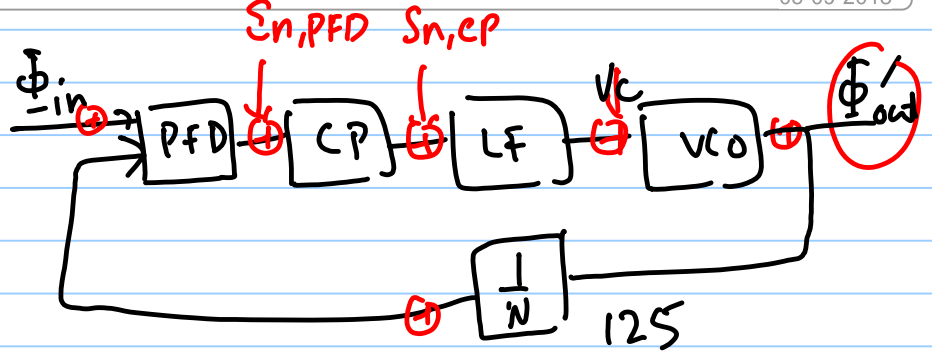
Lecture # 17

Note Title 05-09-2018





ω_u: unity gain freq. $\frac{560}{4\pi}$

Φ_m: Phase margin

$$|LG(j\omega)| = 1$$

$$\left.\frac{d\angle LG}{d\omega}\right|_{\omega=\omega_u} = 0$$

$$C_1, C_2, I_{CP}\Big|_{K_{VCO},R}$$

$$S_R^{\Phi_{out}} = S_R \times |NTF_R|^2$$

Noise Transfer Function (NTF)

Power Spectral Density $\longrightarrow$ $\Phi^{n,out}_{PFD}$ /

$$S^{\Phi_{out}}_{total} = S^{\Phi_{out}}_{PFD} + S^{\Phi_{out}}_{CP} + S^{\Phi_{out}}_{R} + S^{\Phi_{out}}_{VCO} + S^{\Phi_{out}}_{in}$$

$$\Phi^2_{n,total} = \int S^{\Phi_{out}}_{total} \cdot df \qquad [rad^2]$$

$$\sigma_{\Delta t} = \frac{T}{2\pi} \Phi_{n,total}$$

$$= \frac{T}{2\pi} \sqrt{\int S^{\Phi_{out}}_{total} \cdot df} \qquad [s]$$

1 ps = $\sigma_{\Delta t}$ @ 5 GHz.

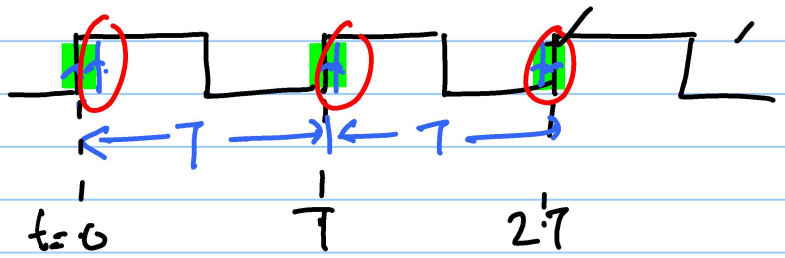
w_n, Φ_m

1 mW

freq = 40 MHz, $\Phi_m = 70°$

w_n = 4 MHz

T: output clock freq.



$$\Delta t_j = (j-1)T - t_j$$

$\Delta t_1, \Delta t_2, \ldots \Delta t_n \ldots$

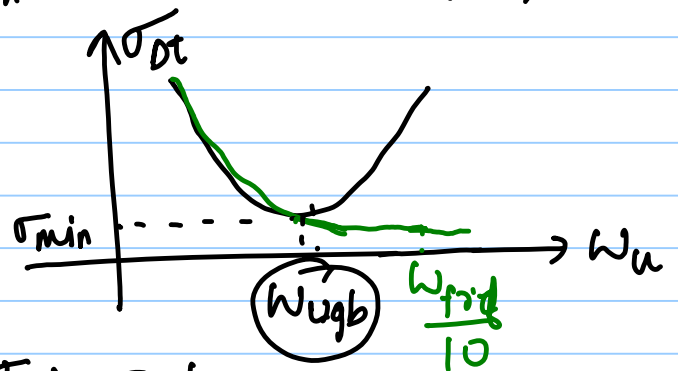
$\sigma_{\Delta t} = \sqrt{E[\Delta t^2]}$

1) $\sigma =$ 1ps, rms , $f_{rq} =$ 40 MHz , $f_{out} =$ 5 GHz , min. Power.

