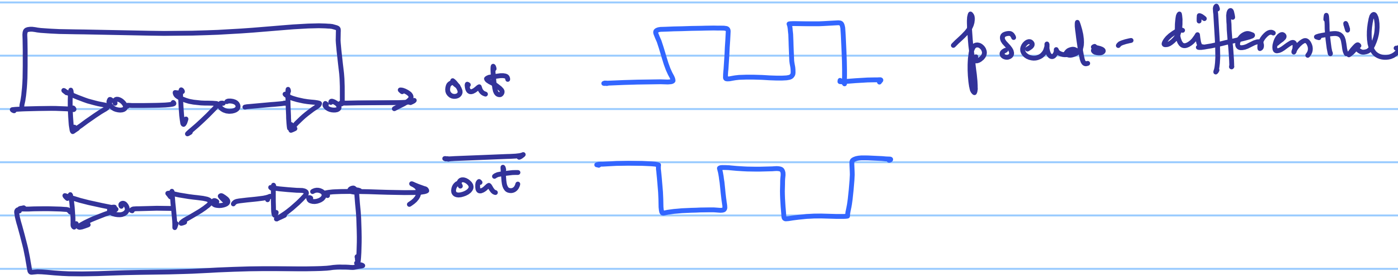
ECE 504 - Lecture 18

Note Title 10/24/2016

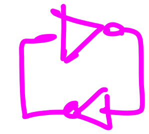
Rail-to-rail Differential

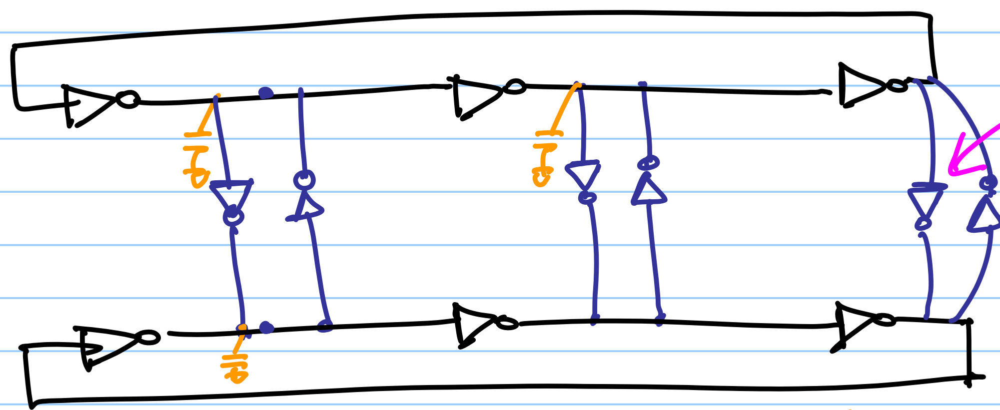


* No way we can match the phase of the two oscillators!

