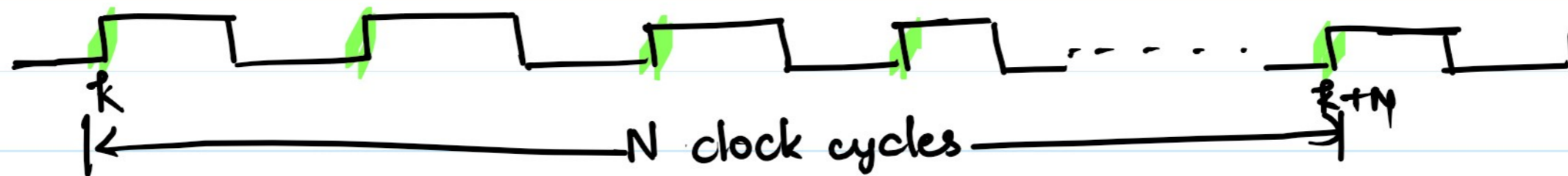
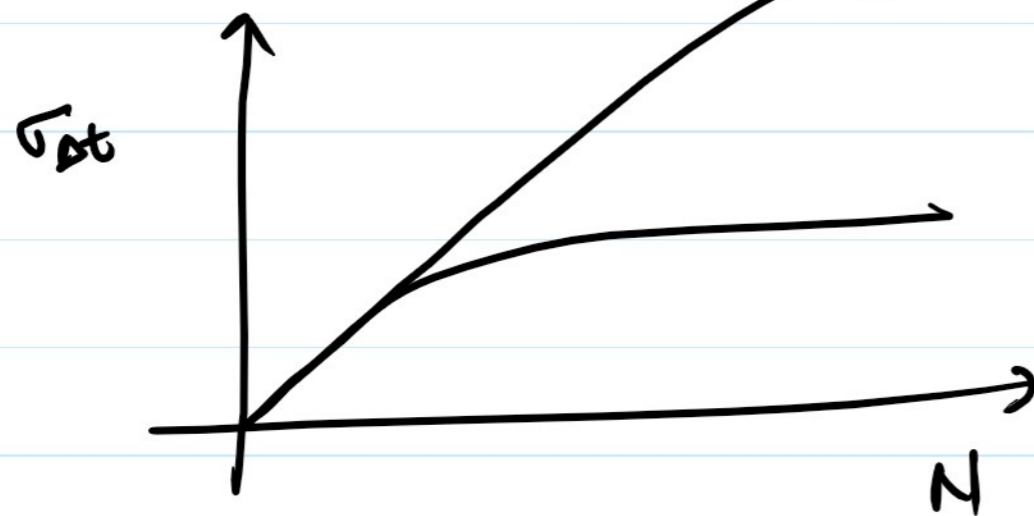


Jitter

- 1) Period jitter
- 2) Cycle-to-cycle jitter
- 3) long-term jitter / accumulated jitter



