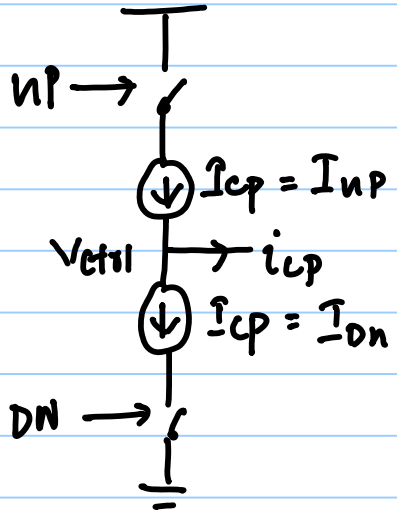
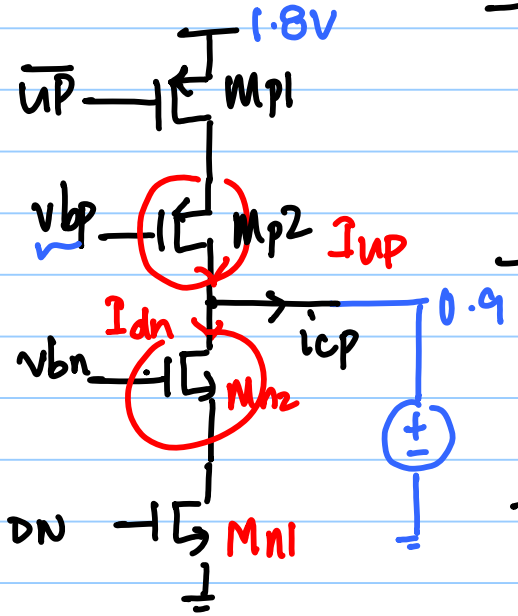
Lecture # 18

Note Title 30-06-2020

Source of non-linearity





- For +ve ϕ_e (Δt)

  $i_{cp} = I_{up}$ for $0 \le t < \Delta t$

- For -ve ϕ_e (Δt)

  $i_{cp} = -I_{dn}$ for $0 \le t < \Delta t$

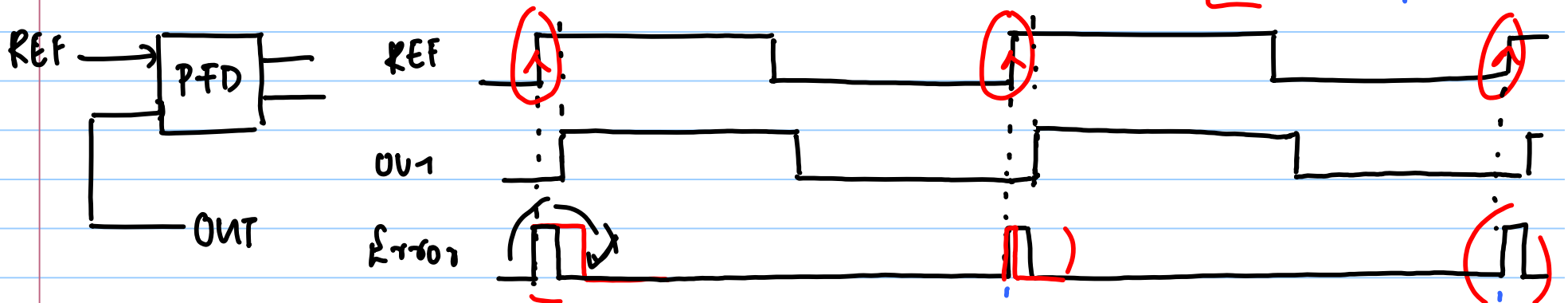
- if $I_{up} \neq I_{dn}$.

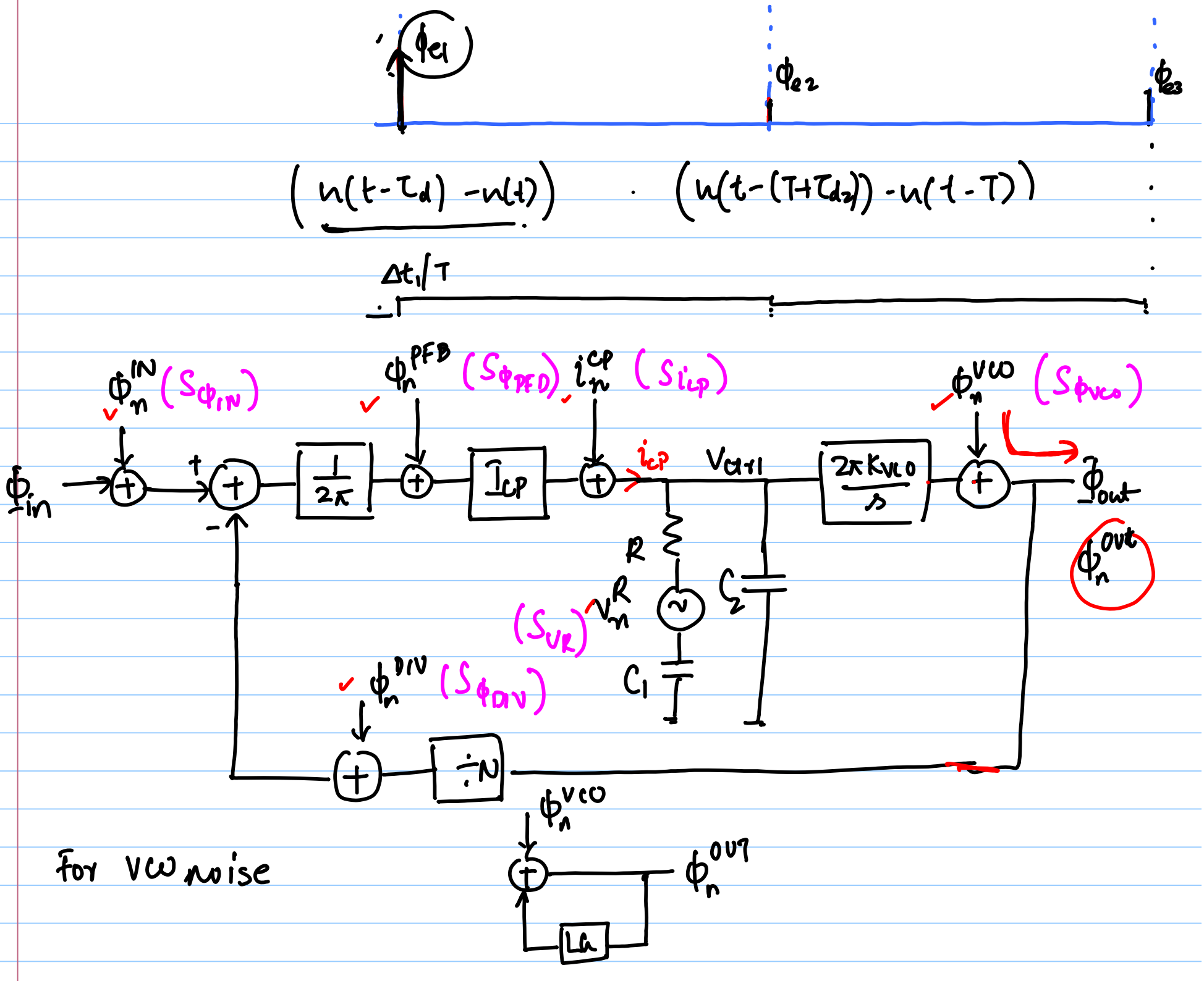
- @ $V_{ctrl} = 0.9V$, $I_{up} = I_{dn}$

