TFE4188 - Introduction to Lecture 8

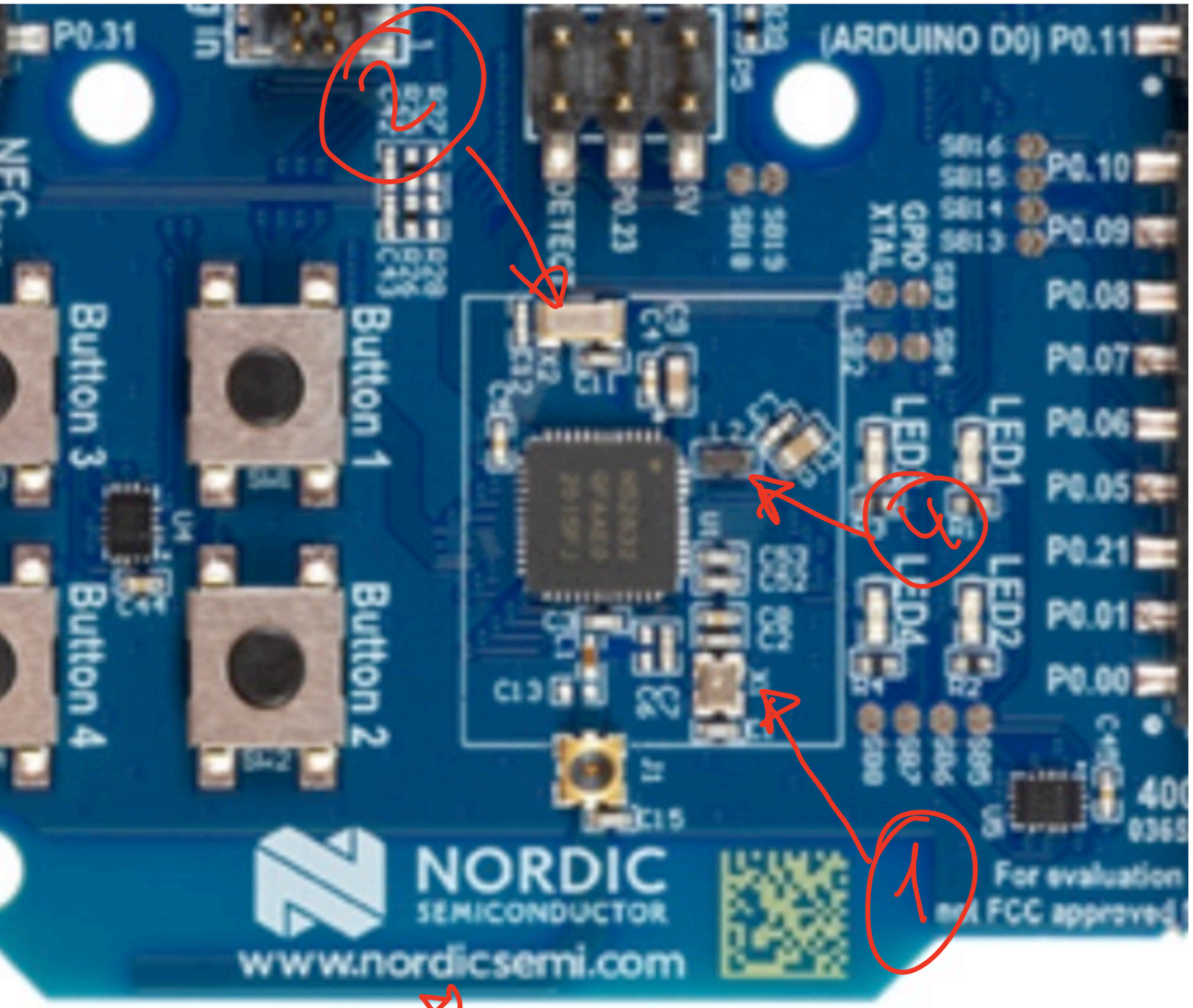
Clocks and PLLs

Goal

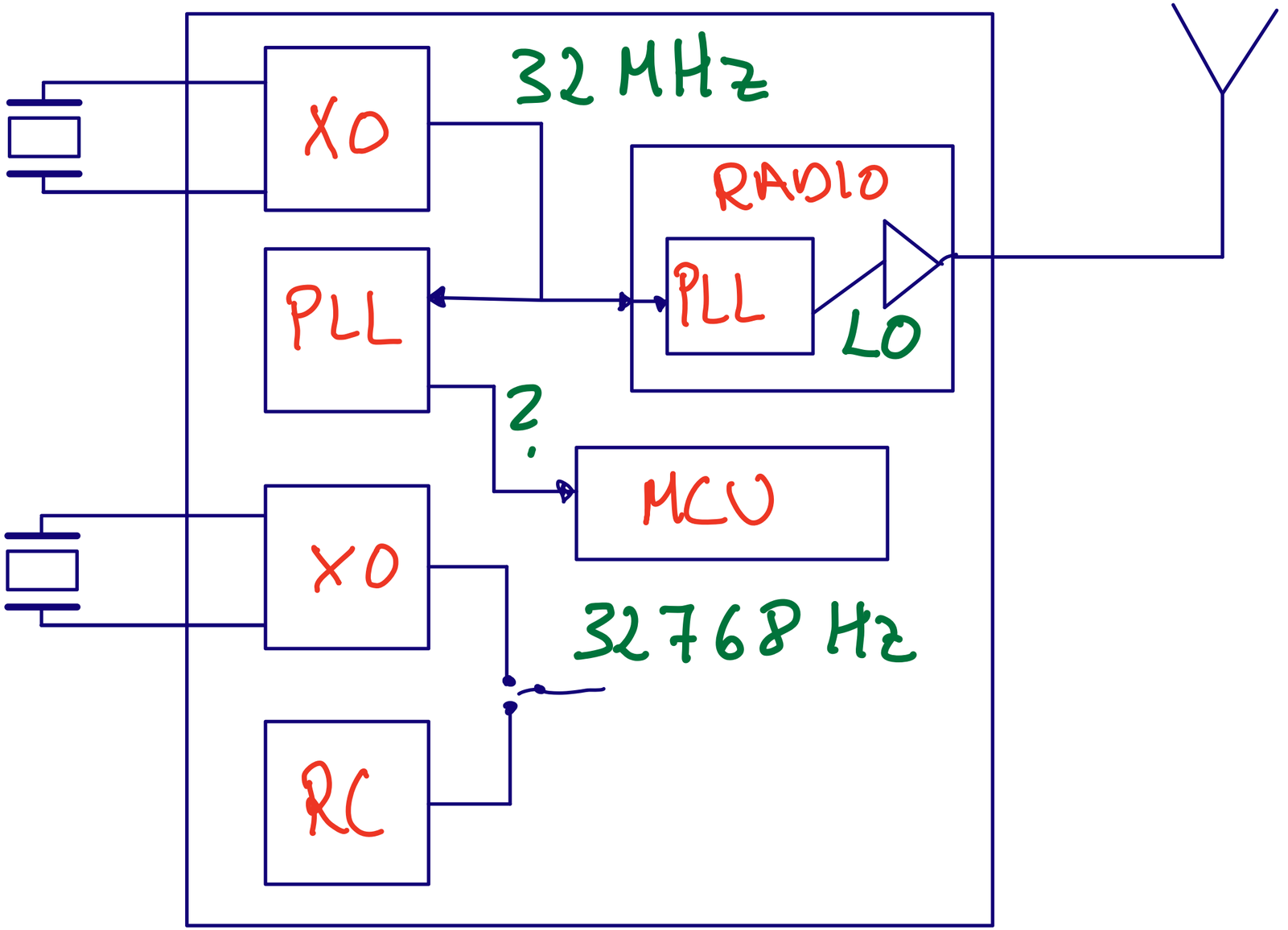
Why do we need to generate clocks

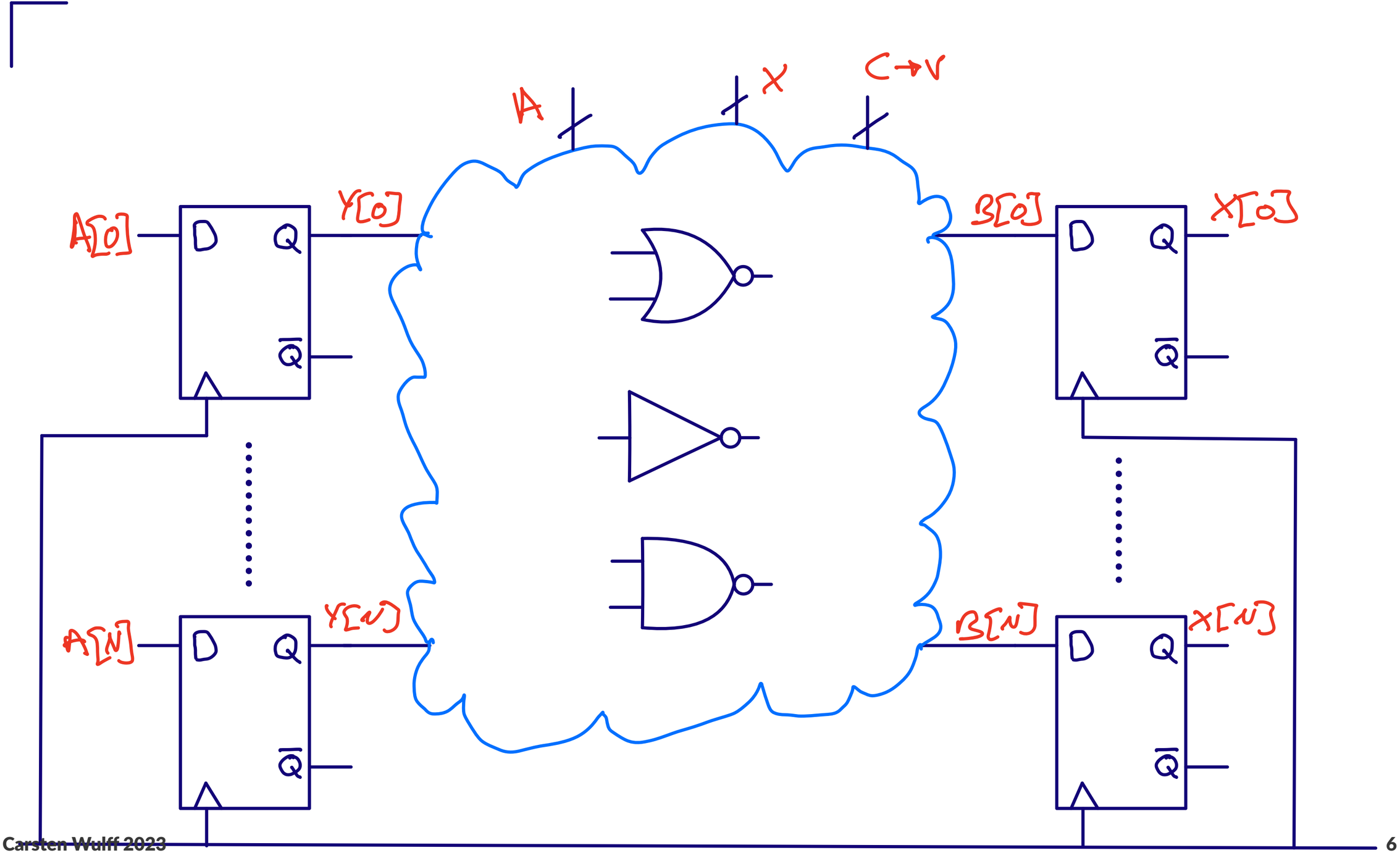
Introduction to **PLLs**

Why



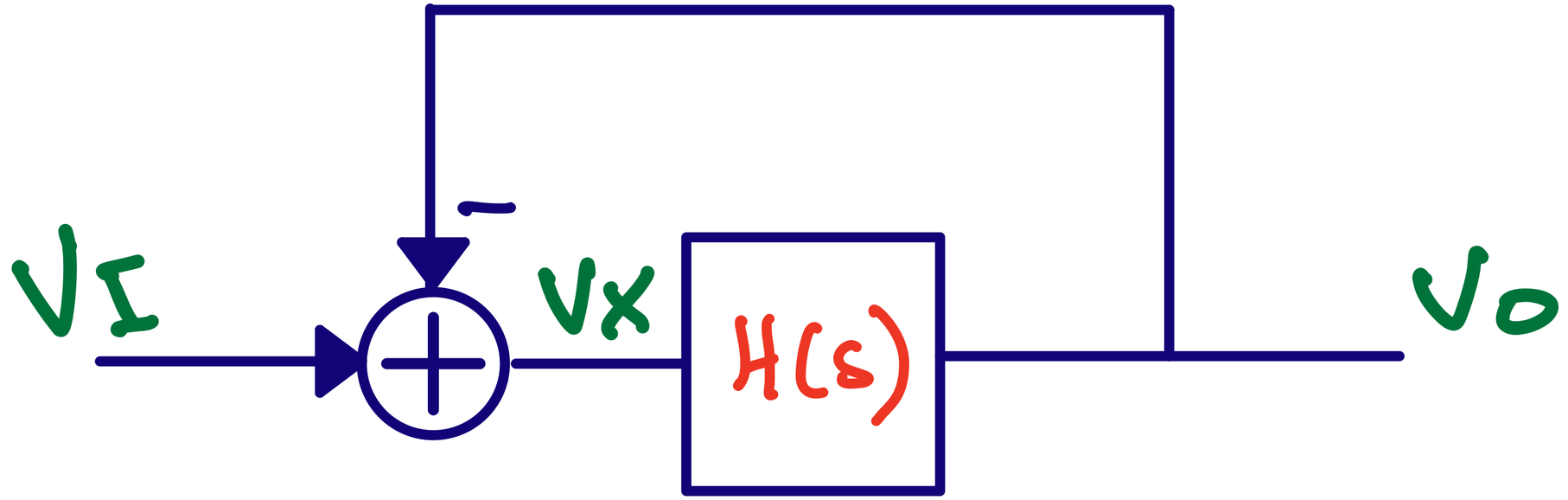
1. 32 MHz crystal
2. 32 KiHz crystal
3. In PCB antenna
4. DC/DC inductor