$$\Delta t [i] = \left( \sum_{k}^{k+N} T_m - N \bar{T}_m \right)$$

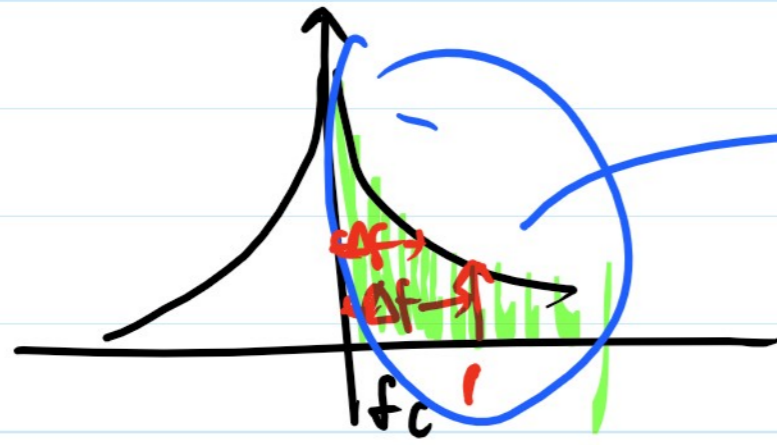


- 4) Phase Jitter

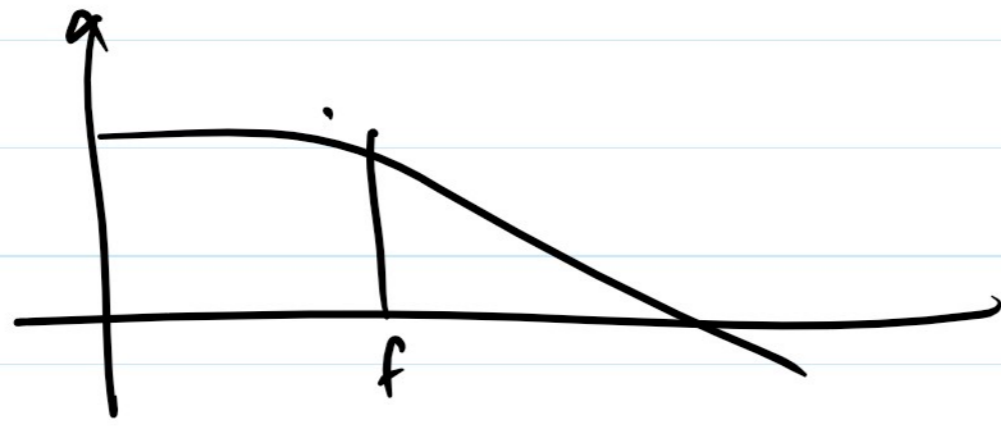
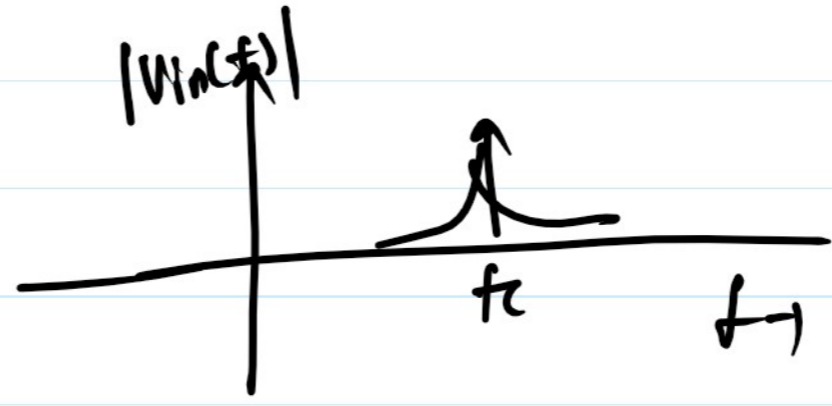
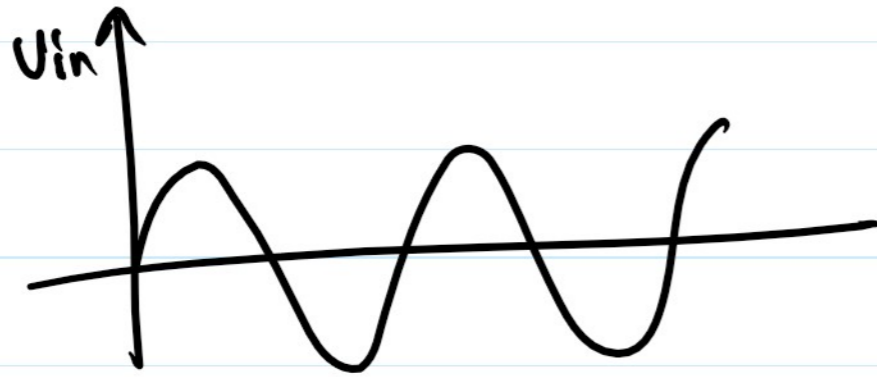
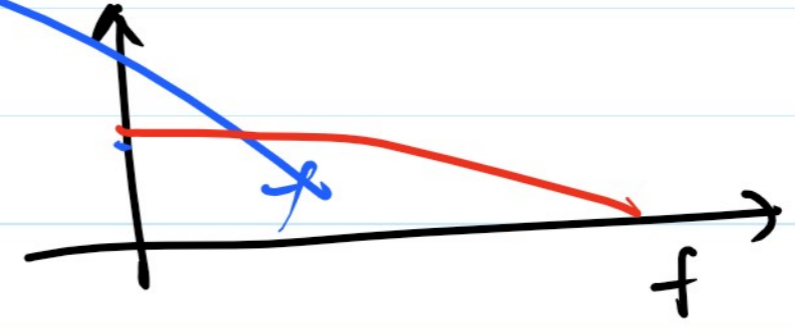