2) $P =$ 1mW , $\omega_u = 4$MHz , $\phi_m = 70^\circ$ ⟶ R, C_1, C_2, I_{cp} ⟶ $\sigma =$ 5ps, rms

3) ~~ω_u~~, ~~ϕ_m~~

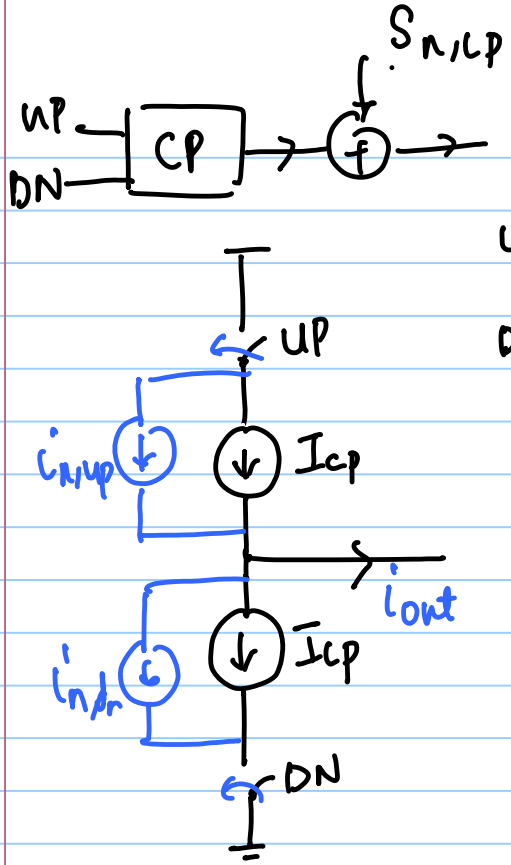
σ^2

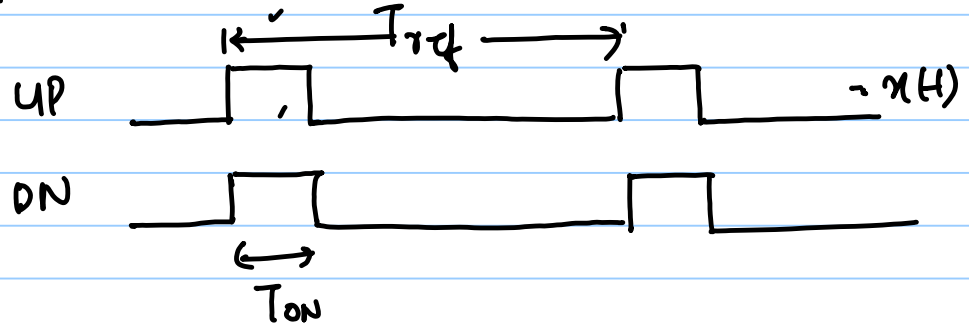


$\sigma_{min} =$ 1ps, rms

$\sigma_{min} <$ 1ps, rms. ⟶ Power

$\sigma_{min} >$ 1ps rms





$$i_{n,out} = (i_{n1} - i_{n2}) \times x(t)$$

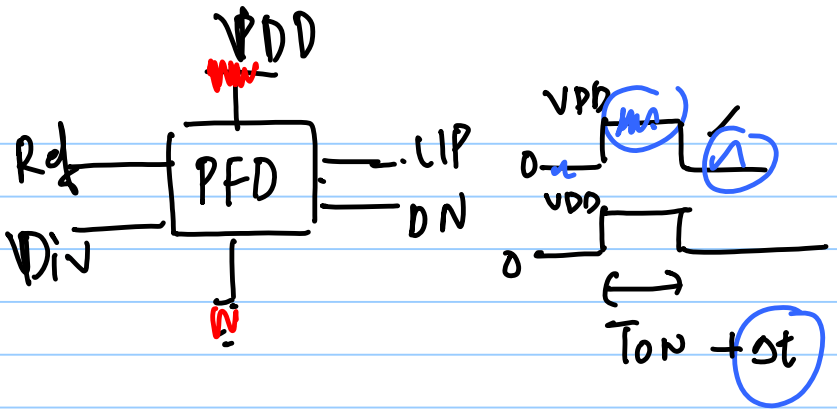
$$= (i_{n1} - i_{n2}) \times \left[a_0 + \sum a_n \cos(n\omega_{ref} t) + b_n \sin(n\omega_{ref} t) \right]$$