Couple the two oscillators

Latch

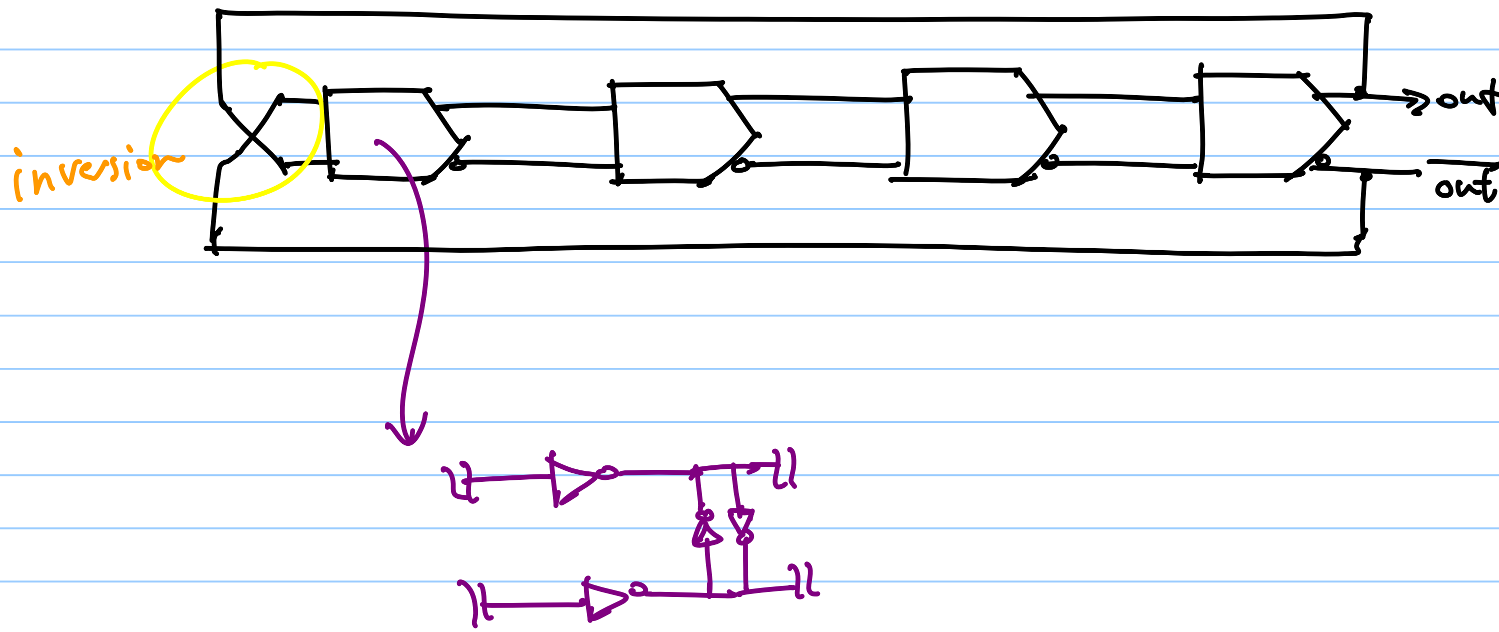




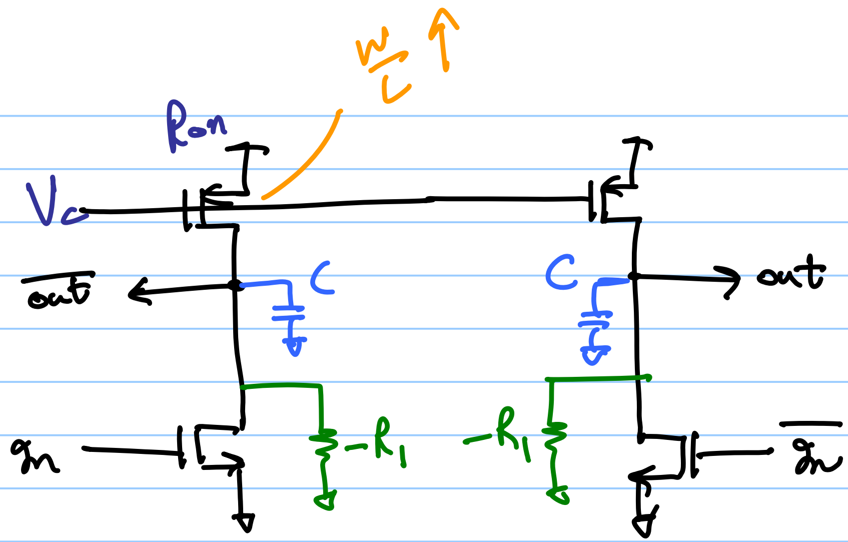
small latches force differential operation

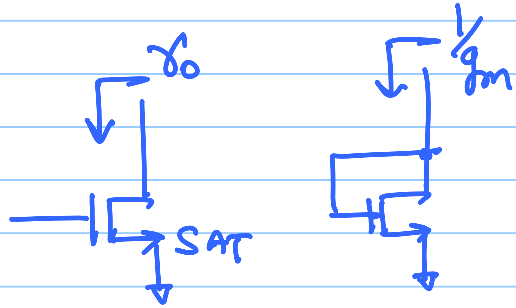
↳ slower oscillation frequency

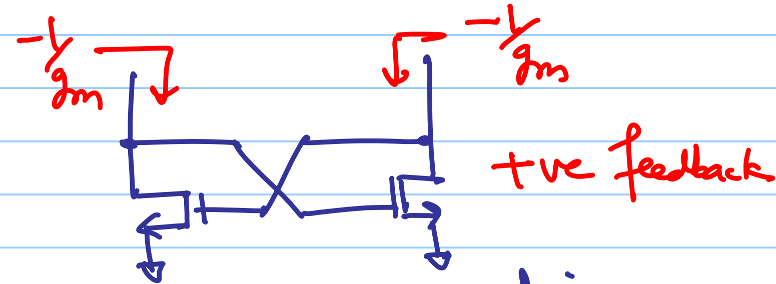
Even stages ?