  @ $V_{ctrl} = 1.2V$, $I_{up} < I_{dn}$

  @ $V_{ctrl} = 0.6V$, $I_{up} > I_{dn}$

$$I = \frac{\mu C_{ox}}{2} \frac{W}{L} (V_{gs} - V_{tn})^2 (1 + \lambda V_{DS})$$

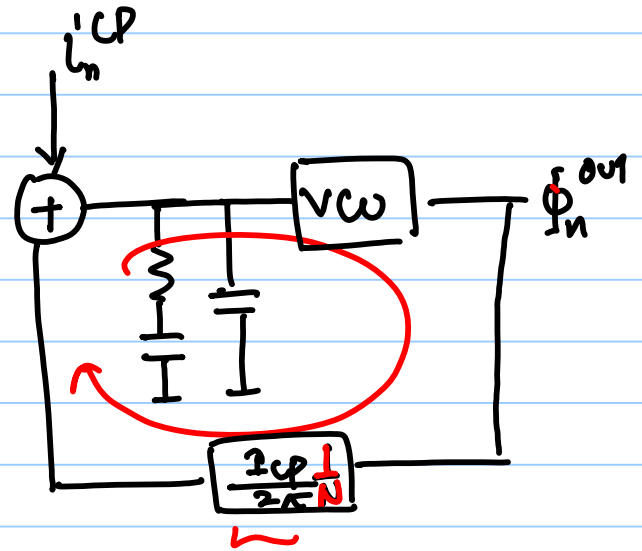



ϕ_{e1}
ϕ_{e2}
ϕ_{e3}
$(u(t-\tau_d) - u(t))$
$(u(t-(T+\tau_{d2})) - u(t-T))$
$\Delta t_1/T$
ϕ_n^{IN} $(S_{\phi_{IN}})$
ϕ_n^{PFD} $(S_{\phi_{PFD}})$
i_n^{CP} $(S_{i_{CP}})$
ϕ_n^{VCO} $(S_{\phi_{VCO}})$
ϕ_{in}
$\frac{1}{2\pi}$
I_{CP}
i_{CP}
V_{ctrl}
$\frac{2\pi K_{VCO}}{s}$
ϕ_{out}
ϕ_n^{out}
R
V_n^R
(S_{V_R})
C_2
C_1
ϕ_n^{DIV} $(S_{\phi_{DIV}})$
$\div N$
for VCO noise
ϕ_n^{VCO}
ϕ_n^{out}
LG

$$\frac{\phi_n^{out}}{\phi_n^{vco}} = \frac{1}{1+LG}$$

$$\frac{\phi_n^{out}}{i_n^{cp}} = \frac{LG}{1+LG} \times \left(\frac{I_{cp}}{2\pi} \times \frac{1}{N}\right)$$