32 MHz
XO
RADIO
PLL
PLL
LO
?
MCU
XO
32768 Hz
RC



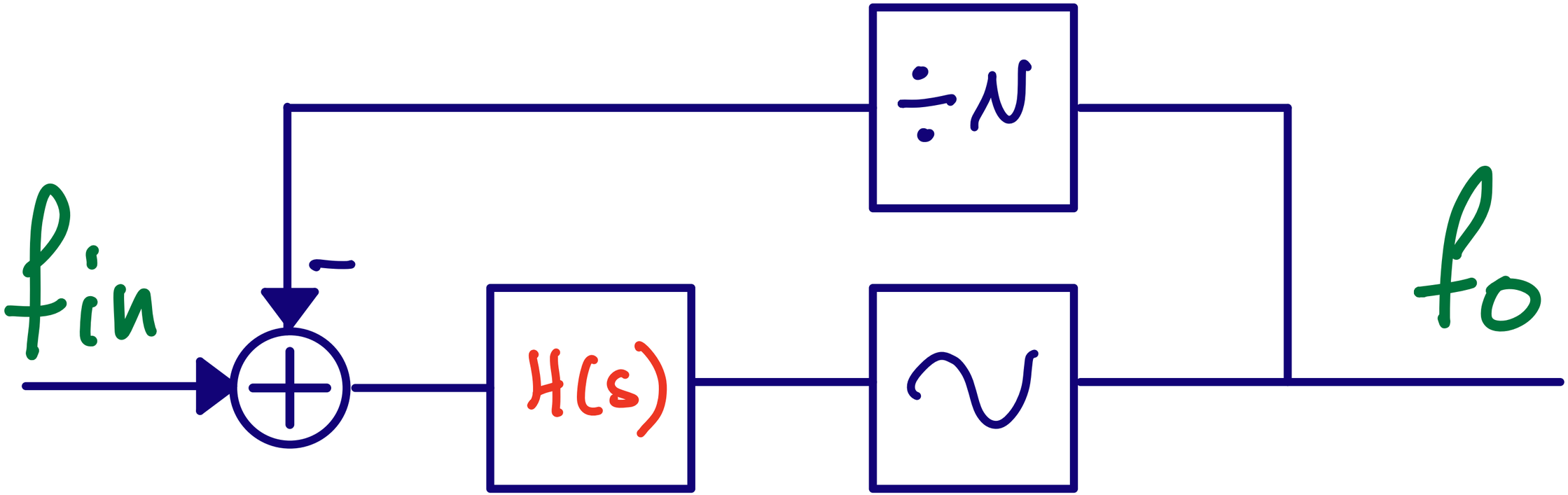
Clk out


PLL

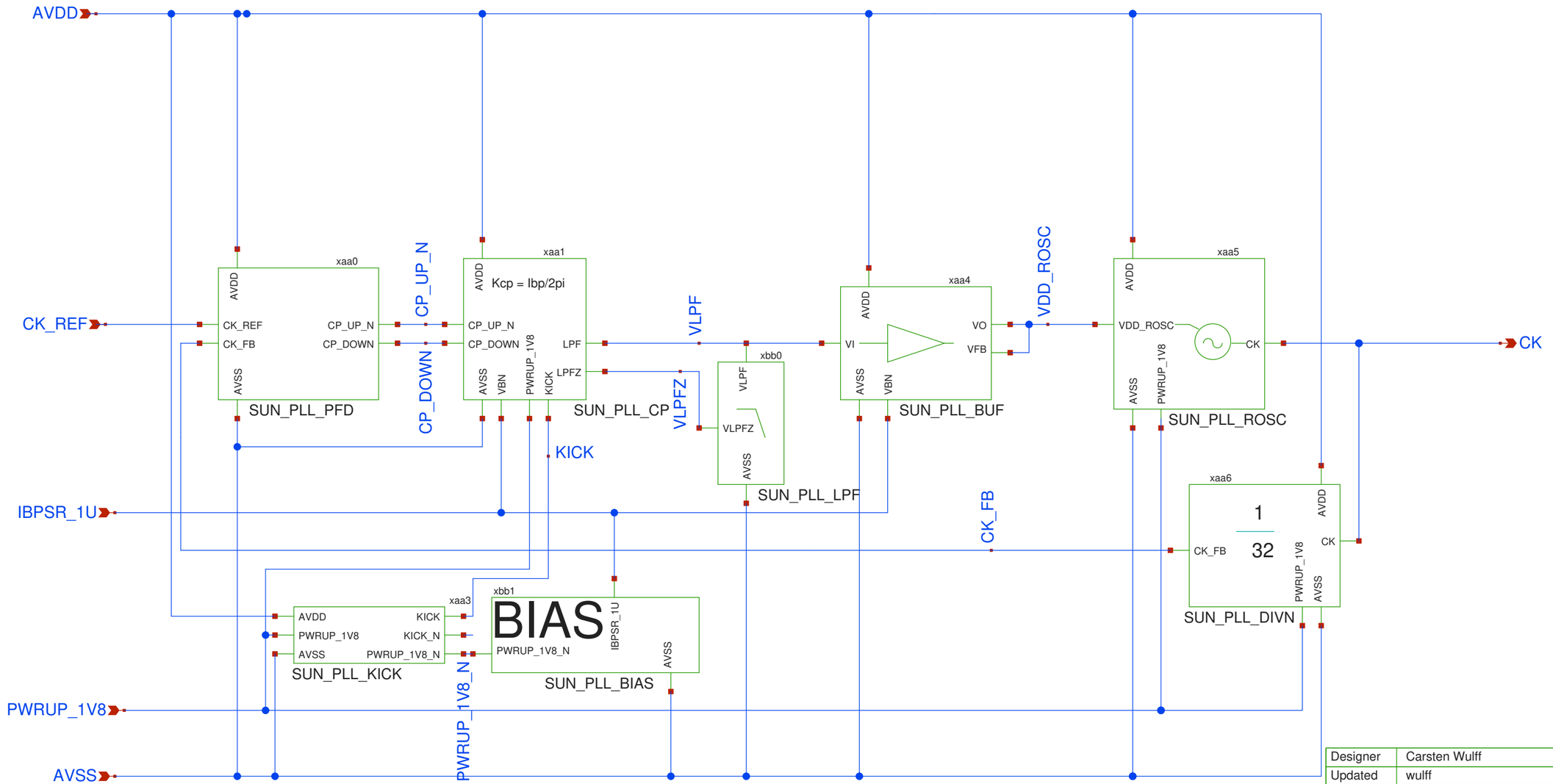


$$V_I - V_o = V_x \qquad V_o = V_x\, H(s)$$

$$V_I = V_o + \frac{V_o}{H(s)} \qquad H(s)=\infty \Rightarrow \qquad V_o = V_I$$


÷N
fin
−
H(s)
fo

16 MHz x 32 = 512 MHz PLL



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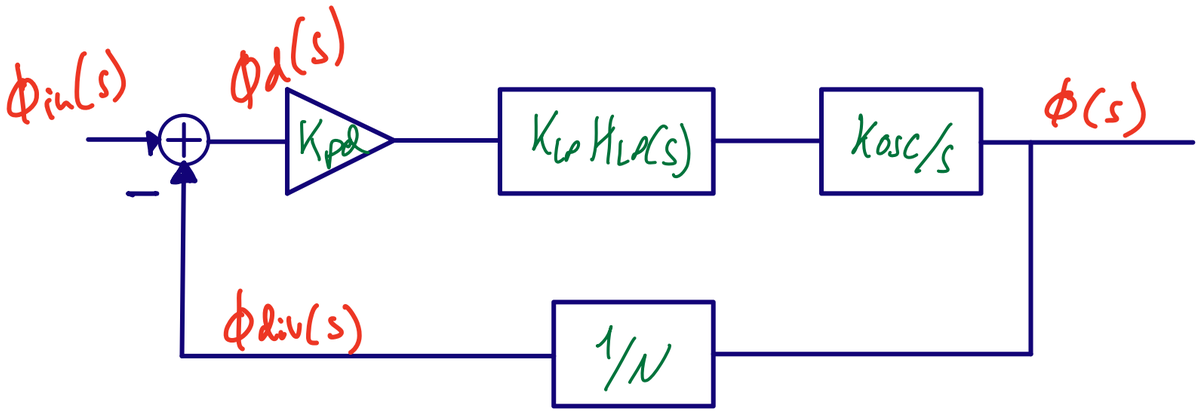
PLLs need calculation!