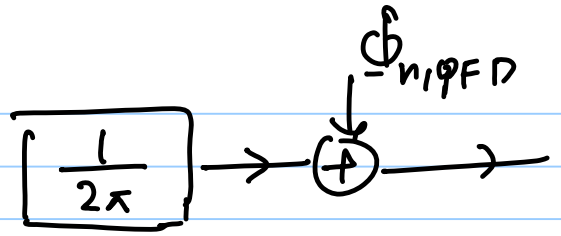
$$i_{out} = i_{n1} - i_{n2}$$

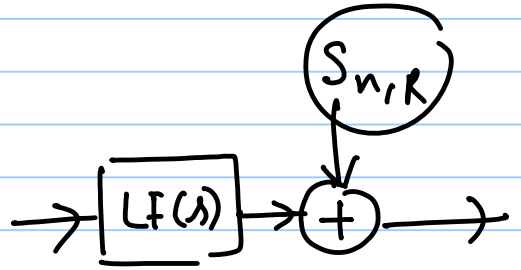
$$i_{n,out}^2 = i_{n1}^2 + i_{n2}^2$$

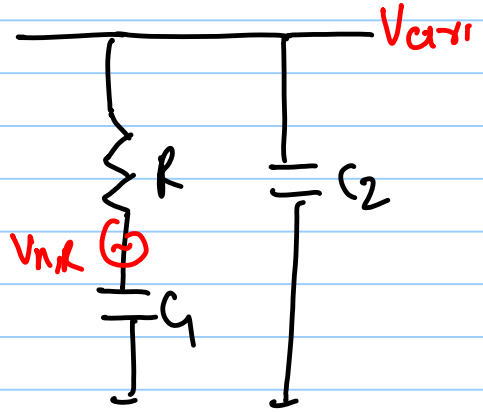
$$S_{n,i_{out}} = \left[\frac{T_{ON}}{T_{Ref}} \right]^2 \left(S_{n1} + S_{n2} \right) = S_{n,CP}$$