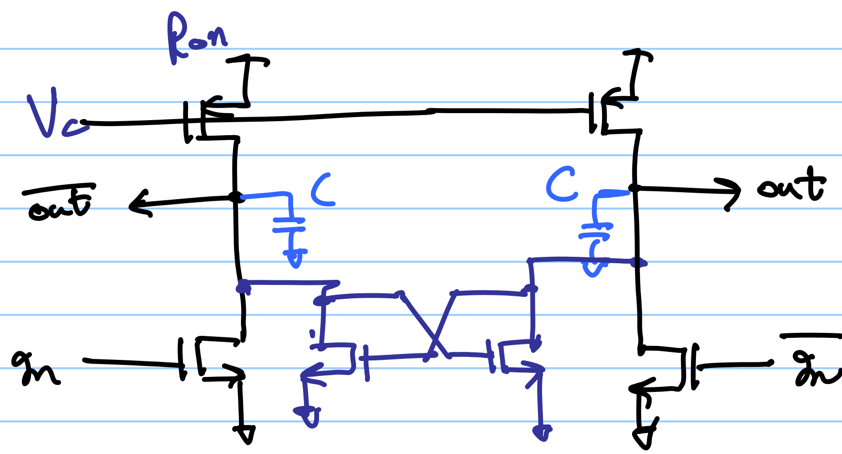
Reduce $\tau = R_{on} C$





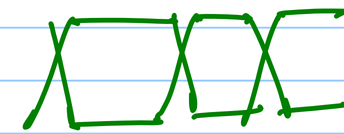


Crosscoupled pair



+ wide tuning range

− Assymmetric output waveforms

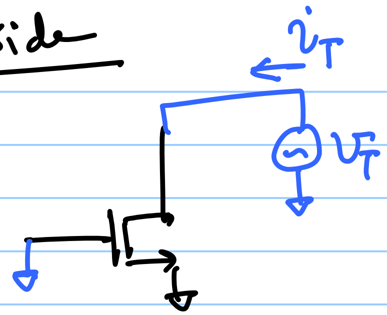


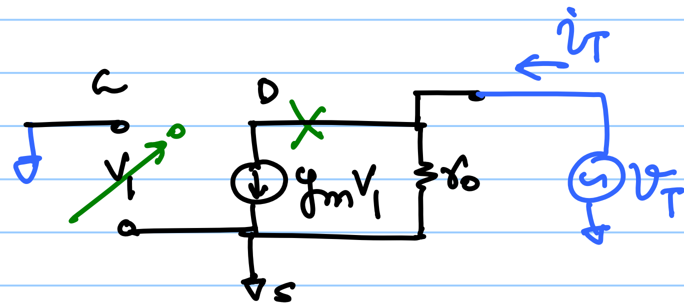
↳ duty cycle distortion

↳ degraded noise performance

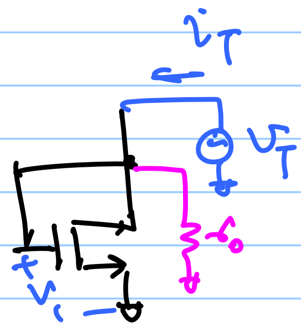
Aside

$$R_{out} \triangleq \frac{v_T}{i_T}$$

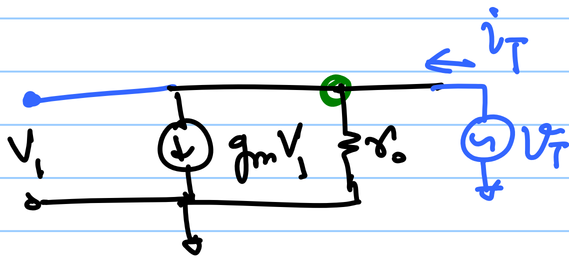




$$R_{out} = r_o$$



Diode Connected MOSFET



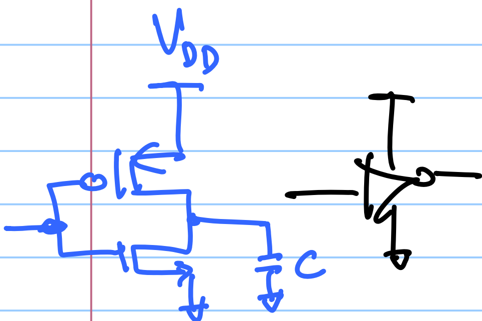
$$v_1 = v_T$$