#noCowboyDesign

$$\phi(t) = 2\pi \int_0^t f(t)dt$$

PLLs are assumed to be linear in phase

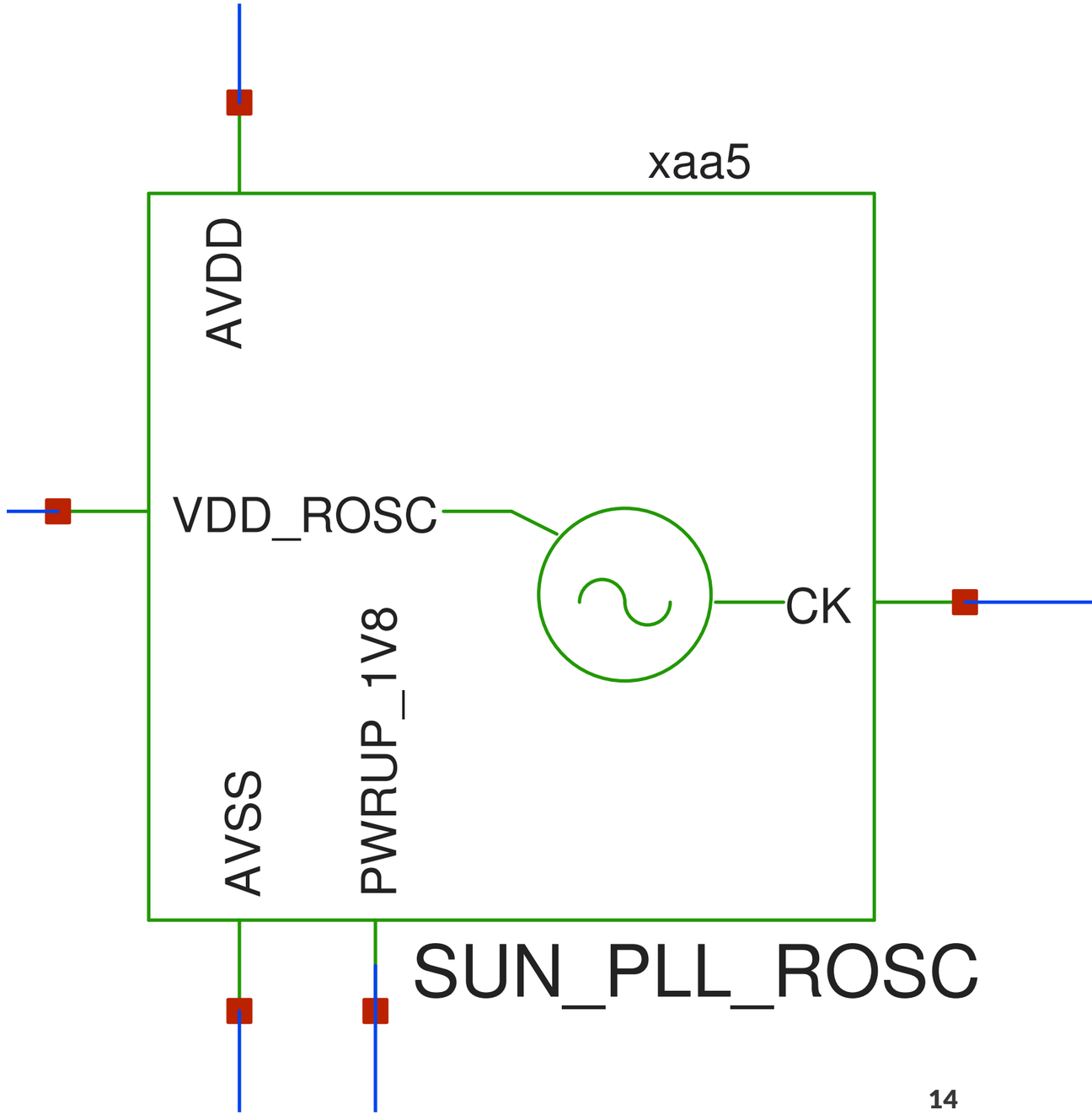


$$\frac{\phi_d}{\phi_{in}} = \frac{1}{1 + L(s)}$$

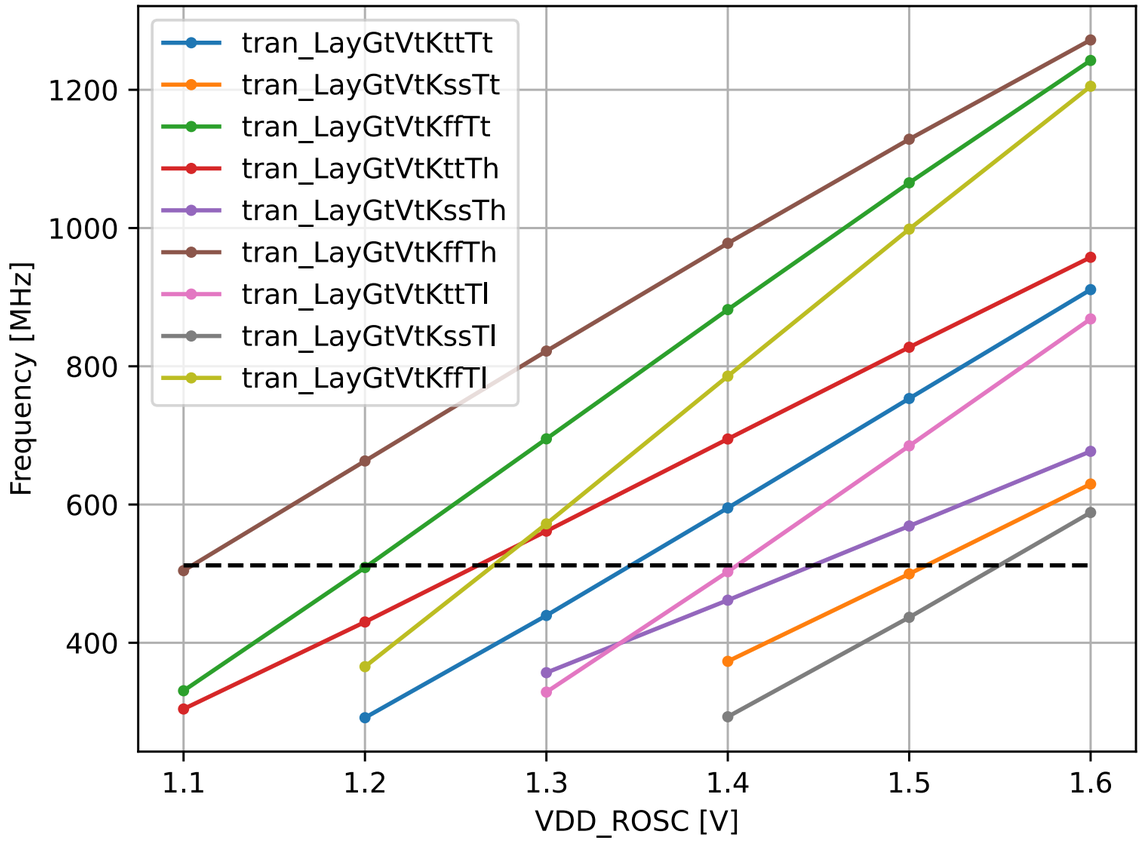
$$L(s) = \frac{K_{osc} K_{pd} K_{lp} H_{lp}(s)}{Ns}$$