$\Delta t$	lps	0	0	0	-lps	0	0	0	lps
$\Delta t$	lps	0	-lps	0	lps	0	-lps	0	lps

↑ Δf ↓



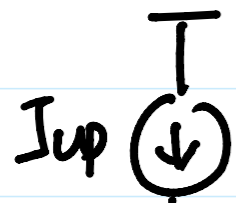
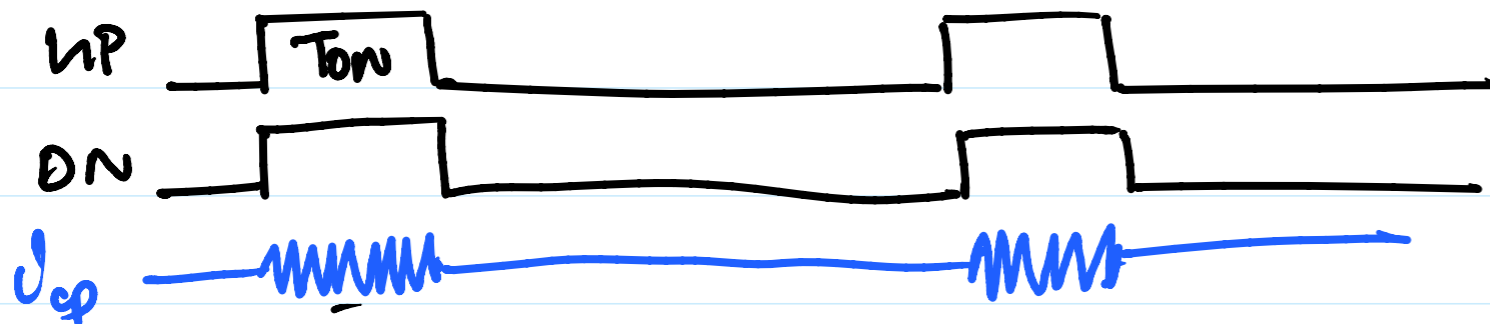
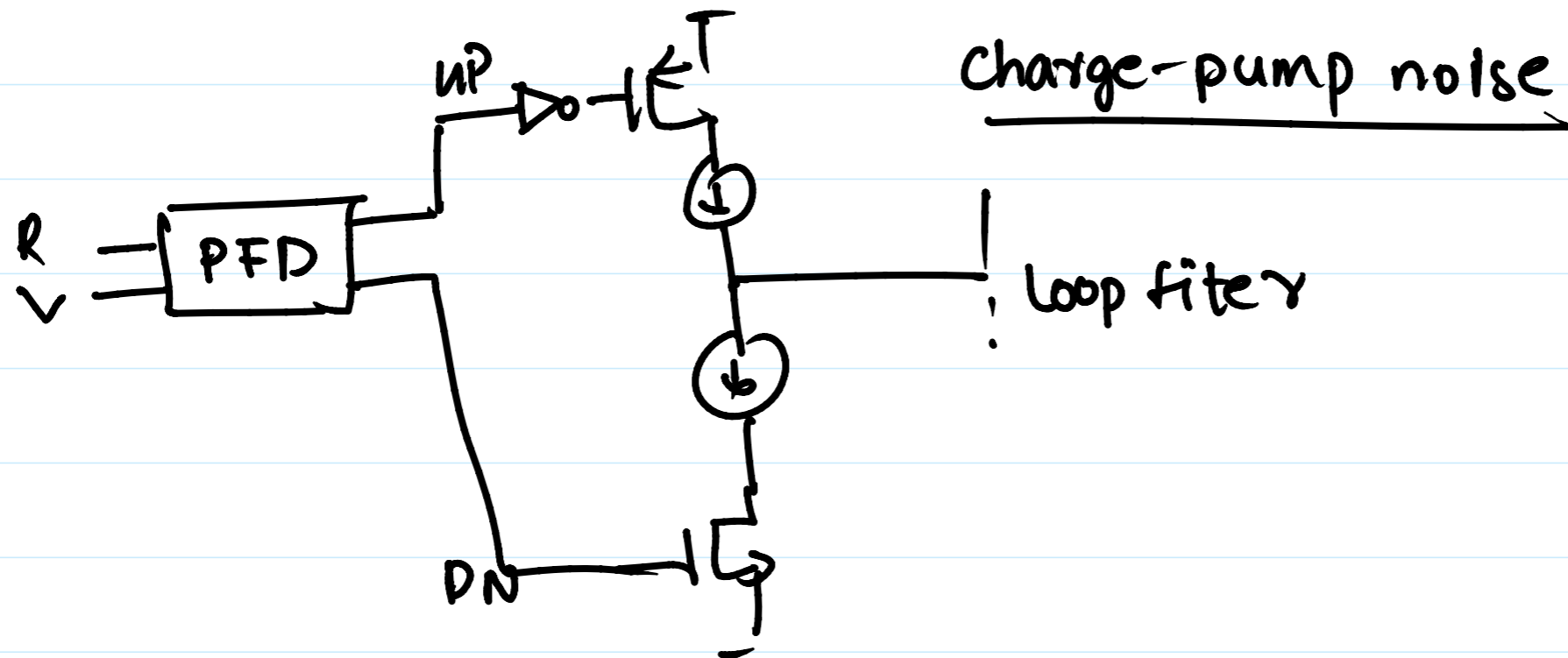
Phase Noise



