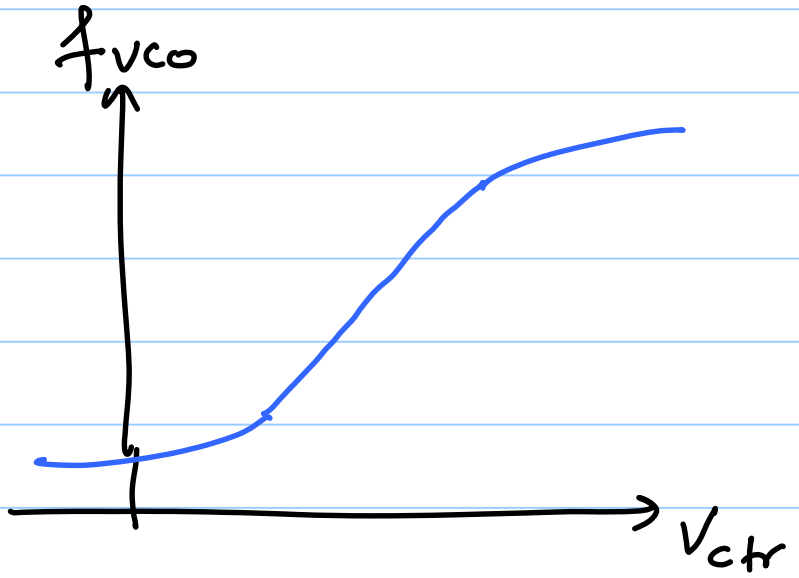
ECE 518 - Lecture 15

Note Title 3/5/2015

VCO tuning curve

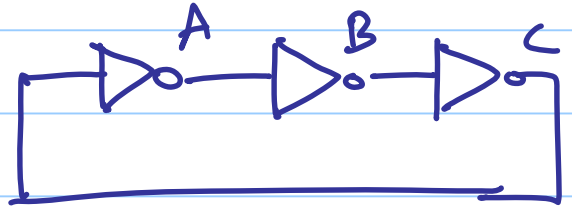


See slides on PSS analysis in Spectre RF

Ring oscillator

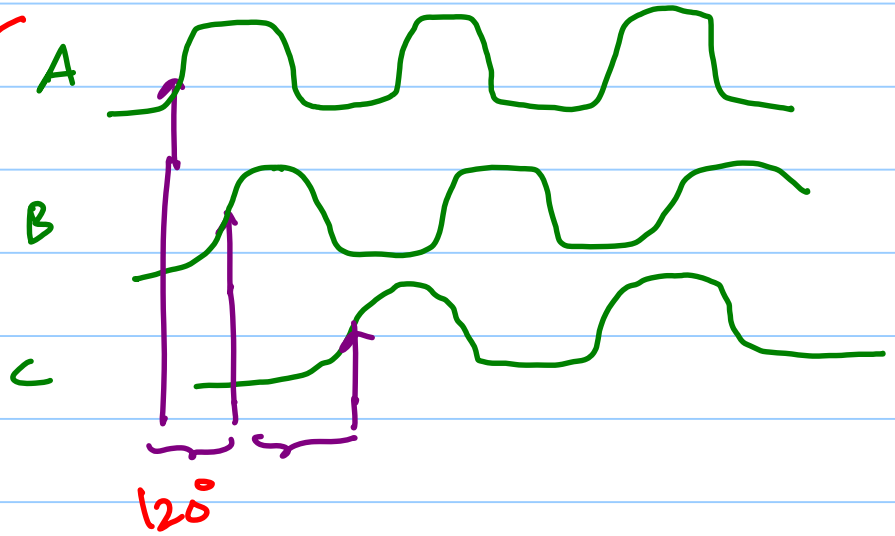
$A_0 \geq 2$

$\omega_{osc} = \omega_0 \sqrt{3}$



$\omega_0 = \frac{1}{RC}$

3-stage Ring oscillator



each stage has $\Rightarrow$ 180° phase shift

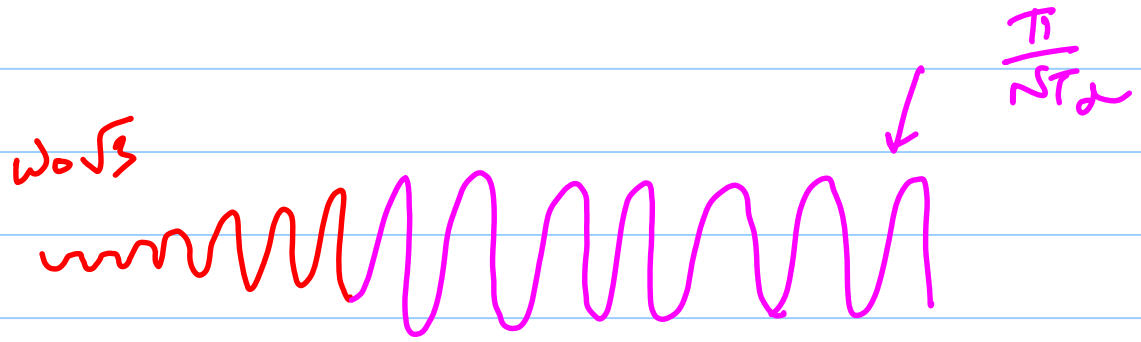
60° excess phase shift