$$= \frac{2\pi}{I_{cp}} \frac{(LG \times N)}{1+LG}$$



$$LG = \frac{1}{2\pi} I_{cp} F(s) \frac{2\pi K_{vco}}{s} \times \frac{1}{N}$$

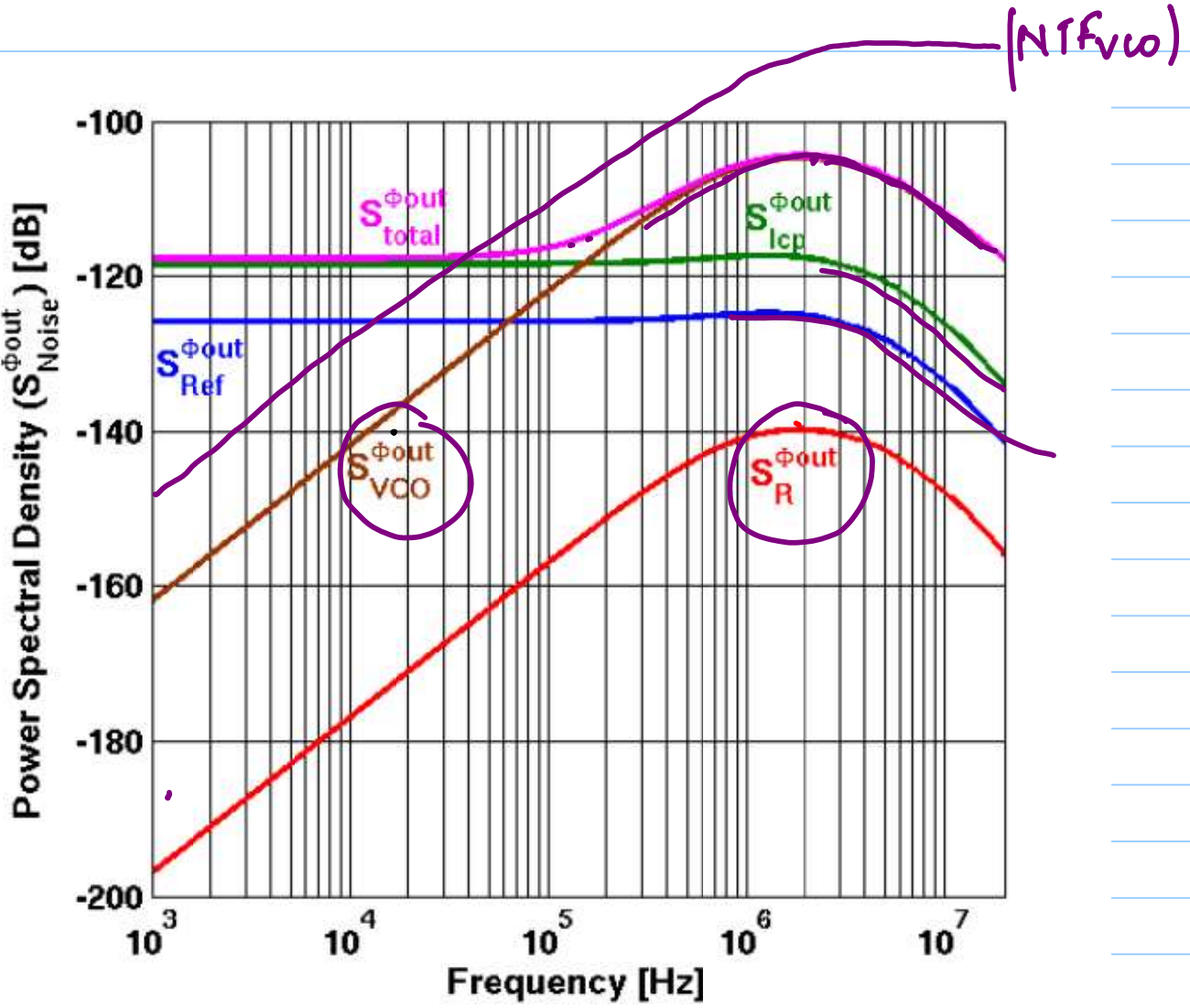
$$S_{\phi_{out}}^{\phi_{IN}} = S_{\phi_{IN}} \cdot |NTF_{IN}|^2$$

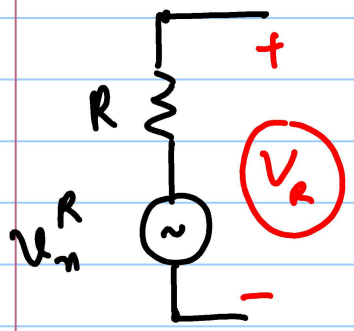
$$S_{\phi_{out}}^{i_{cp}} = S_{i_{cp}} \cdot |NTF_{CP}|^2$$

$$S_{\phi_{out}}^{V_R} = S_{V_R} \cdot |NTF_R|^2$$

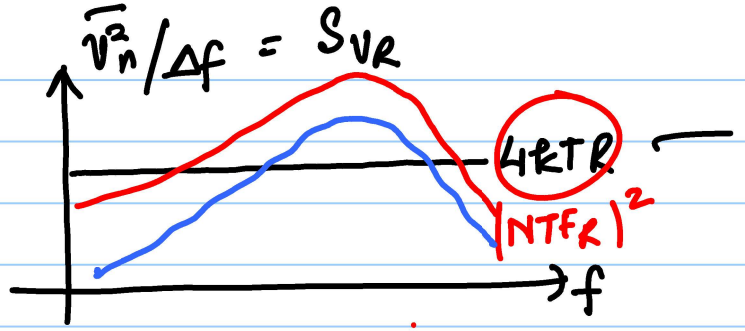
$$S_{\phi_{out}}^{\phi_{vco}} = S_{\phi_{vco}} \cdot |NTF_{vco}|^2$$

$$S_{\phi_{out}}^{Total} = S_{\phi_{out}}^{\phi_{IN}} + S_{\phi_{out}}^{i_{cp}} + S_{\phi_{out}}^{V_R} + S_{\phi_{out}}^{\phi_{vco}}$$

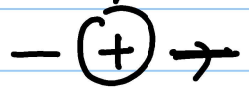

(NTFvco)
-100
-120
-140
-160
-180
-200
$S^{\Phi out}_{total}$
$S^{\Phi out}_{Icp}$
$S^{\Phi out}_{Ref}$
$S^{\Phi out}_{VCO}$
$S^{\Phi out}_{R}$
Power Spectral Density ($S^{\Phi out}_{Noise}$) [dB]
10^3
10^4
10^5
10^6
10^7
Frequency [Hz]

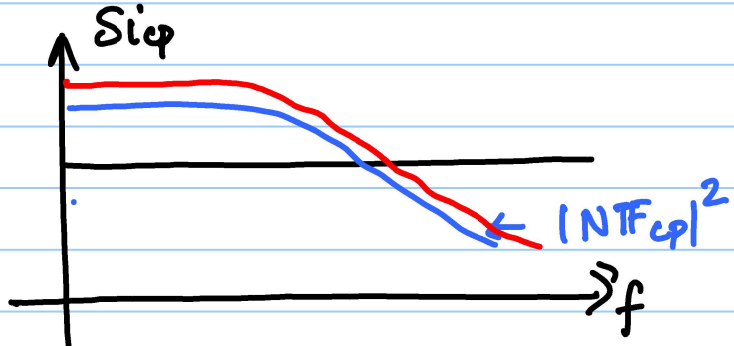


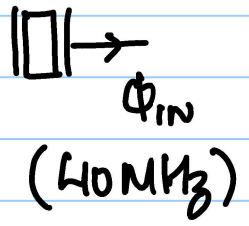
$$\frac{\overline{v_n^2}}{\Delta f} = 4kTR$$