Voltage controlled oscillator

$$K_{osc} = 2\pi \frac{df}{dV_{cntl}}$$

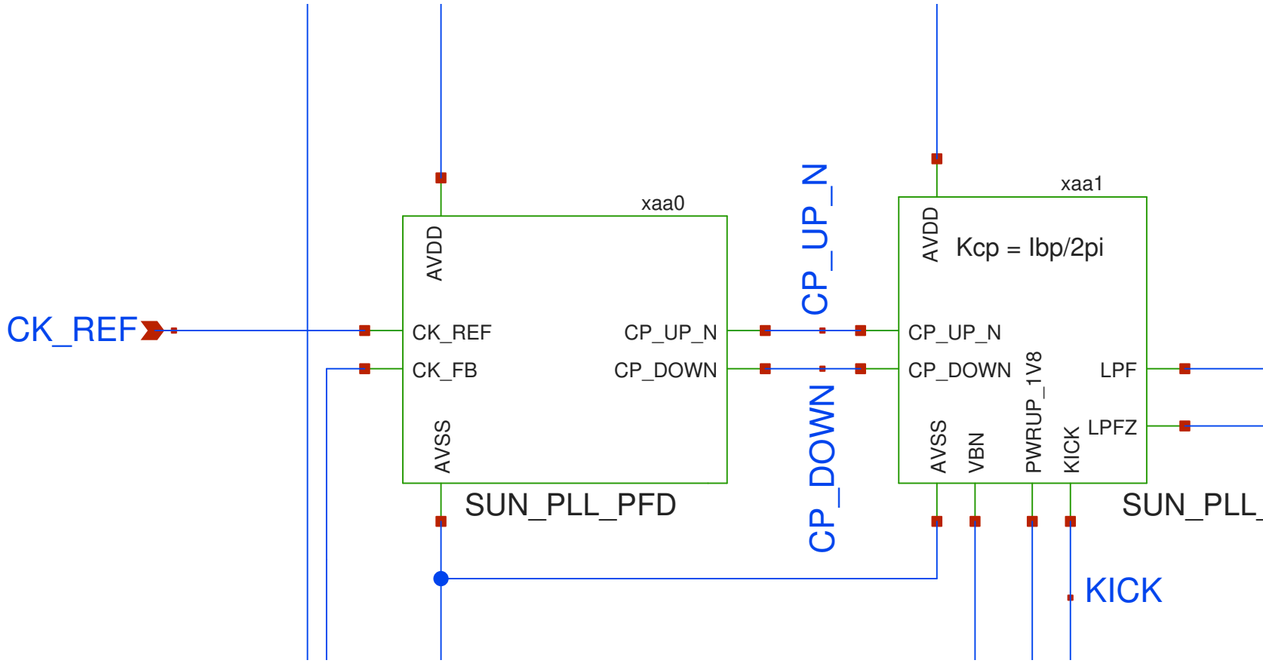


SUN_PLL_SKY130NM/ sim/ROSC/



Phase detector and charge pump

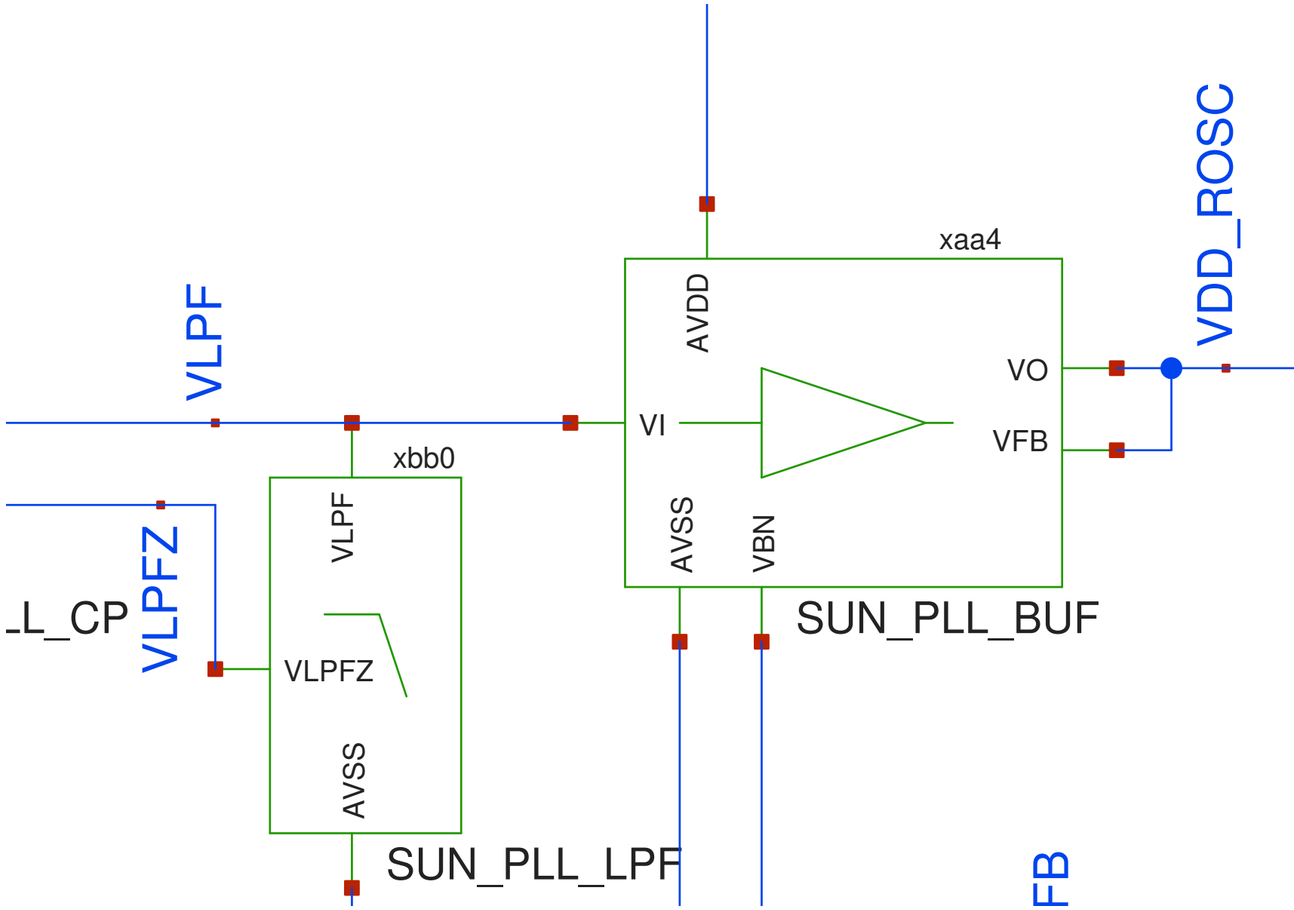
$$K_{pd} = \frac{I_{cp}}{2\pi}$$



Loop filter

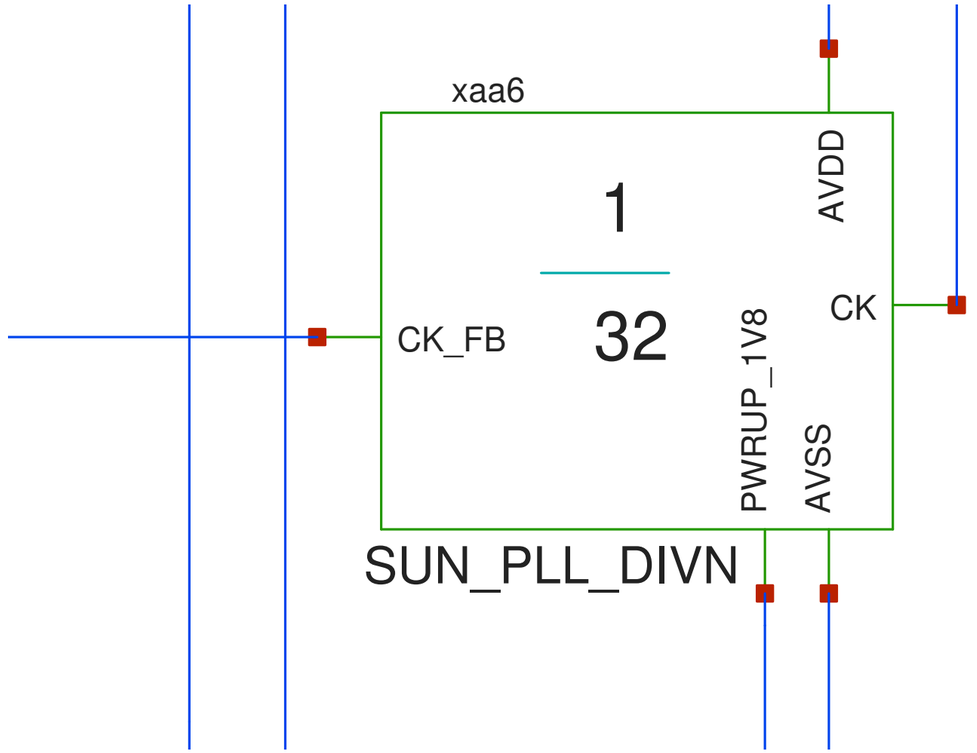
$$K_{lp}H_{lp}(s) = K_{lp}\left(\frac{1}{s} + \frac{1}{\omega_z}\right)$$

$$K_{lp}H_{lp}(s) = \frac{1}{s(C_1 + C_2)} \frac{1 + sRC_1}{1 + sR\frac{C_1C_2}{C_1+C_2}}$$