$$g_m V_1 + \frac{v_T}{r_o} - i_T = 0$$

$$v_T\left(g_m + \frac{1}{r_o}\right) = i_T$$

$$R_{out} = \frac{v_T}{i_T} = \frac{1}{g_m + 1/r_o} = \frac{1}{g_m} \| r_o \simeq 1/g_m$$

Tuning by Supply Voltage.



* Inverter delay is a strong function of V_{DD}

$$\tau = R_{on} C = \frac{1}{k'(V_{DD} - V_{THN})} \cdot C$$

$$f_{osc} \propto \frac{1}{2N\tau} = \frac{k'(V_{DD} - V_{THN})}{2NC}$$

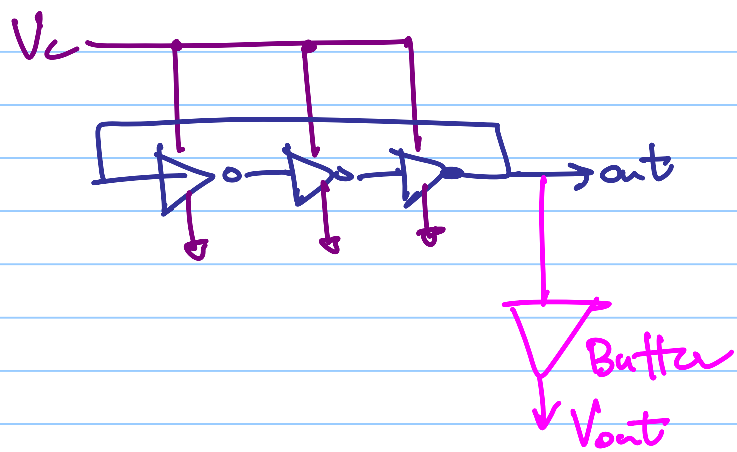
$$V_{DD}\uparrow \Rightarrow R_{on}\downarrow \Rightarrow \tau\downarrow \Rightarrow f_{osc}\uparrow$$

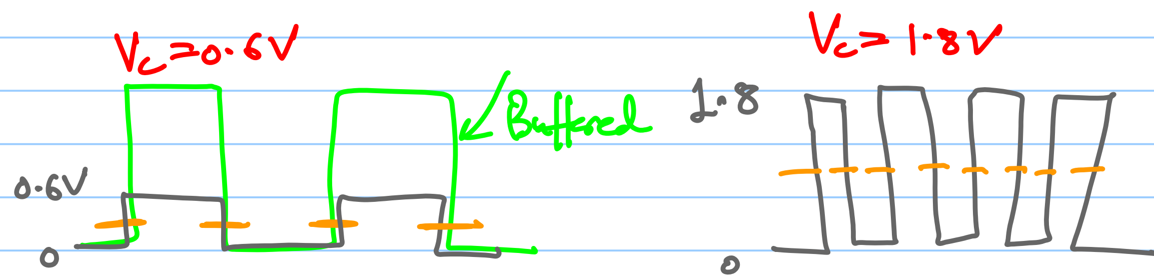
* Wide tuning range!

