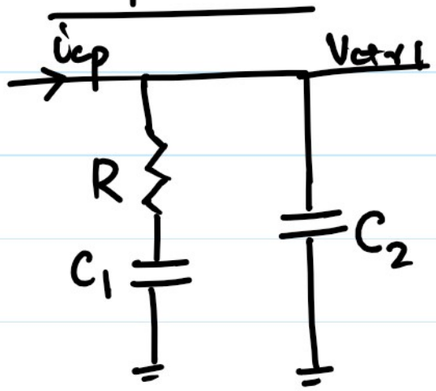
Lecture 32

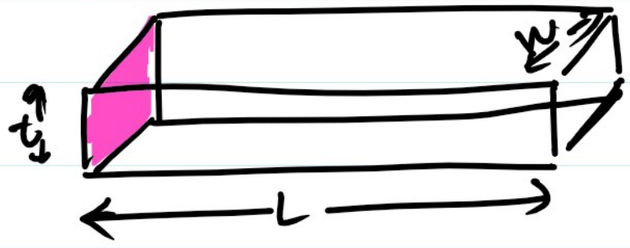
Monday, March 27, 2017 9:58 AM

Loop filter



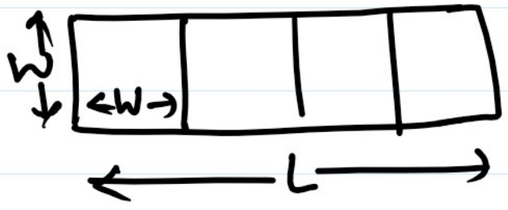
Passives R & C are integrated on-chip.
- Area of R&C is important for integration.
- PVT variations for R&C have to be compensated for desired loop dynamics

Resistor



$$R = \rho \frac{L}{A} \quad [\Omega]$$

$$R = \rho \times \frac{L}{W \times t}$$



$$R = \frac{\rho}{t} \frac{L}{W}$$

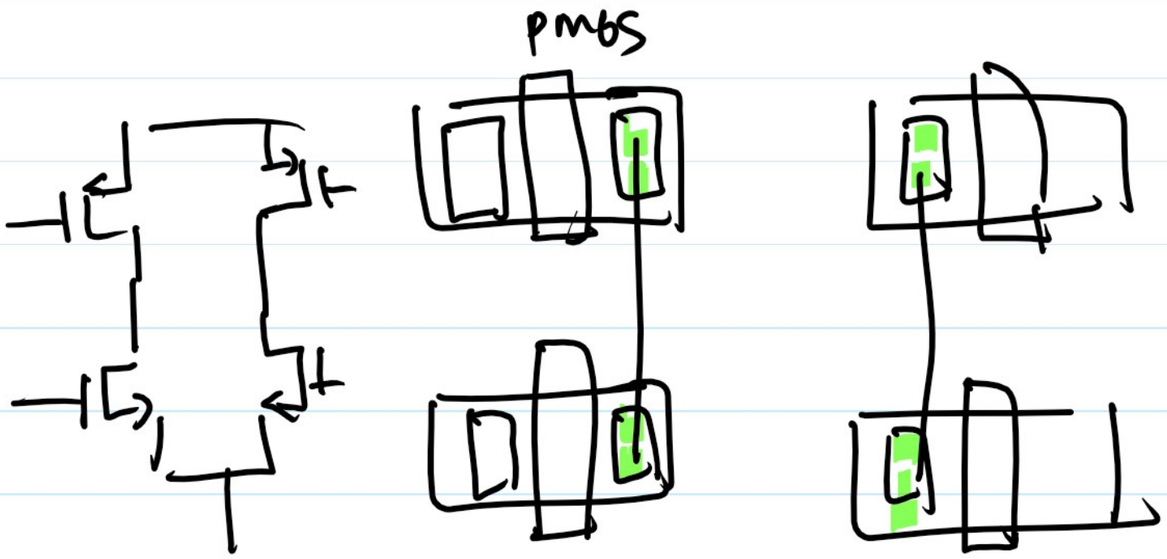
$$= R_{SH} \frac{L}{W}$$

ρ - resistivity of material $[\Omega\text{-cm}]$

R_{SH} - sheet resistivity $[\Omega/\square]$

	ρ	
Cu	1.7×10^{-6}	[Ω-cm]
Al	2.7×10^{-6}	
N-type Silicon	0.25	[Ω-cm]
SiO_2	10^{14}	