Divider

$$K_{div} = \frac{1}{N}$$

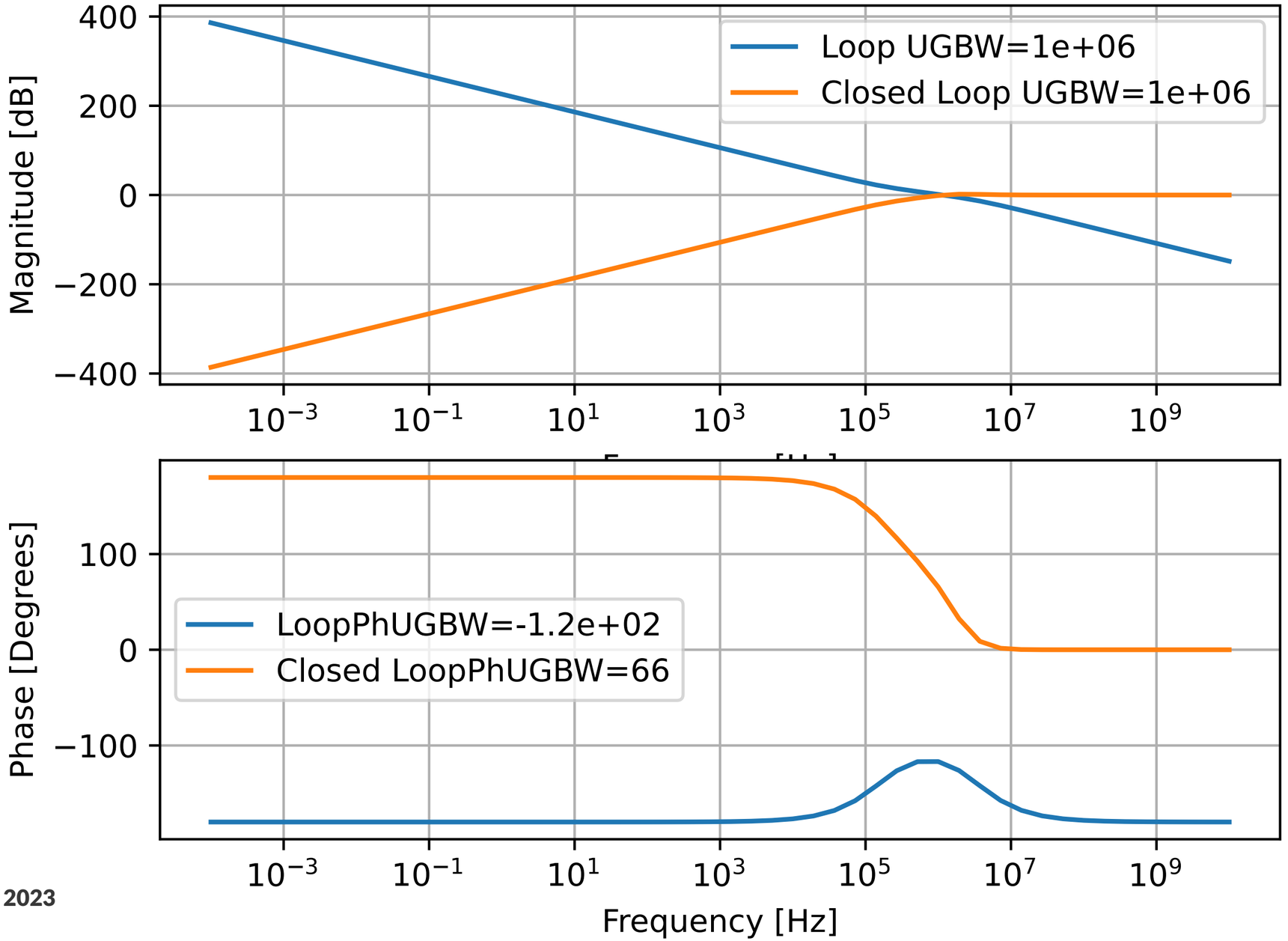


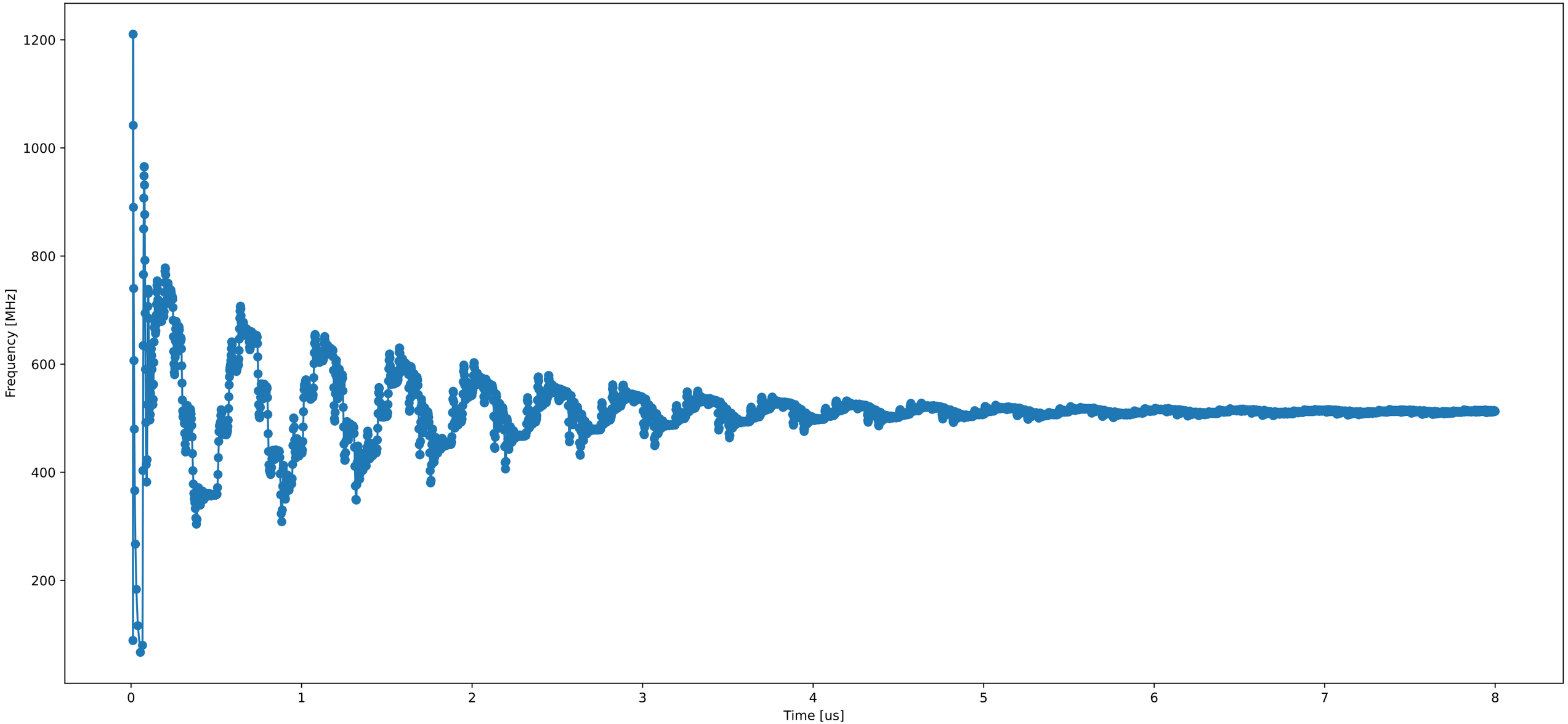
Loop function

$$L(s) = \frac{K_{osc} K_{pd} K_{lp} H_{lp}(s)}{Ns}$$

Python model

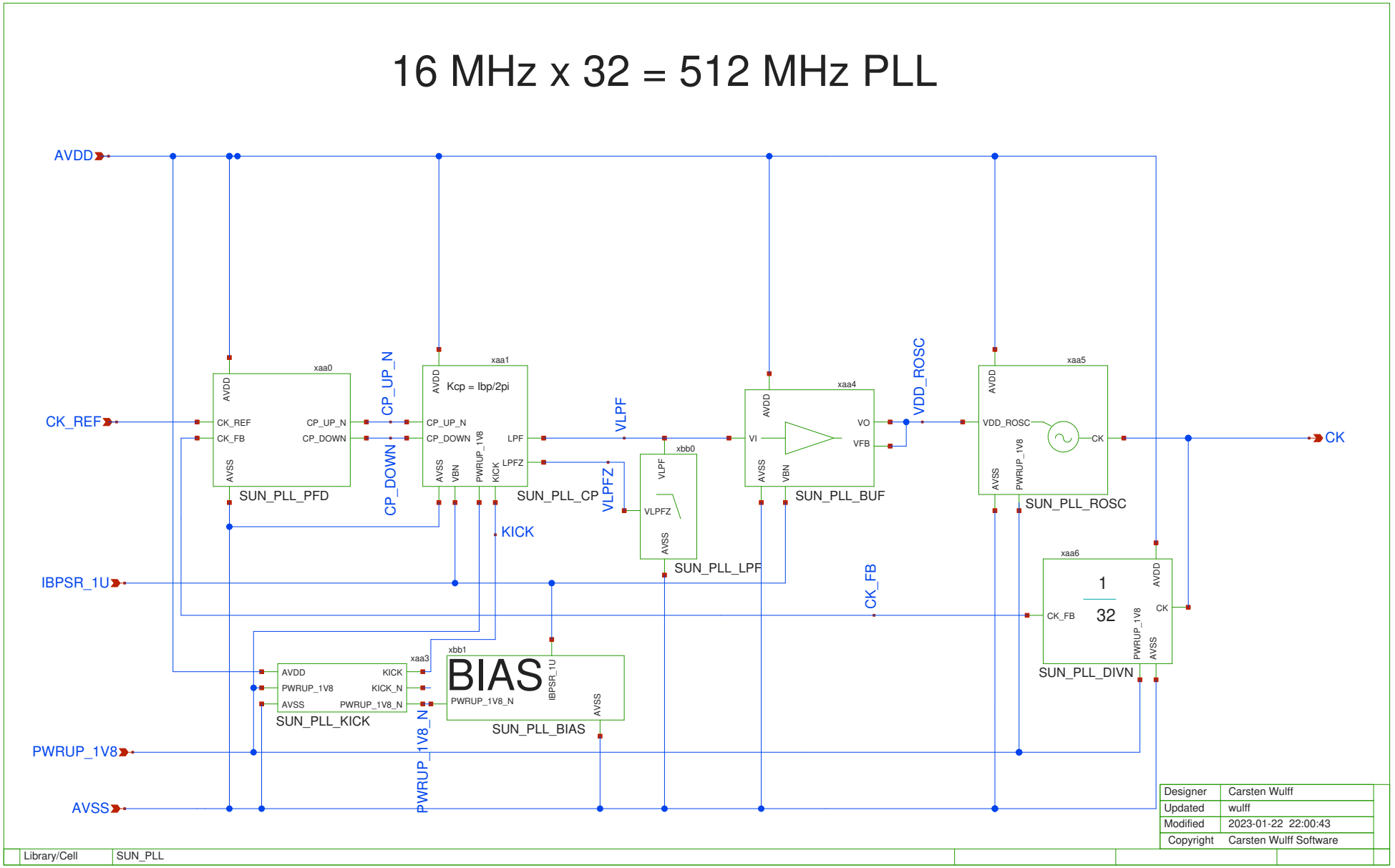
sun_pll_sky130nm/py/pll.py


Magnitude [dB]
400
200
0
−200
−400
Loop UGBW=1e+06
Closed Loop UGBW=1e+06
10^{-3}
10^{-1}
10^{1}