$240^\circ = 360^\circ - 120^\circ$

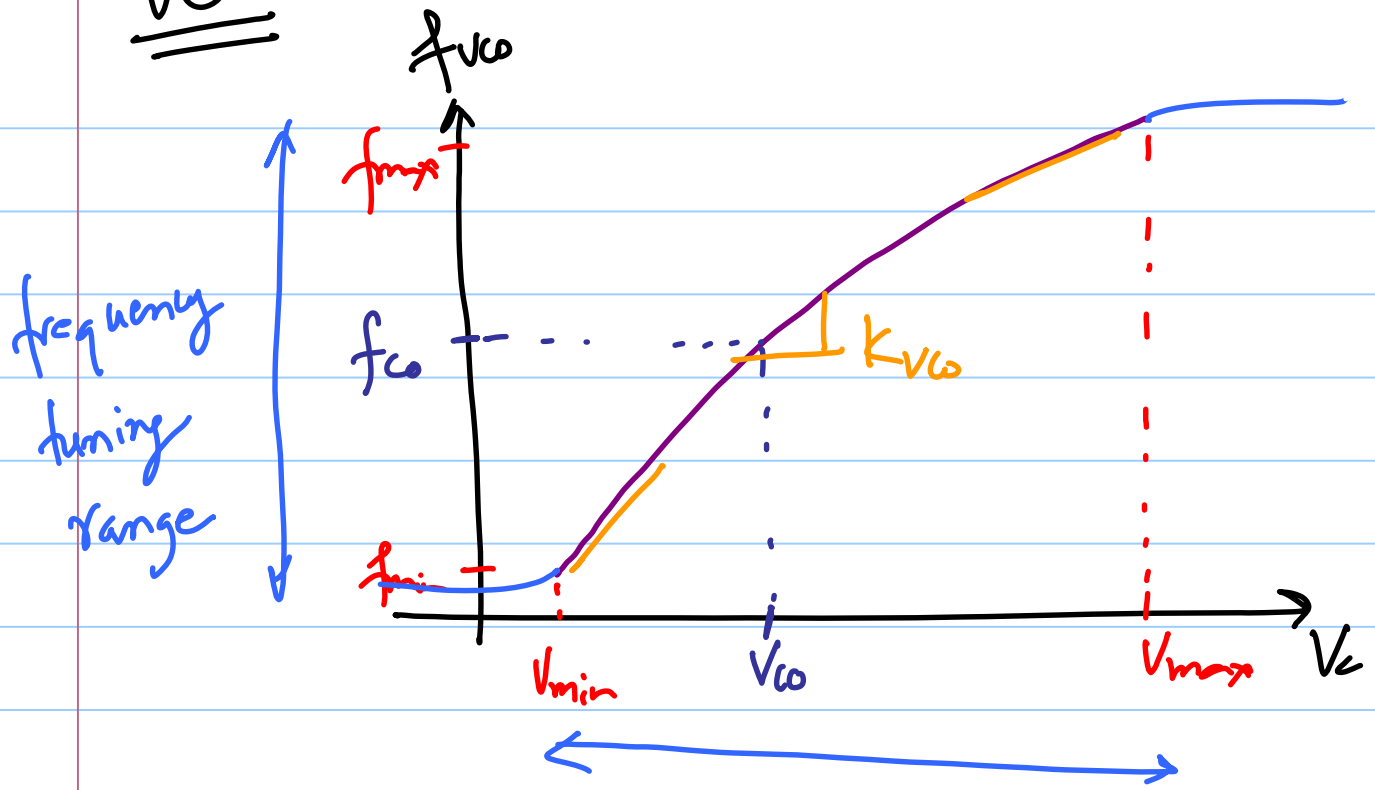
$$2 \times 3\pi T_d = T_{ck}$$

$$T_{ck} = 6T_d \triangleq 2N T_d$$

$$\omega_{osc} = \frac{2\pi}{T_{ck}} = \frac{2\pi}{2NT_d} = \boxed{\frac{\pi}{NT_d}}$$



VCO



$$f_{VCO} = f_{CO} + 2\pi K_{VCO}(V_C - V_{CO})$$

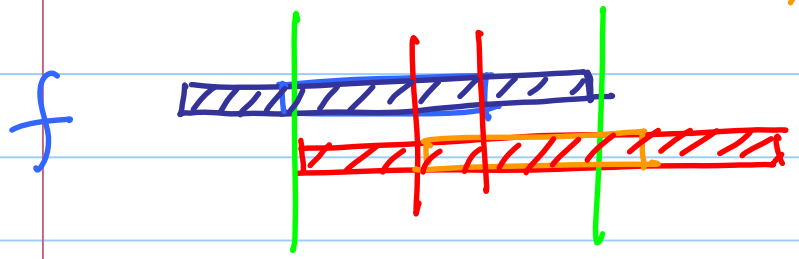
incremental phase

$$\phi_{out} = 2\pi K_{VCO} \int_{-\infty}^{t} V_C \, dt$$

↳ $\phi_{out}(s) = \frac{2\pi K_{vco} \cdot V_c(s)}{s}$