Eg: $T_{ref} = 25ns$, $T_{ON} \uparrow$



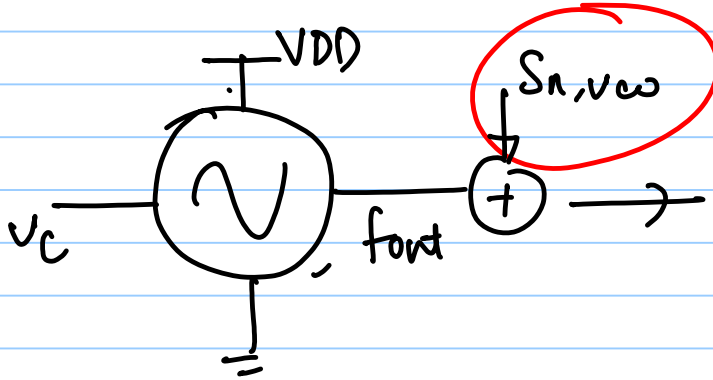






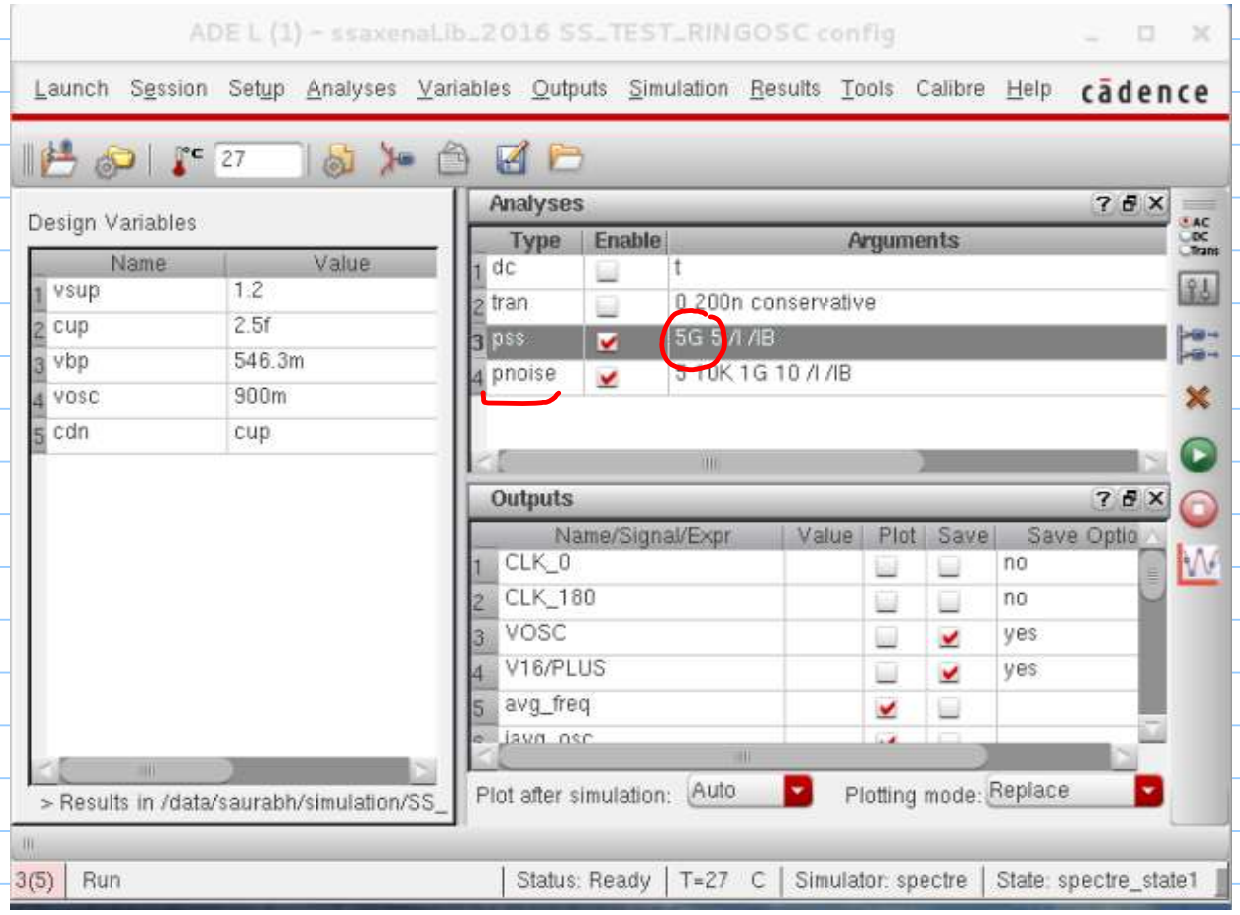
$$S_R = 4kTR$$

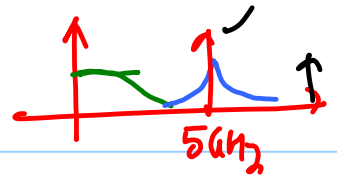
$$S_{n,R} = 4kTR \times \left| \frac{1/sC_2}{R + \frac{1}{sC_1} + \frac{1}{sC_2}} \right|^2$$



$$T = 1/f_{out}$$

PSS Periodic Steady State Analysis.