10^{3}
10^{5}
10^{7}
10^{9}
Phase [Degrees]
100
0
−100
LoopPhUGBW=-1.2e+02
Closed LoopPhUGBW=66
Frequency [Hz]

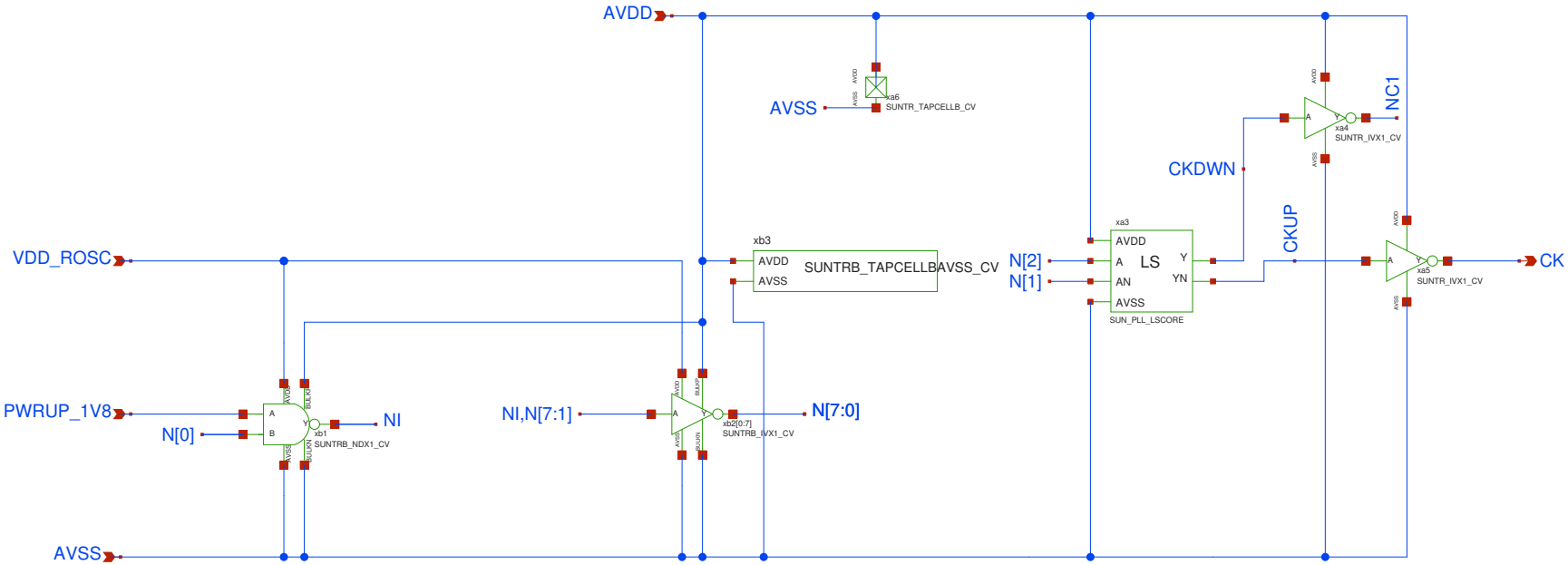

1200
1000
800
600
400
200
Frequency [MHz]
0
1
2
3
4
5
6
7
8
Time [us]

SUN_PLL_SKY130NM

/Users/wulff/pro/aicex/ip/sun_pll_sky130nm/work/../design/SUN_PLL_SKY130NM/SUN_PLL.sch



Ring oscillator with level shifter.