Performance Metrics:

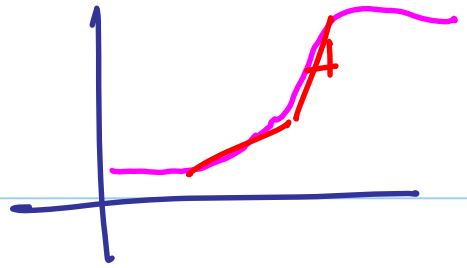
* Tuning Range
  ↳ Need wide-enough tuning range to cover all the PVT variations
    ↳ PVT can cause >50% freq variation



Digital ASIC clock gens → 5x tuning range

Ex. 100MHz – 500MHz

* Tuning linearity



↳ Affects loop dynamics → BW & ϕ_m

↳ 2x – 3x variation in K_{VCO} if not linearized

* can "linearize" VCO

* Power:

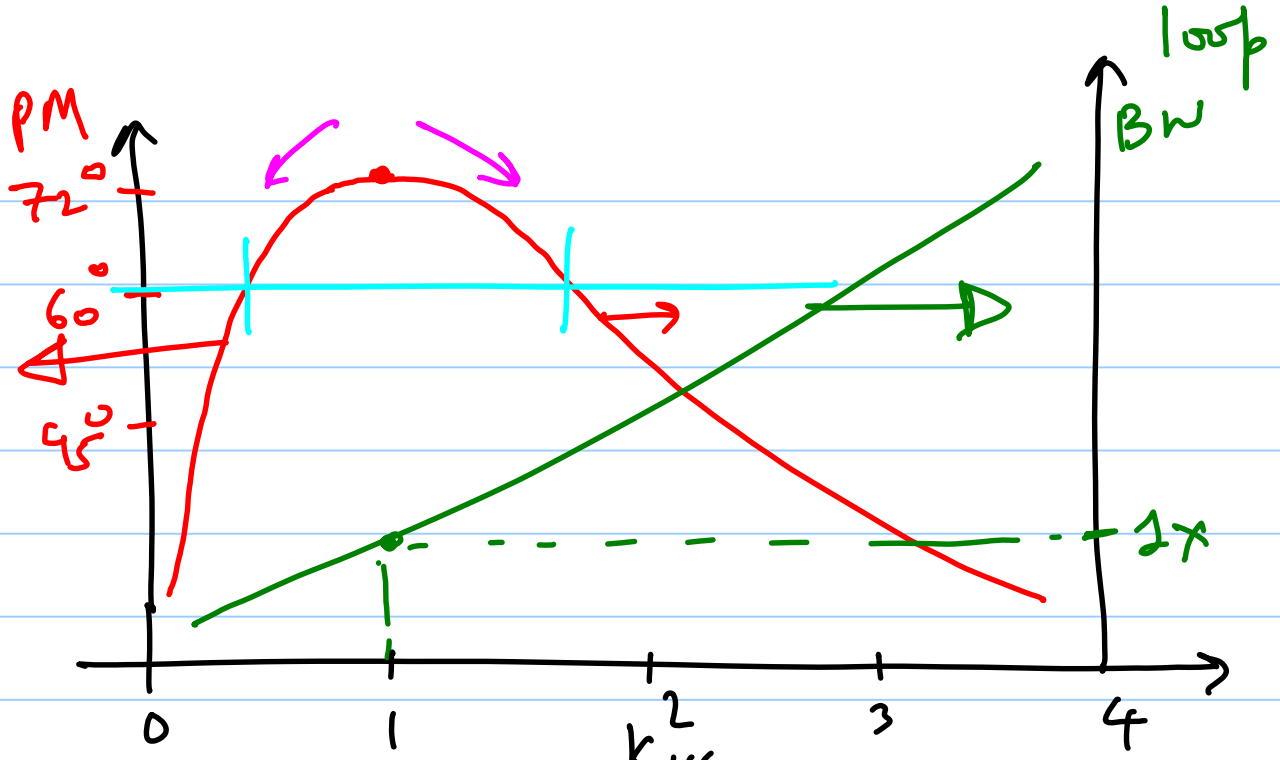
↳ Meet jitter specs with lowest possible power