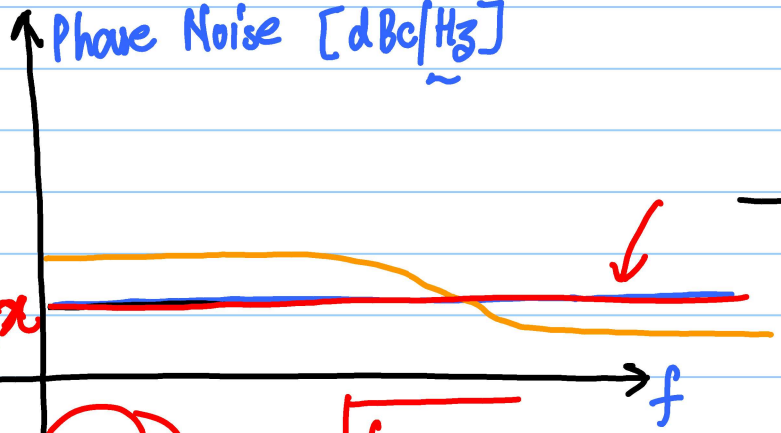


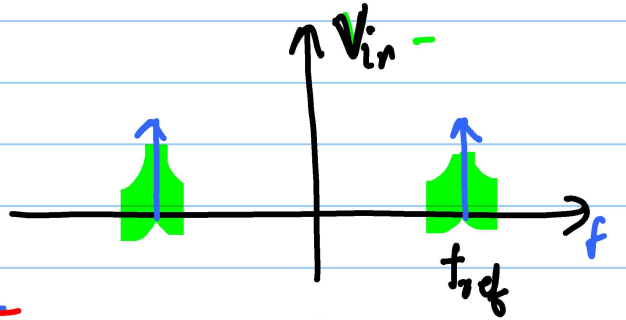
$$S_{i_{cp}} = \frac{8kT}{3} g_m$$

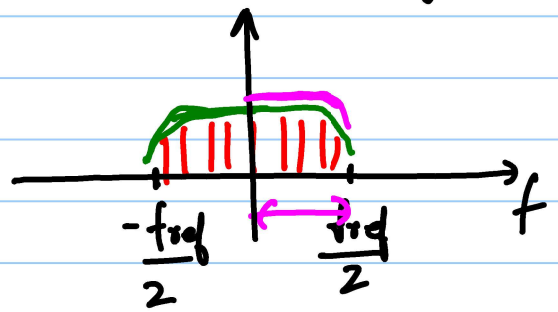




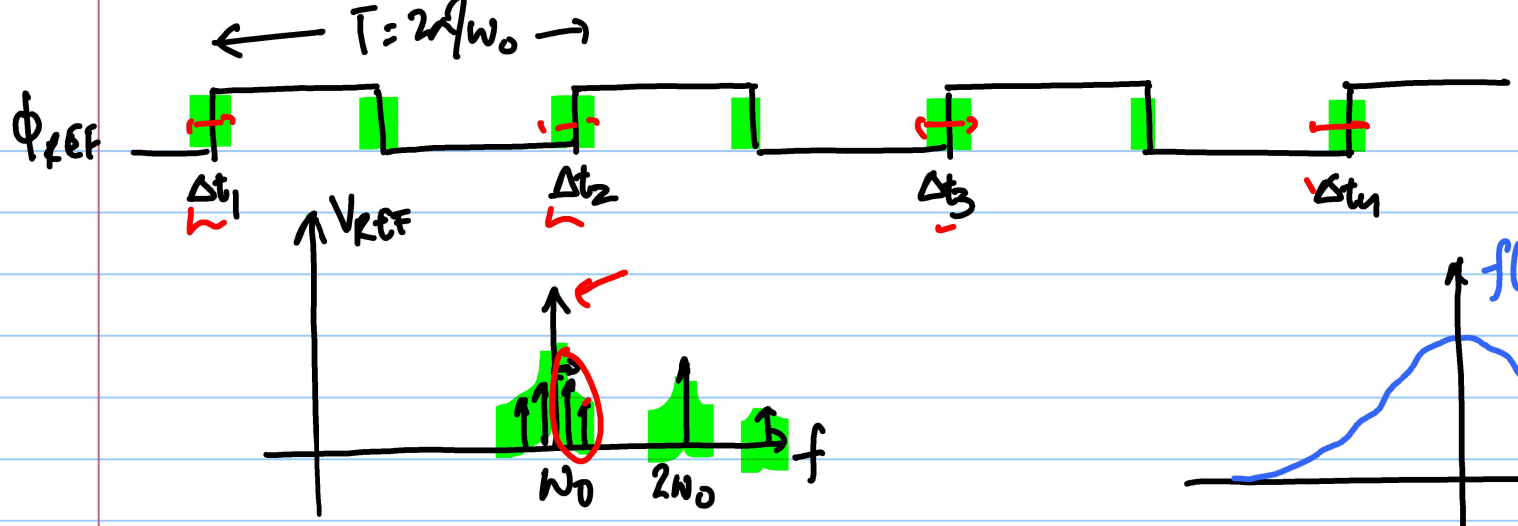


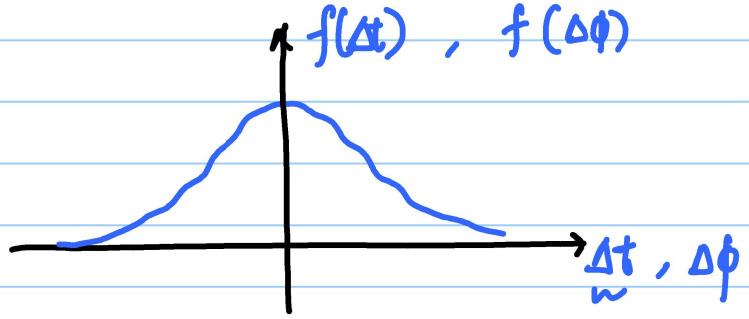






(i/p) total ref. jitter = 300 fs $= \frac{1}{2\pi}\sqrt{\int_{in} x \cdot df}$

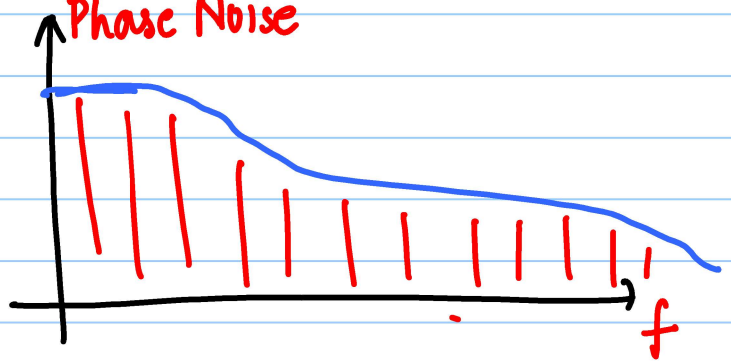




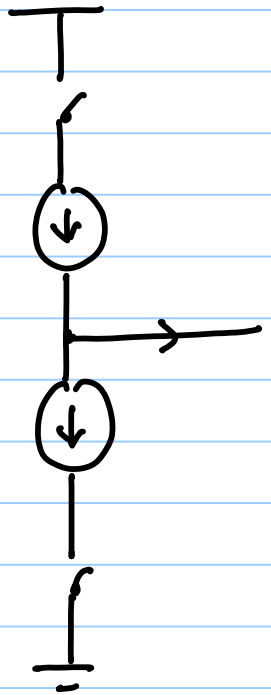