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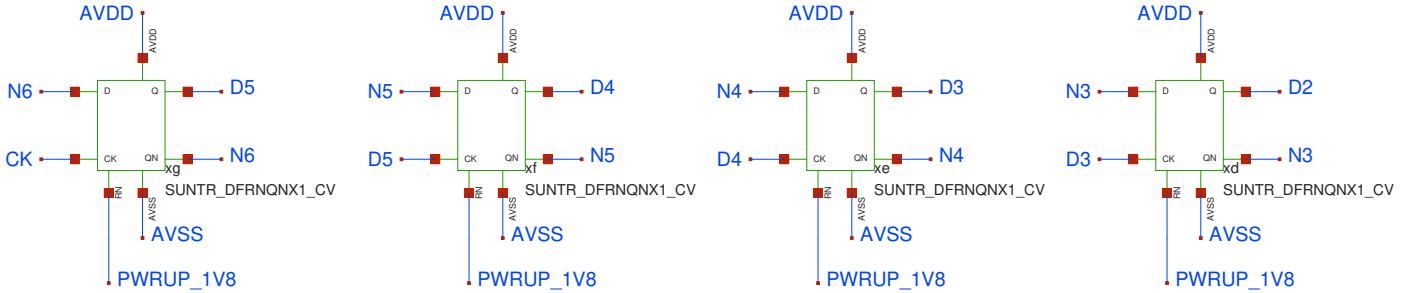
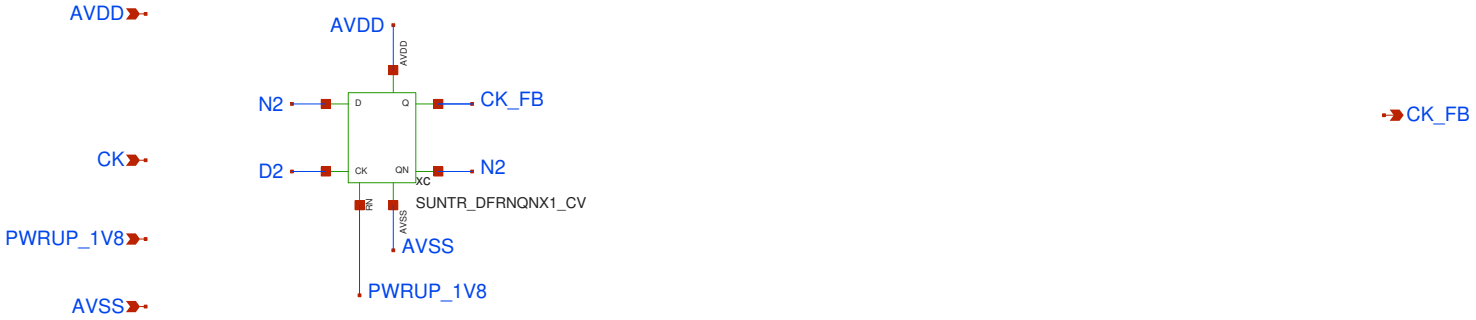
Library/Cell	SUN_PLL_ROSC





Divide by 32

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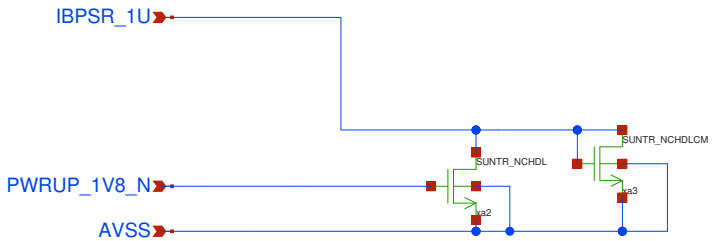
Library/Cell	SUN_PLL_DIVN

Current bias



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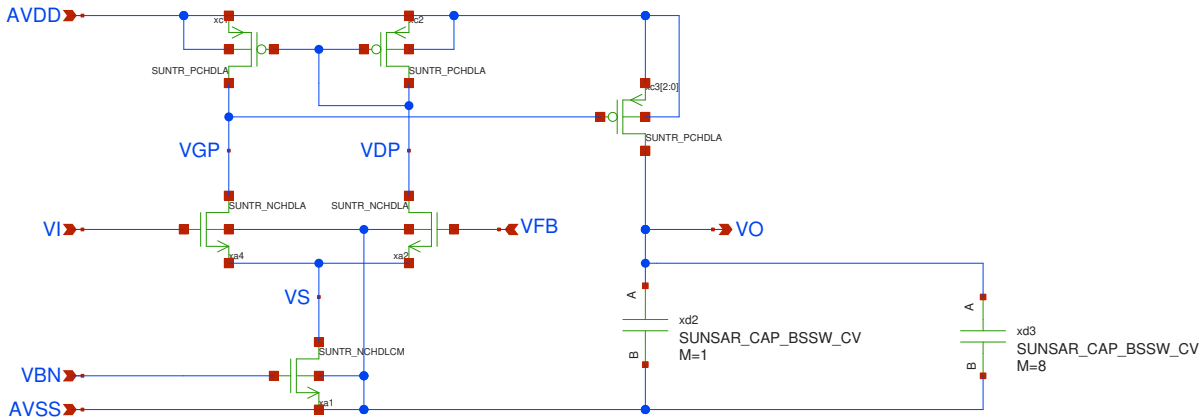
Library/Cell	SUN_PLL_BIAS

SUN_PLL_SKY130NM/SUN_PLL_BUF.sch



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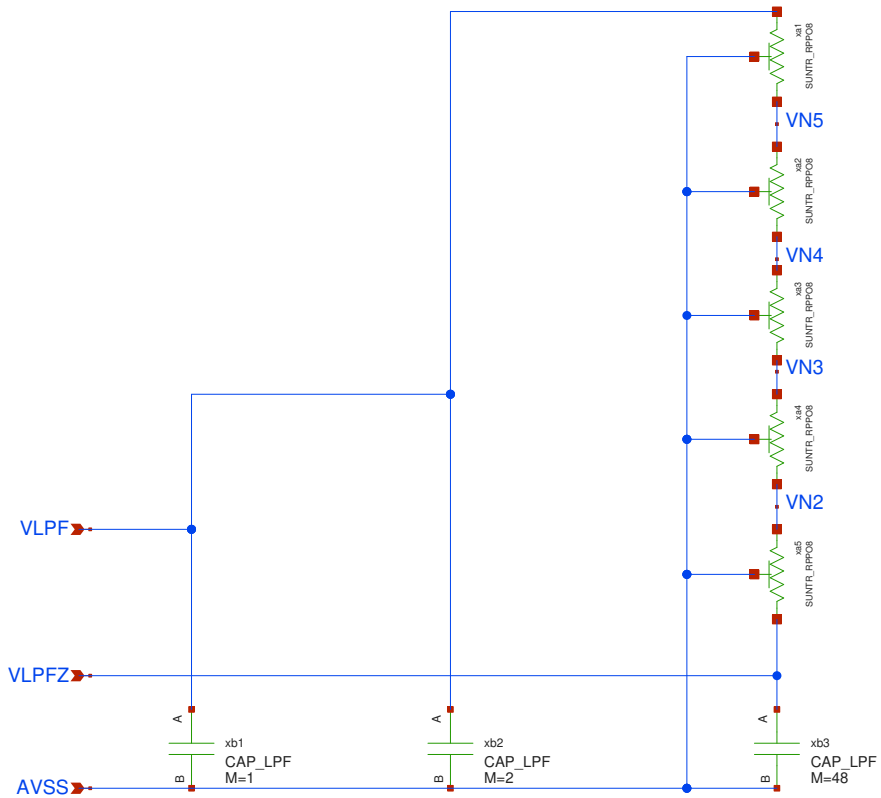
Library/Cell	SUN_PLL_BUF				

SUN_PLL_SKY130NM/SUN_PLL_LPF.sch



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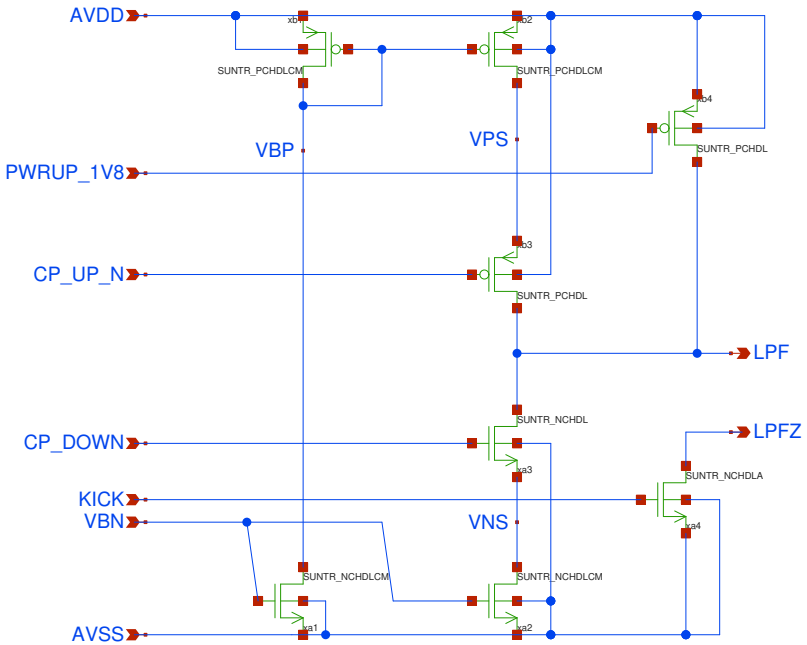
Library/Cell	SUN_PLL_LPF				