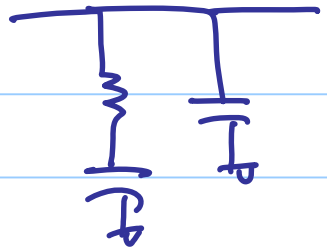
"NCV^2f"

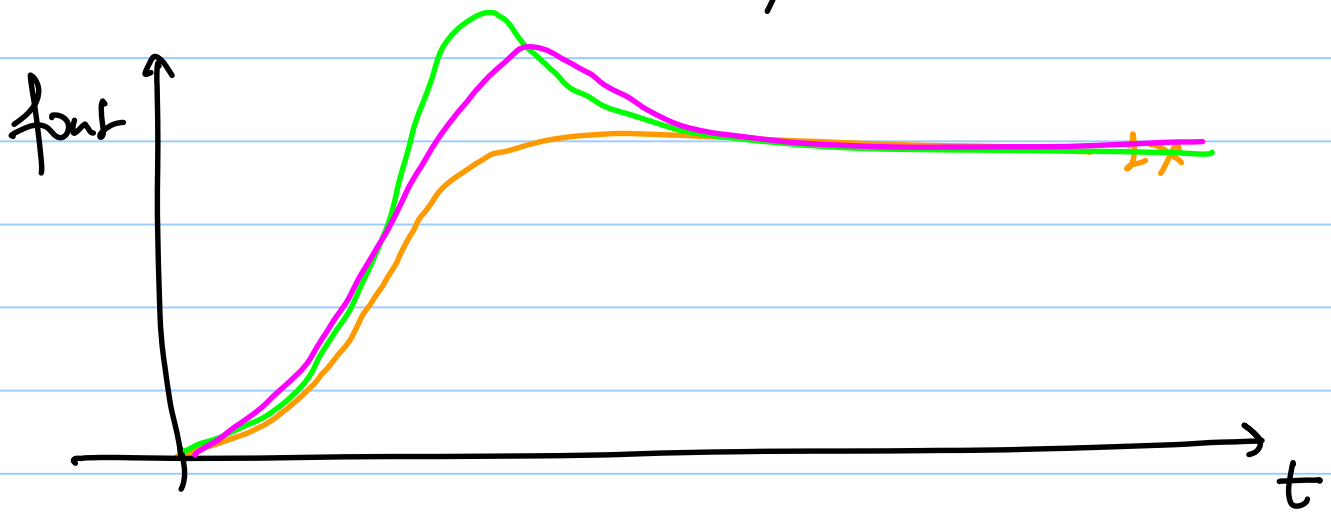
Power supply rejection:

↳ Critical in ASIC PLLs

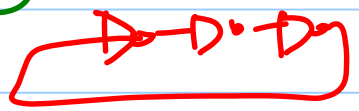
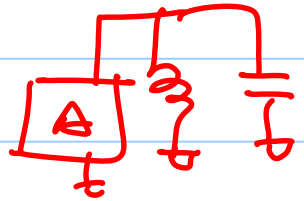
↳ Typically limits the jitter performance

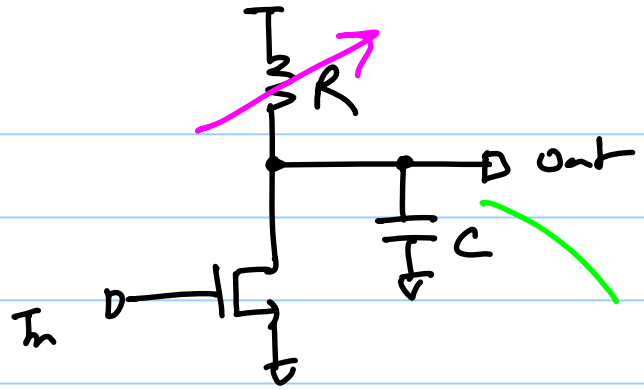

PM
72°
60°
45°
loop
BW
1x
0
1
2
3
4
$\frac{K_{VCO}}{K_{VCO,ideal}}$



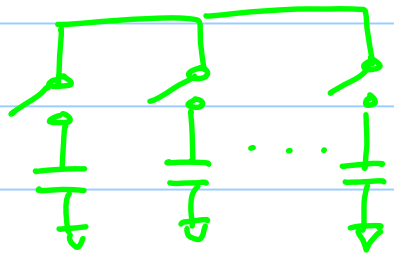

fout
1x
t

VCOs

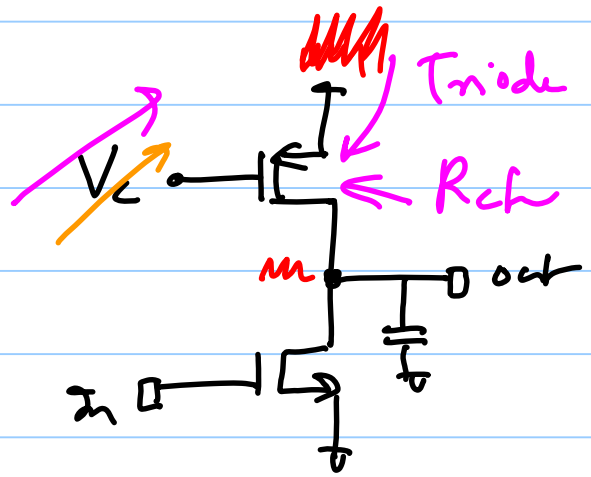
- Ring-based
  - 
  - low swing
  - full-V_{DD} swing
- LC-Based
  - 



$$\omega_{osc} = \frac{\sqrt{3}}{RC}$$ for 3-stage



Digital control

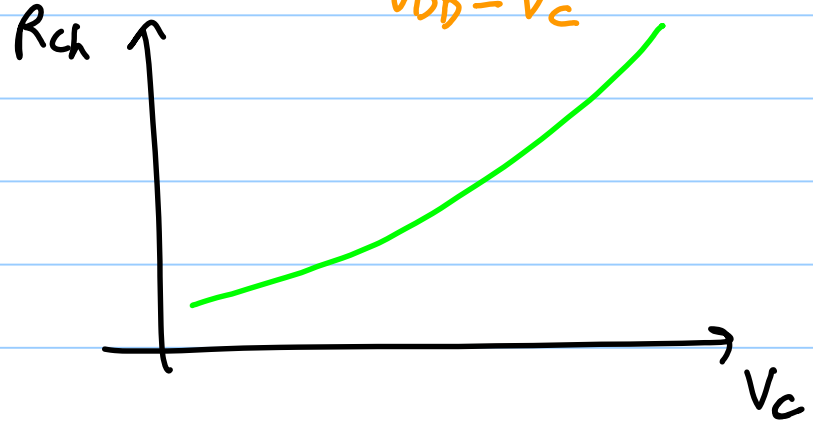


Single-ended stage

$$R_{ch} = \frac{1}{\beta[(V_{SG} - V_{THP}) - V_{SD}]}$$

V_{SD}: deep triode

$V_{DD} - V_c$



Differential Stage