$\Delta\phi_{REF}$: $\frac{2\pi \cdot \Delta t_1}{T}$, $\frac{2\pi \Delta t_2}{T}$, ...

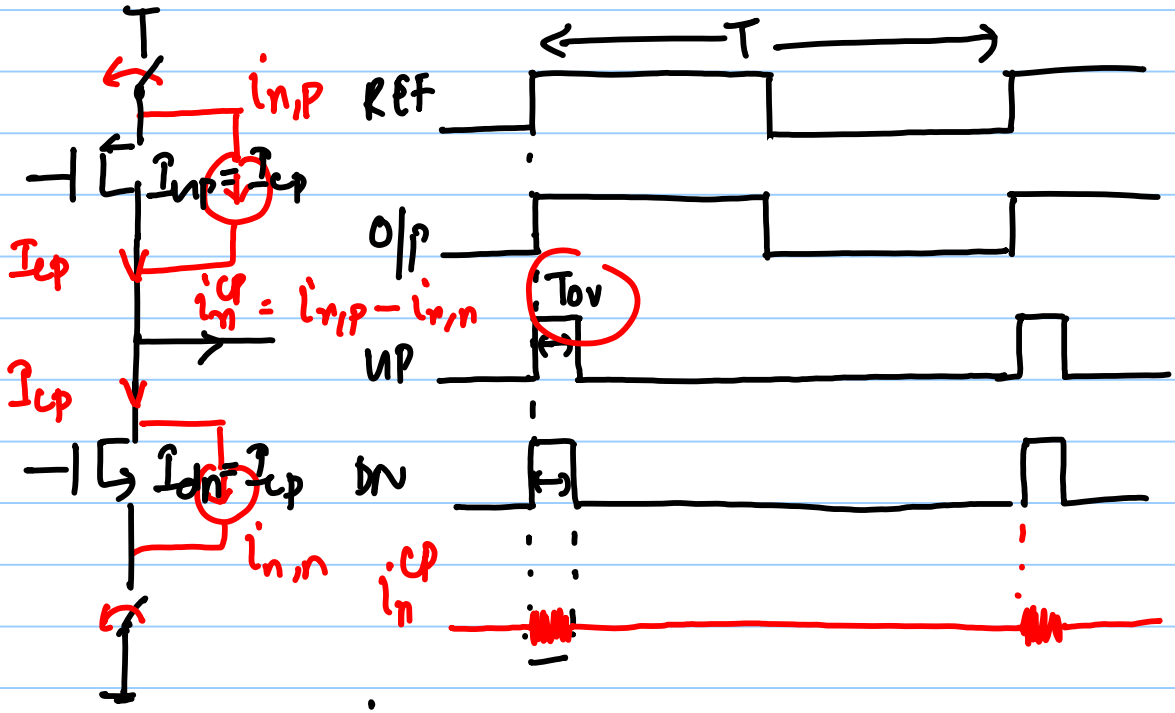
$\phi_{er}(1)$, $\phi_{er}(2)$, ...

Power spectral density for ϕ_{er} → Phase Noise of a clock.



= σ for r.v. ϕ_{er}





$$S_n^{i_{cp}} = \frac{T_{ov}}{T}\left[S_n^{i_{PMOS}} + S_n^{i_{NMOS}}\right] \checkmark$$

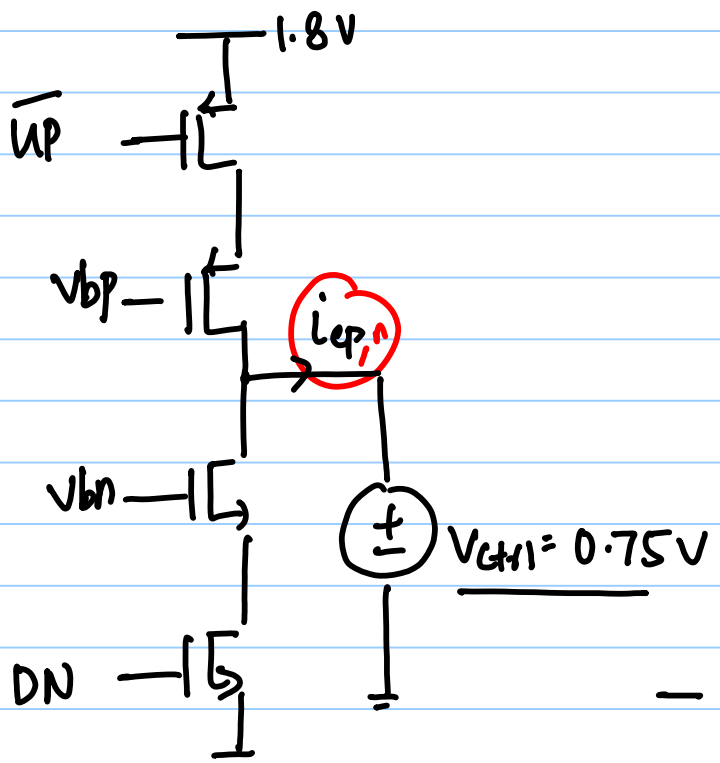
$$i_n^{cp} = i_n^{PMOS} - i_n^{NMOS} \checkmark$$