Charge pump



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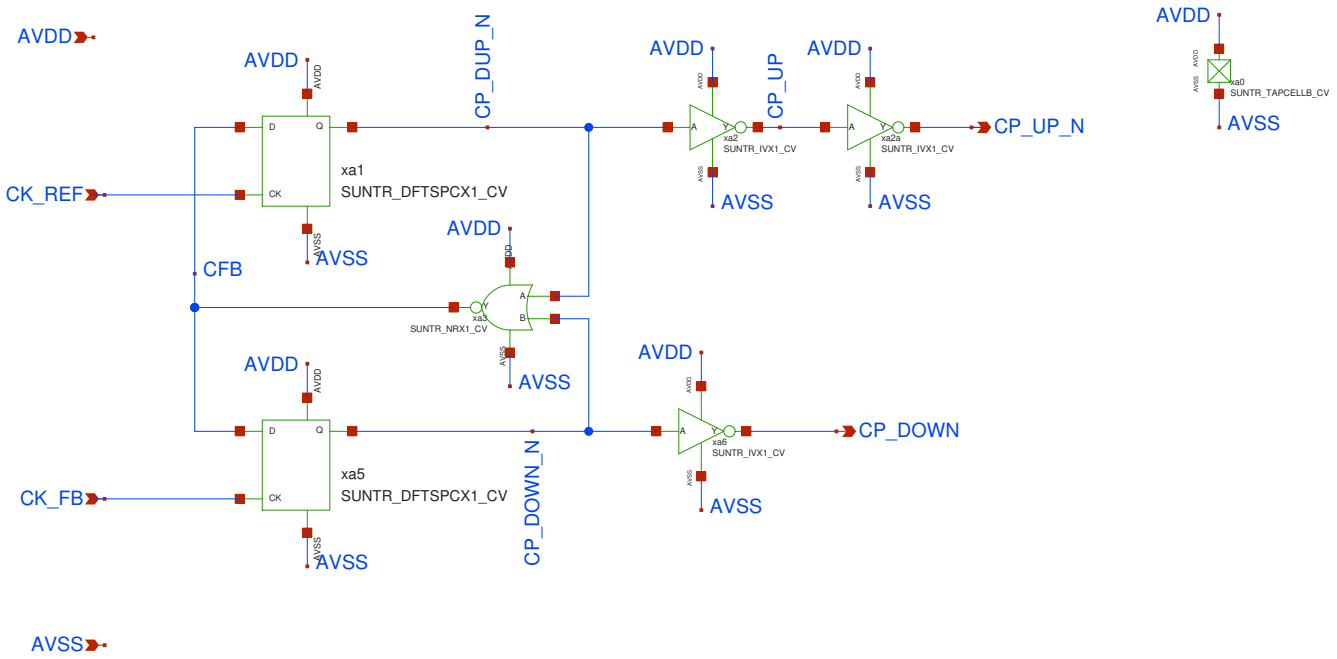
Library/Cell	SUN_PLL_CP

Phase-Frequency Detector (PFD)



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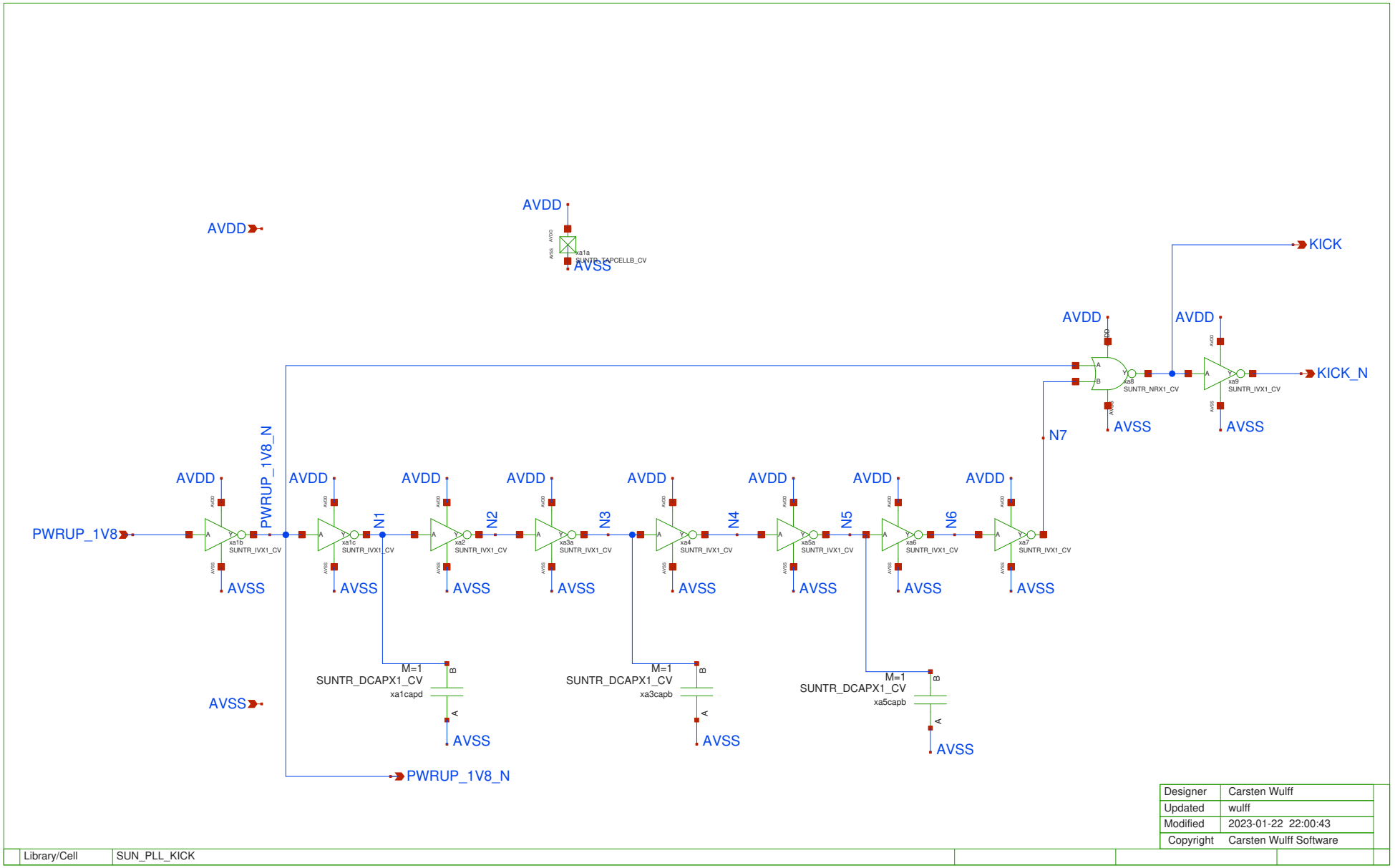
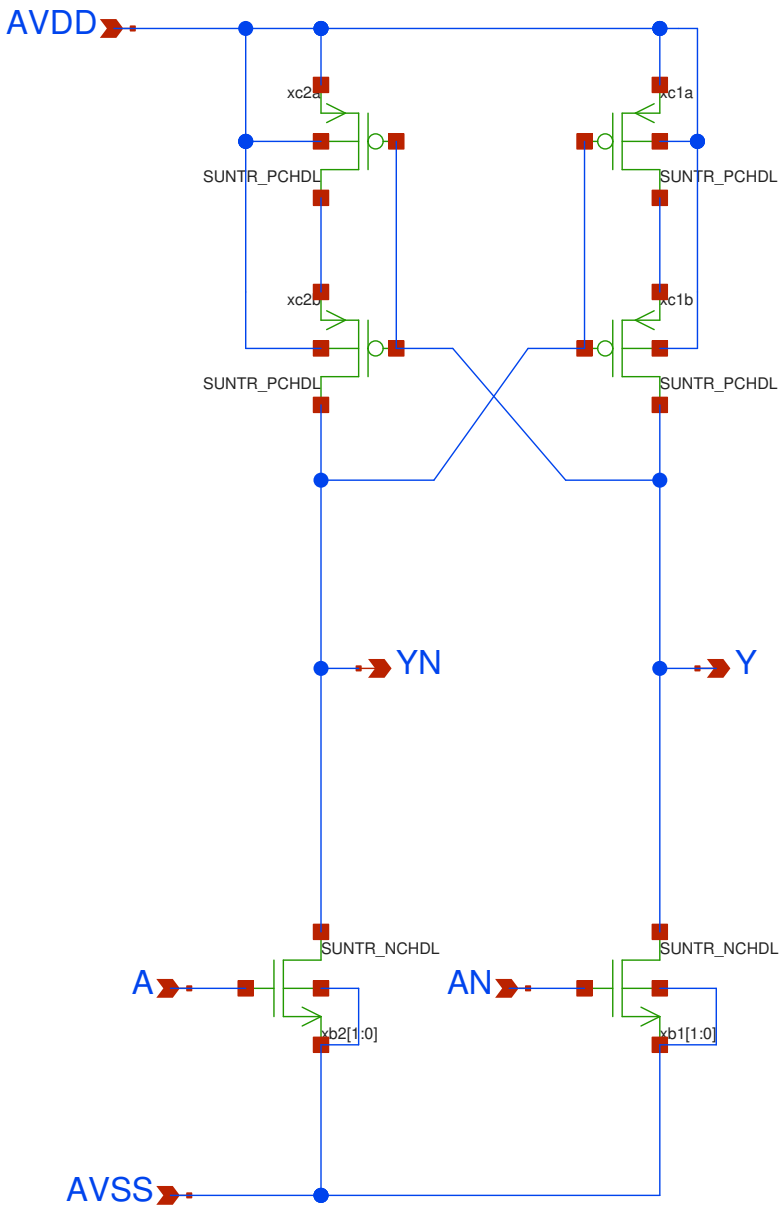
Library/Cell	SUN_PLL_PFD				

SUN_PLL_SKY130NM/SUN_PLL_KICK.sch



SUN_PLL_SKY130NM/SUN_PLL_LSCORE.sch



Thanks!