* $P_d = CV^2 f$ if $f_{osc} = \alpha V_{DD}$

$= \alpha C V_{DD}^3 = \frac{C f_{osc}^3}{\alpha^2}$

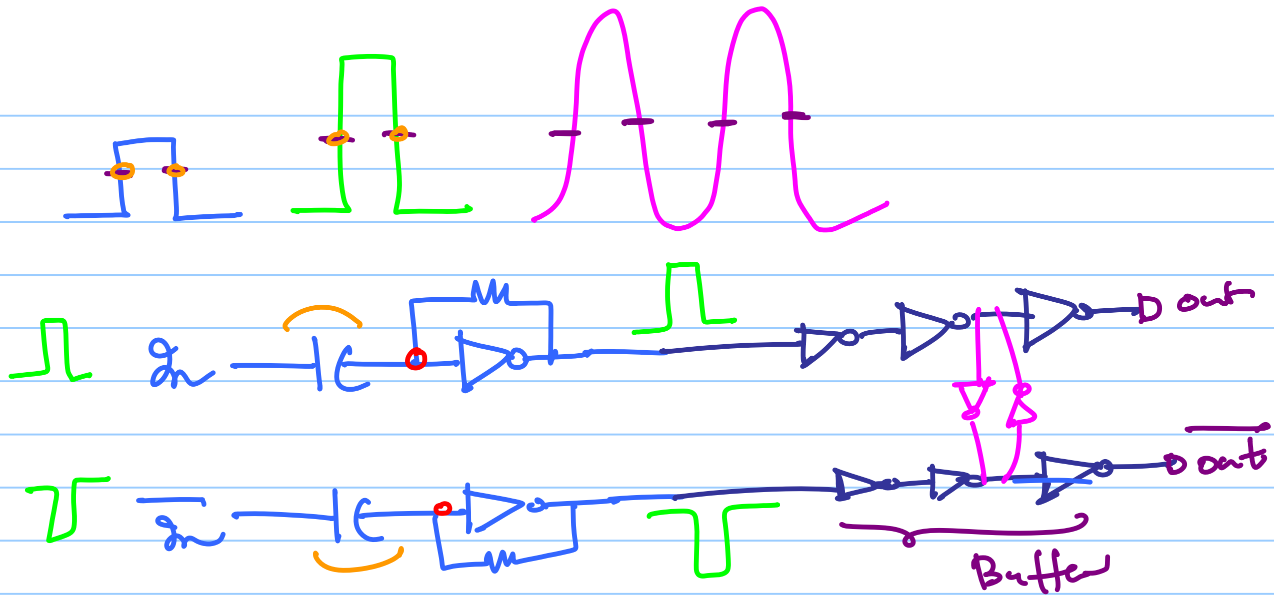
* Automatic power scaling



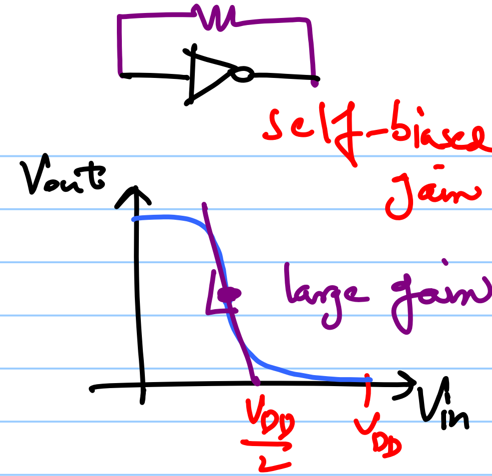


VCO Buffers :

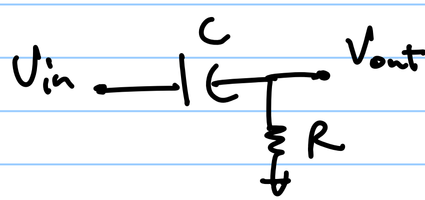
* Buffers convert low-swing VCO output to full-swing
  - ↳ 50% output duty cycle
  - ↳ fast rise/fall times
  - ↳ low power
  - ↳ PSRR
  - ↳ Add low capacitance to the VCO



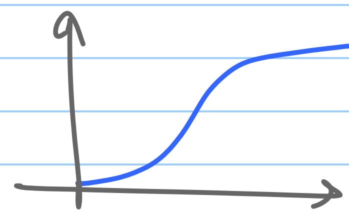
in
out
in
out
Buffer

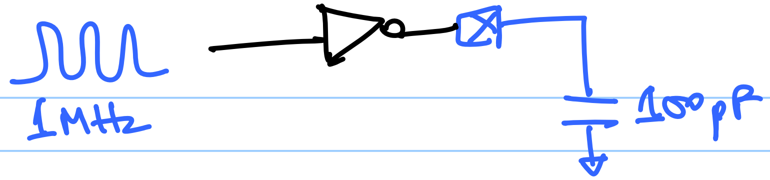


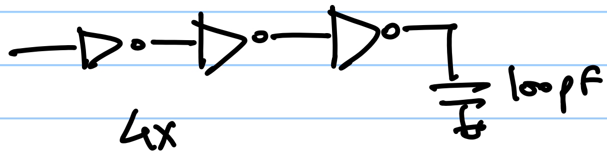
self-biased
gain
Vout
large gain
Vin
VDD/2
VDD