$$\overline{i_n^{icp\,2}} = \overline{i_n^{PMOS\,2}} + \overline{i_n^{NMOS\,2}}$$

$$S_n^{i_{cp}} = S_n^{i_{PMOS}} + S_n^{i_{NMOS}}$$

$$S_n^{i_{PMOS}} = 4KTY g_{mp} = \frac{8KT}{3} g_{mp}$$

$$S_n^{i_{NMOS}} = 4KTY g_{mn} = \frac{8KT}{3} g_{mn}.$$



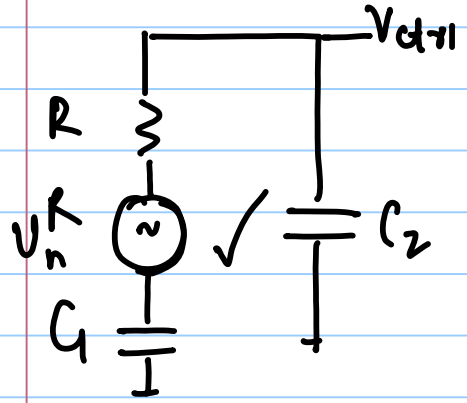
CP is clocked at ref. -frequency.

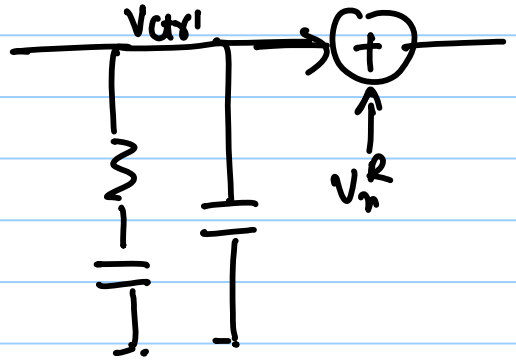
Steady state with ref. period

- PSS : Periodic steady state

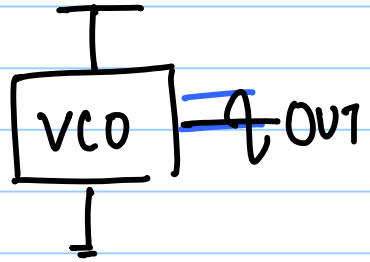
operating point in periodic steady state.

- PNOISE :

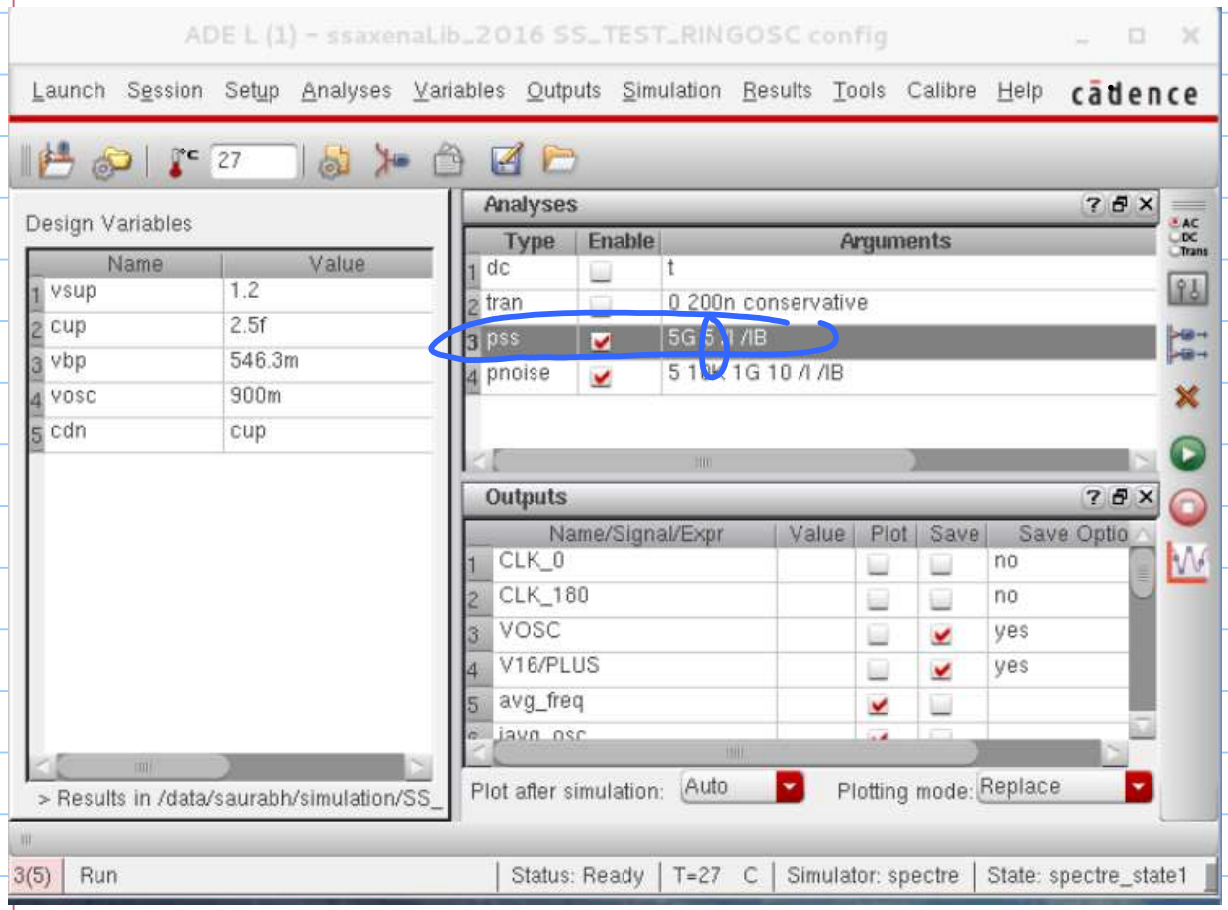




VCO (Voltage Controlled Oscillator)