Noise Sources in CP-PU

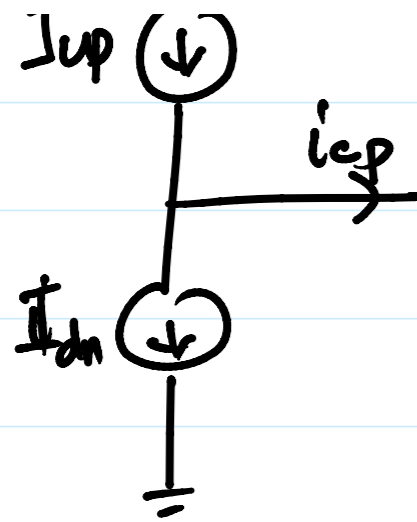
# Noise Sources in CP-PLL

- 1.) PFD + CP
- 2.) Resistor
- 3.) VCO
- 4.) Input ref. noise
- 5.) Divider noise



$$i_{cp} = I_{up} - I_{dn}$$

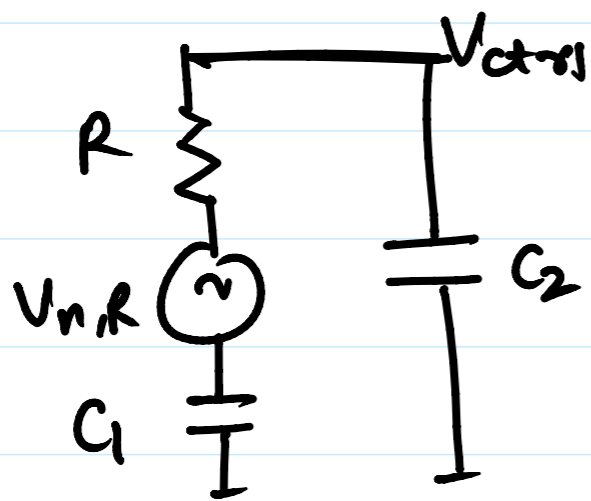
$$\overline{i_{cp}^2} = \overline{I_{up}^2} + \overline{I_{dn}^2}$$



$$\overline{i_{cp,n}^2} = \overline{I_{up,n}^2} + \overline{I_{dn,n}^2}$$

$$S_{i_{cp}} = \frac{T_{0N}}{T_{ref}} (S_{i_{up}} + S_{i_{dn}}) \quad [A^2/Hz]$$

## 2) Resistor Noise



$$\begin{aligned} \frac{V_{ctrl}(s)}{V_{n,R}} &= \frac{Y_{SC_2}}{R + \frac{1}{sC_2} + \frac{1}{sC_1}} = \frac{Y_{SC_2}}{R + \frac{C_1 + C_2}{sC_1C_2}} \\ &= \frac{C_1}{s \underbrace{RC_1C_2 + C_1 + C_2}_{H_R(s)}} \end{aligned}$$

$$V_{ctrl}(s) = H_R(s) V_{n,R}$$

$$|V_{ctrl,n}|^2 = |H_R(s)|^2 4kTR$$