Choosing Analyses -- ADE L (1)

Analysis: tran, dc, ac, noise, xf, sens, dcmatch, stb, pz, sp, envlp, pss, pac, pstb, pnoise, pxf, psp, qpss, qpac, qpnoise, qpxf, qpsp, hb, hbac, hbnoise, hbsp

Periodic Noise Analysis

PSS Beat Frequency (Hz)

Multiple pnoise

Sweeptype: relative — Relative Harmonic: 1

Output Frequency Sweep Range (Hz)

Start-Stop — Start: 10k — Stop: 10

Sweep Type: Logarithmic — Points Per Decade: 10 / Number of Steps

Add Specific Points

Sidebands

Method: default / fullspectrum

Maximum sideband: 5

When using shooting engine, default value is 7

Output

voltage — Positive Output Node: /I — Select

Negative Output Node: /IB — Select

Input Source

none

Noise Type: sources

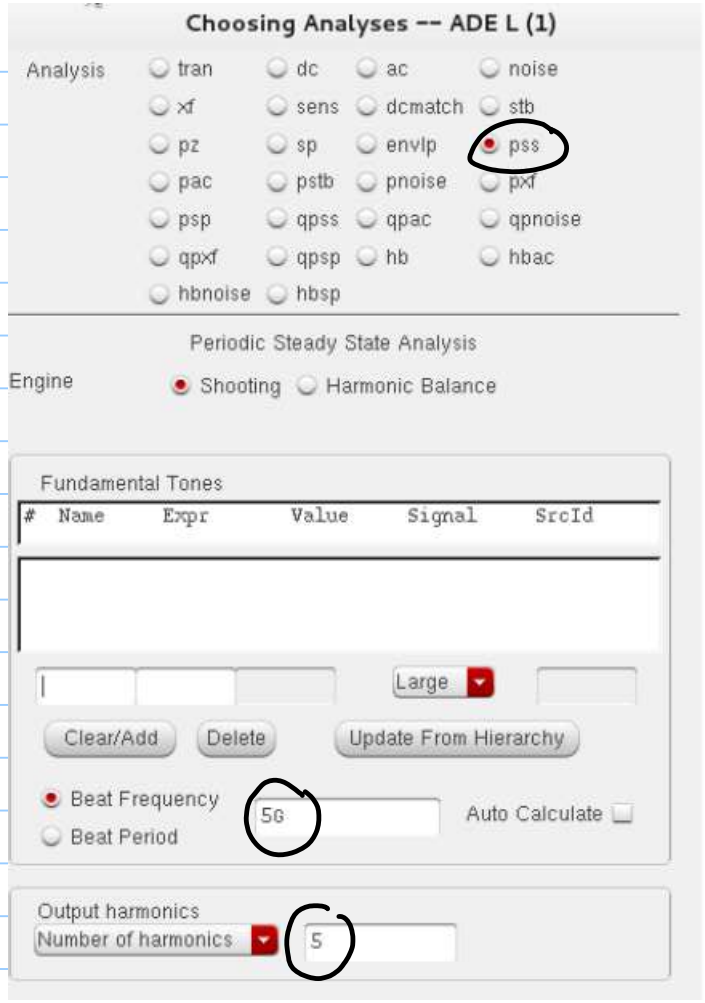
sources: single sideband (SSB) noise analysis