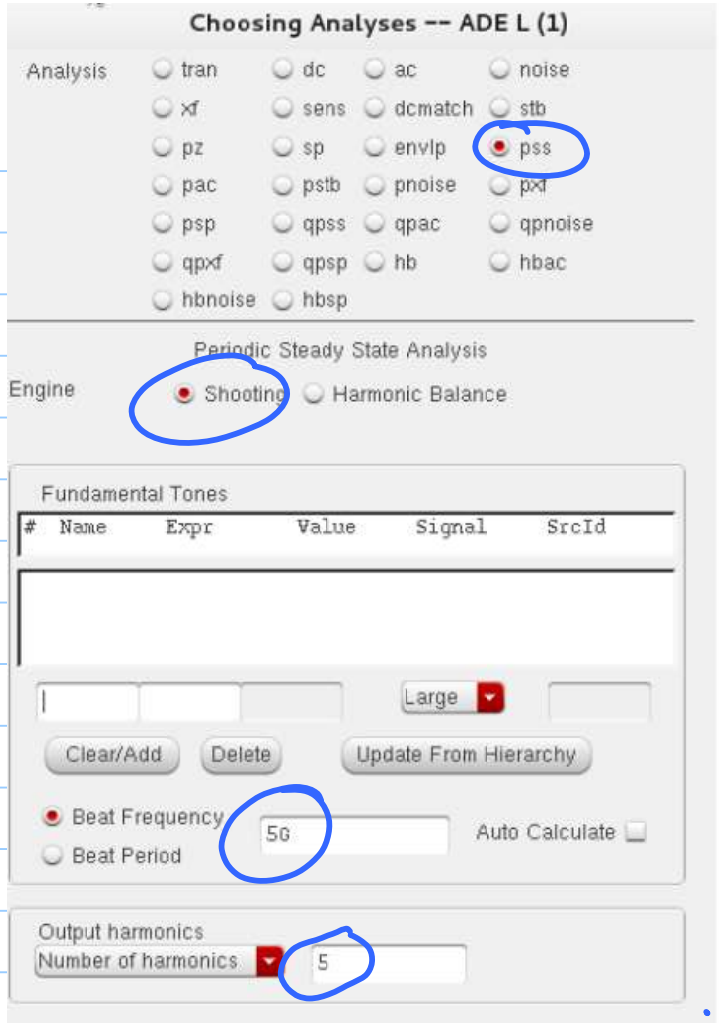


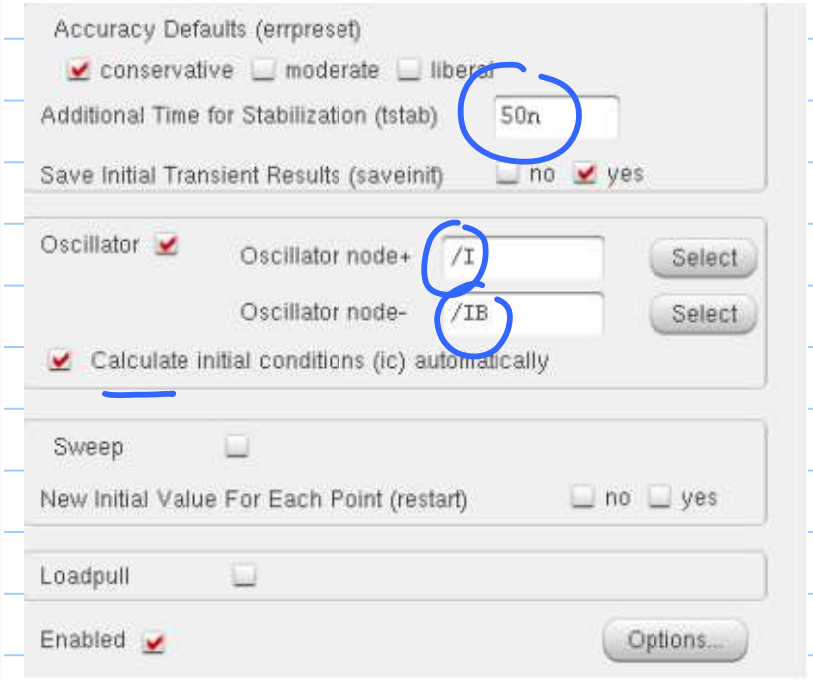
- PSS
- PNOISE ✓

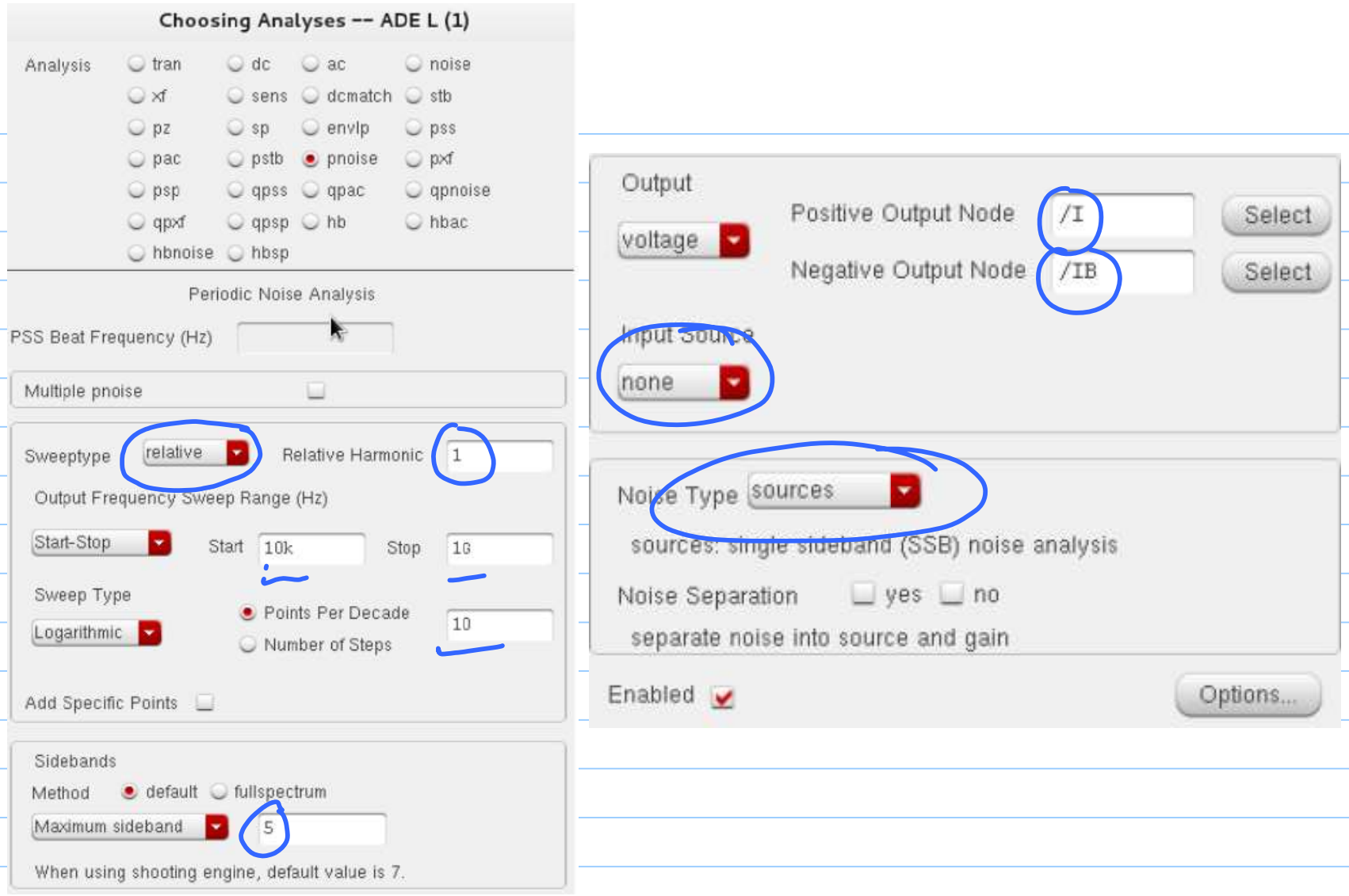


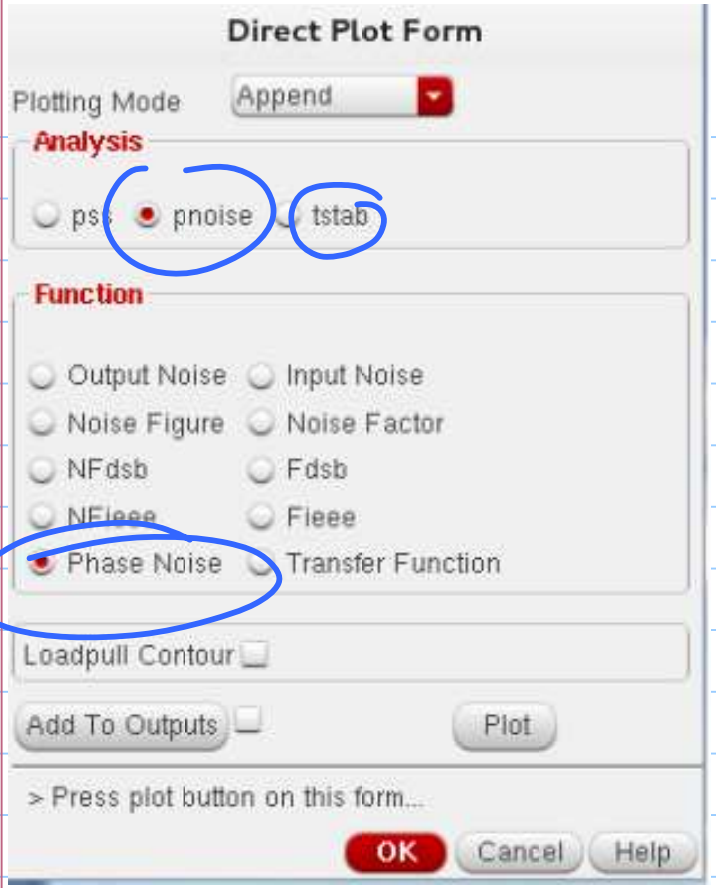
- @ 5GHz

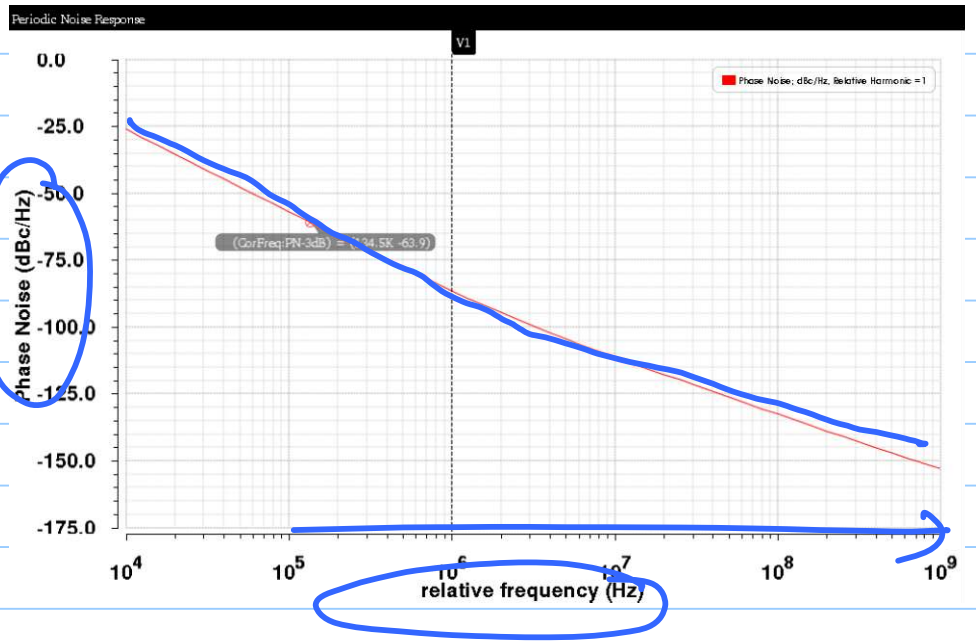
1, 1B


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
50
Auto Calculate
Beat Period
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...


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
1G
Sweep Type
Logarithmic
Points Per Decade
Number of Steps
10
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...


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
0.0
-25.0
-75.0
-150.0
-175.0
Phase Noise (dBc/Hz)
10^4
10^5
10^8
10^9
relative frequency (Hz)