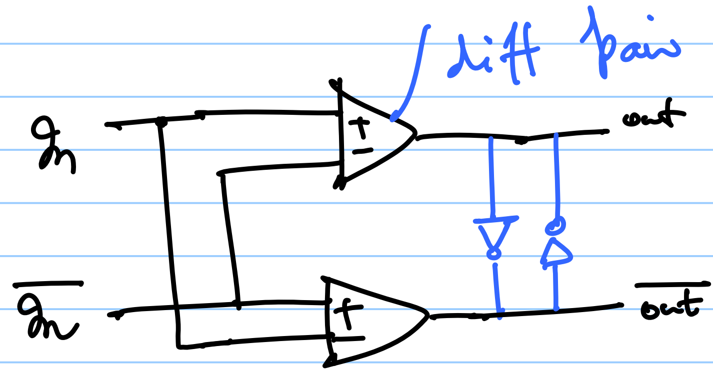
C
Vin
Vout
R



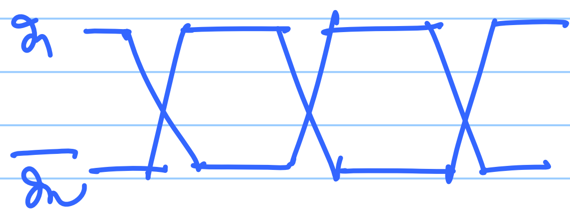




Buffer Design

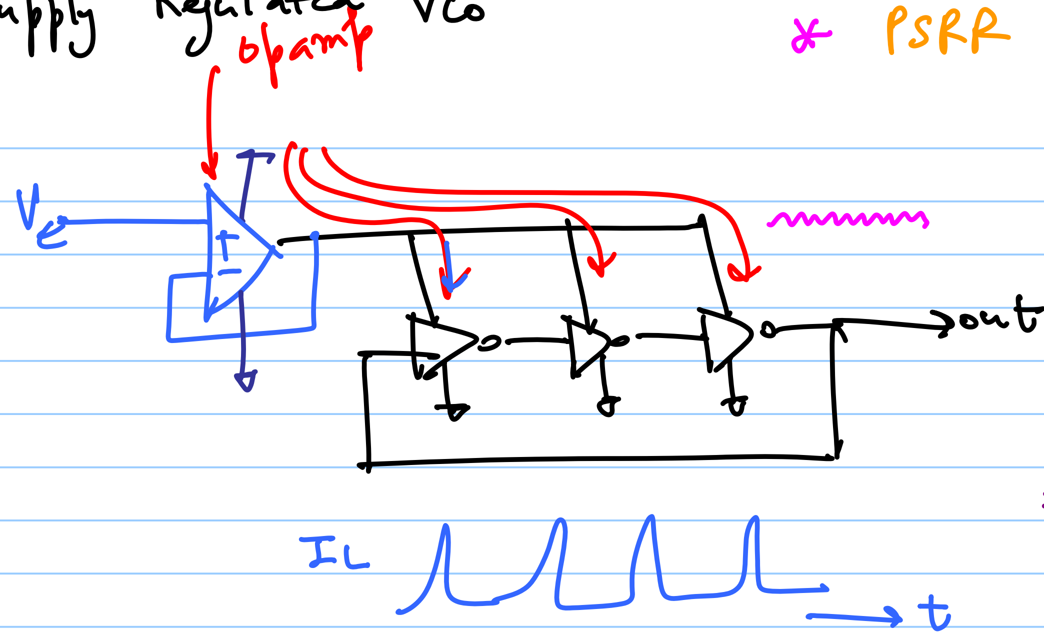


diff pair
in
$\overline{\text{in}}$
+
−
out
$\overline{\text{out}}$



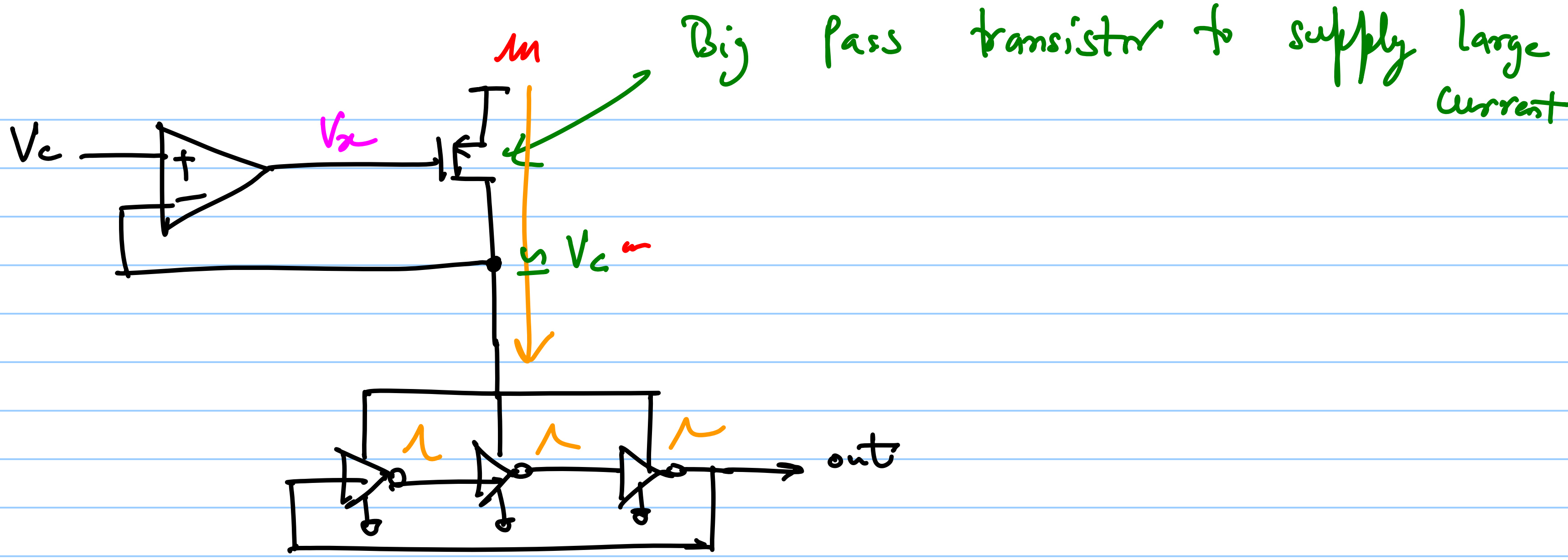
in
$\overline{\text{in}}$

Supply Regulated VCO



* PSRR is good, but limited by opamp's PSRR
  - ↳ 5-10x power penalty
    - ↳ large opamp bias

* Opamp output swing limit limits the frequency tuning range



* Current is drawn from supply, not from opamp's output
↳ opamp is low-power

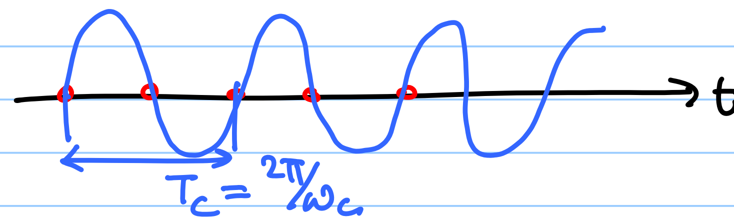
* Pass device alleviates opamp output swing requirements

* Trade off between pass device size & PSRR.