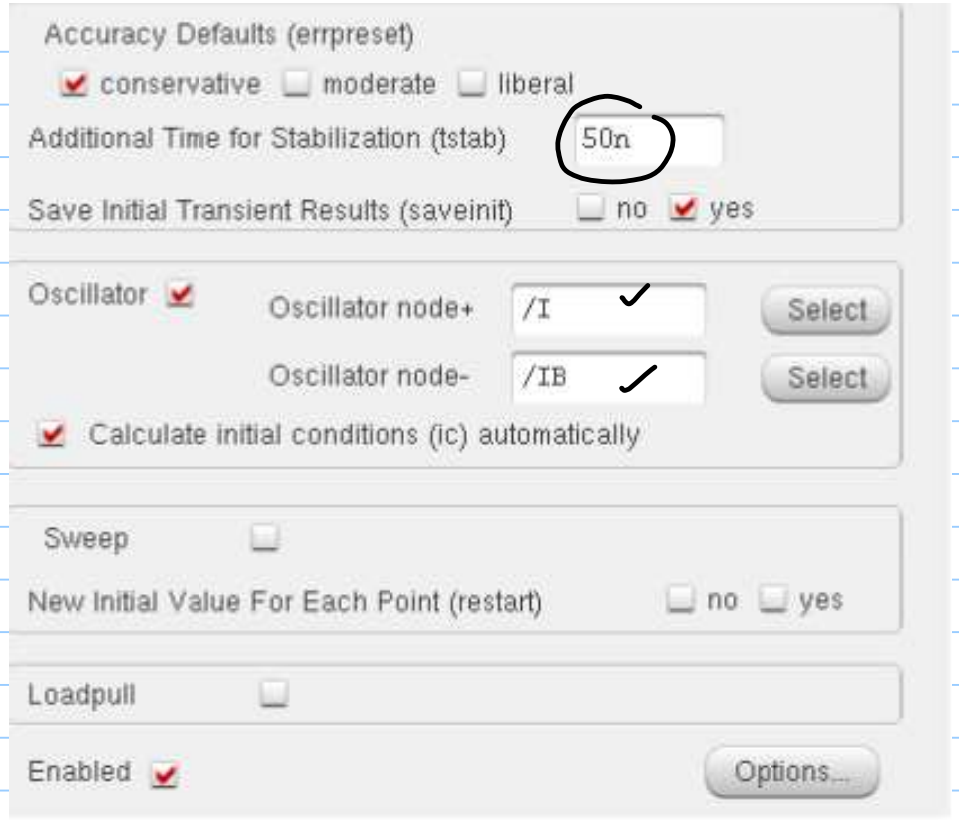
Noise Separation: yes / no

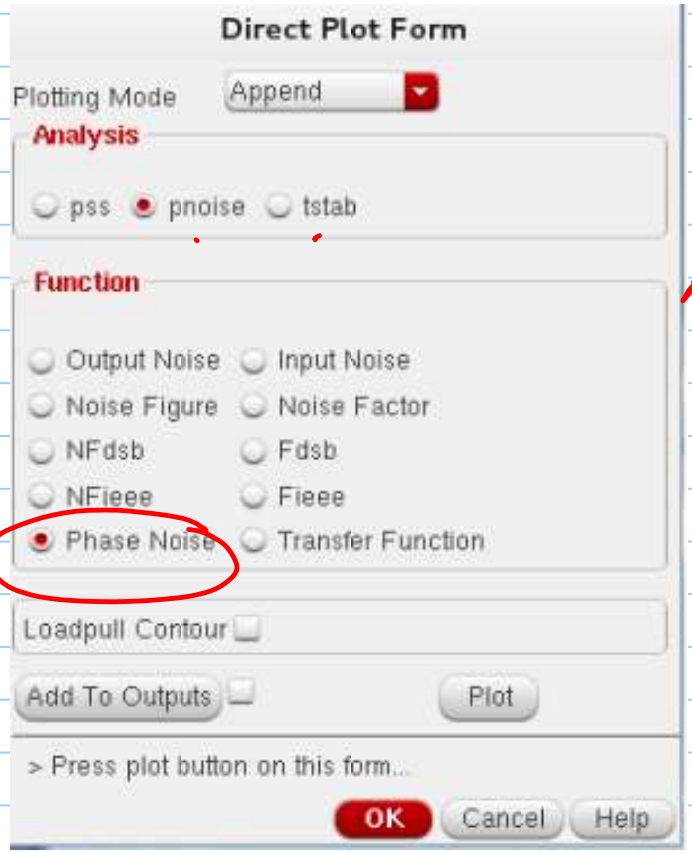
separate noise into source and gain

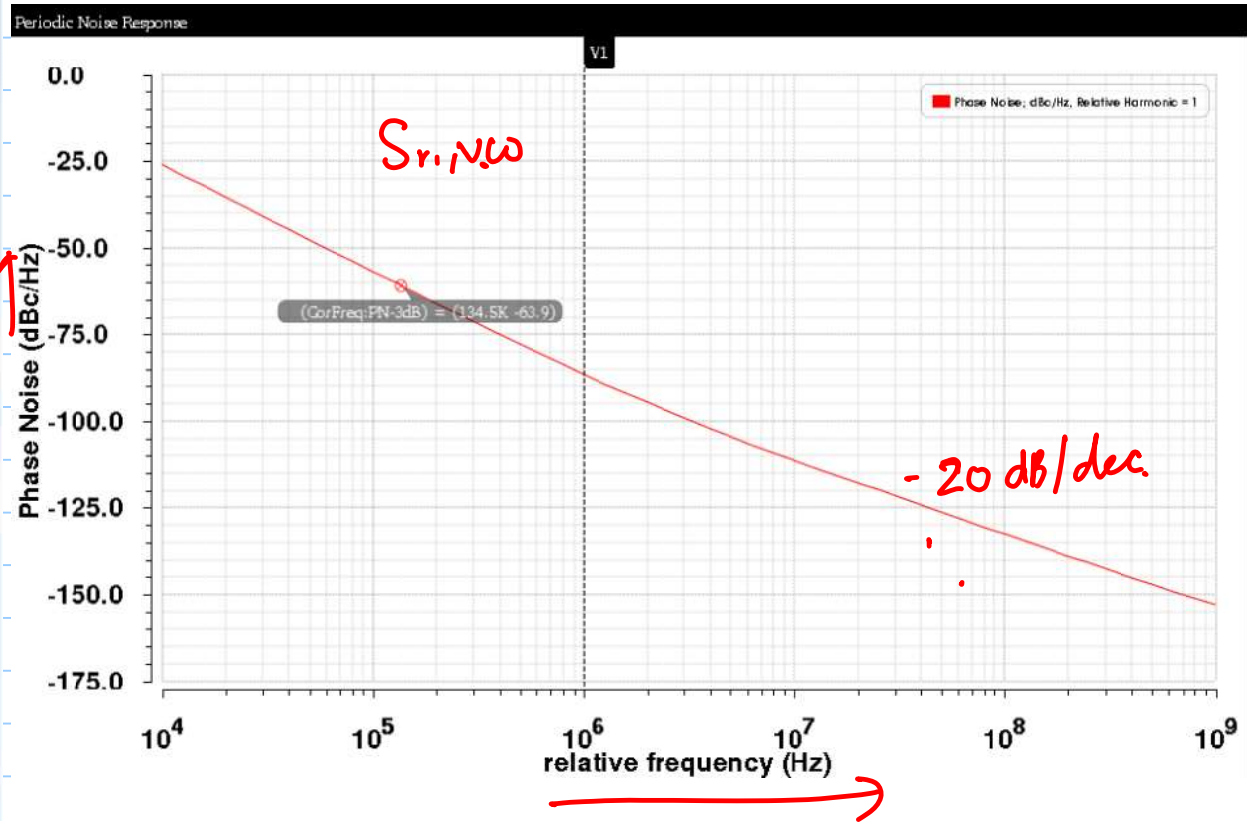
Enabled

Options...


Choosing Analyses -- ADE L (1)
Analysis
tran
dc
ac
noise
xf
sens
dcmatch
stb
pz
sp
envlp
pss
pac
pstb
pnoise
pxf
psp
qpss
qpac
qpnoise
qpxf
qpsp
hb
hbac
hbnoise
hbsp
Periodic Steady State Analysis
Engine
Shooting
Harmonic Balance
Fundamental Tones
Name Expr Value Signal SrcId
Large
Clear/Add
Delete
Update From Hierarchy
Beat Frequency
Beat Period
50
Auto Calculate
Output harmonics
Number of harmonics
5


Accuracy Defaults (errpreset)
conservative
moderate
liberal
Additional Time for Stabilization (tstab)
50n
Save Initial Transient Results (saveinit)
no
yes
Oscillator
Oscillator node+
/I
Select
Oscillator node-
/IB
Select
Calculate initial conditions (ic) automatically
Sweep
New Initial Value For Each Point (restart)
no
yes
Loadpull
Enabled
Options...


Direct Plot Form
Plotting Mode
Append
Analysis
pss
pnoise
tstab
Function
Output Noise
Input Noise
Noise Figure
Noise Factor
NFdsb
Fdsb
NFieee
Fieee
Phase Noise
Transfer Function
Loadpull Contour
Add To Outputs
Plot
> Press plot button on this form...
OK
Cancel
Help


Periodic Noise Response
V1
Phase Noise; dBc/Hz, Relative Harmonic = 1
Sr.No
(CorFreq:PN-3dB) = (134.5K -63.9)
- 20 dB/dec.
0.0
-25.0
-50.0
-75.0
-100.0
-125.0
-150.0
-175.0
Phase Noise (dBc/Hz)
10^4
10^5
10^6
10^7
10^8
10^9
relative frequency (Hz)