Oscillator Phase Noise

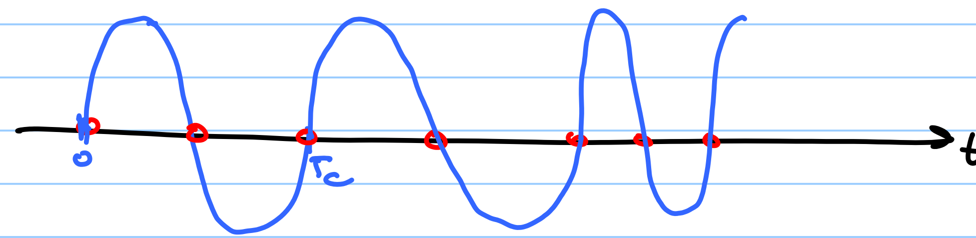
Ideal Oscillator

$A\cos(\omega_c t)$



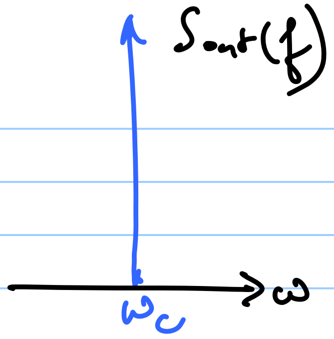
Noisy Oscillator

$A\cos(\omega_c t + \phi_n(t))$

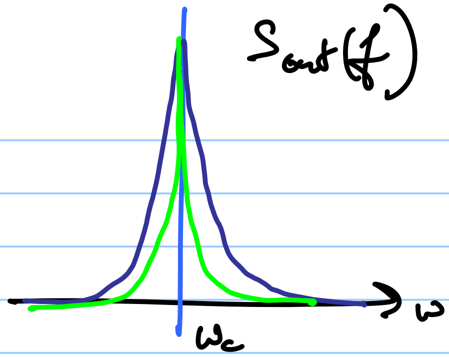


$\phi_n(t)$ is a random phase quantity that deviates zero crossings from multiples of T_c.

PSD:

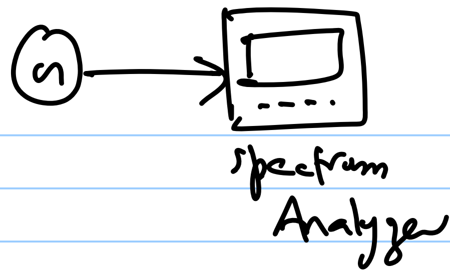


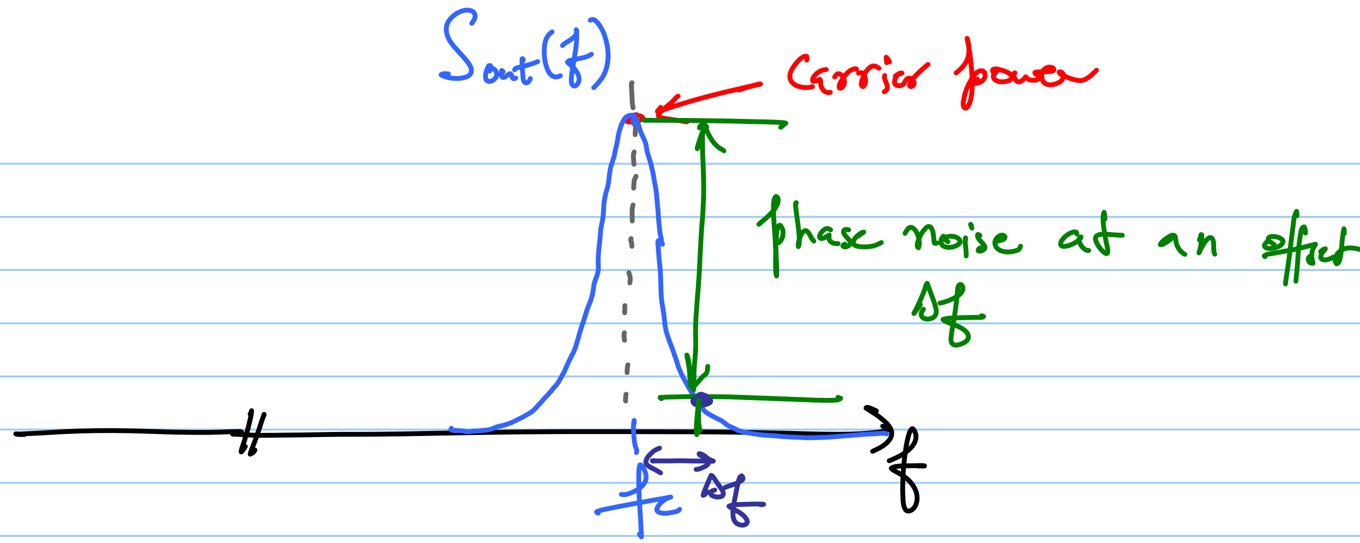
Ideal



Real

⇒ Impulse is broadened by the phase noise





Ex GSM: < -115 dBc/Hz at 60 kHz offset