$$R_{tot} = R_{poly} + 2R_{contact}$$



$$R = R_{sh}\left(\frac{L}{W}\right)$$

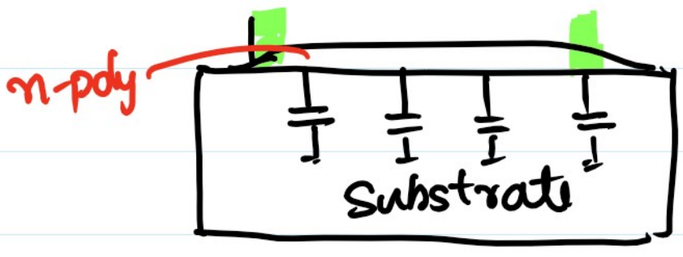
Variation in integrated Resistors

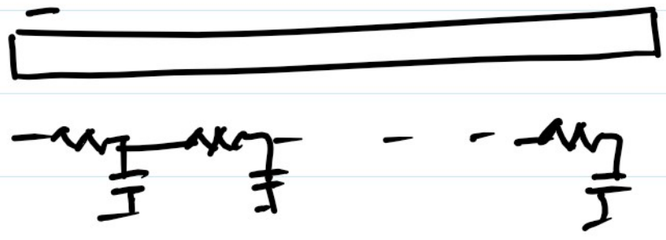
R_{sh} – Doping concentration / profile

$\Delta L, \Delta W$ — Accuracy of given technology
Lithographic techniques.

$$\frac{\Delta R}{R} = \frac{\Delta R_{sh}}{R_{SH}} + \frac{\Delta L}{L} + \frac{\Delta W}{W} \qquad \pm 20\text{-}30\%$$

$R = 1 K\Omega$.
$L = 1\mu m$, $W = 0.2\ \mu m$
$L = 10\mu m$, $W = 2\mu m$ — Lesser variation ($\pm \Delta R$)
Larger area.





Variation in Resistance due to temperature & voltage.

$$R(T) = R(T_0)\left[1 + TC_1 (T - T_0) \times 10^{-6} + TC_2 (T - T_0)^2 \times 10^{-6}\right]$$

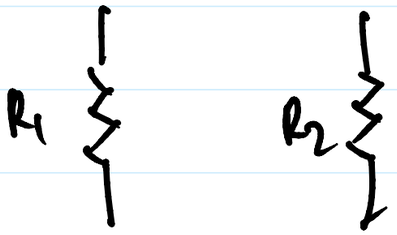
TC_1 - Linear temp. coefficient [ppm/°C]

TC_2 quadratic " $[ppm/^\circ C]^2$

$$R(V) = R(V_0)\left[1 + VC_1 (V-V_0)\times 10^{-6} + VC_2 (V-V_0)^2 \times 10^{-6}\right]$$

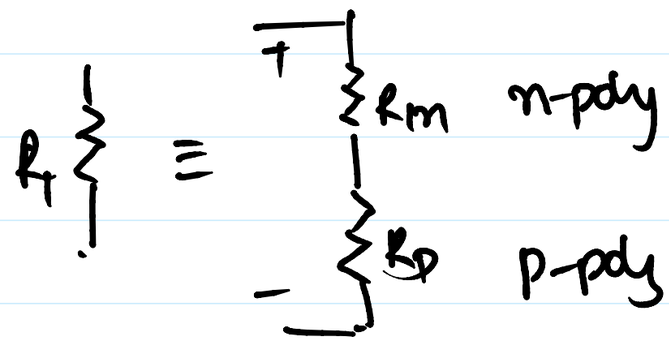
VC_1 Linear voltage coefficient $[ppm/V]$

VC_2 quadric " " $[ppm/V]^2$



Better matching — Only n-poly, Only p-poly } Accuracy / density

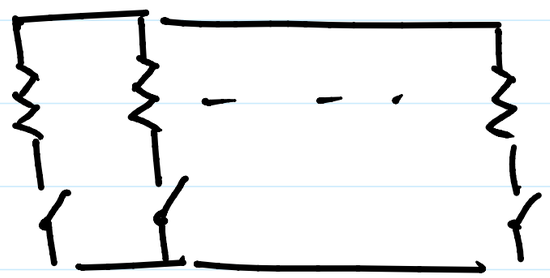
n-poly	$+TC_{1,n}$
p-poly	$-TC_{1,n}$



R — $\pm x\%$

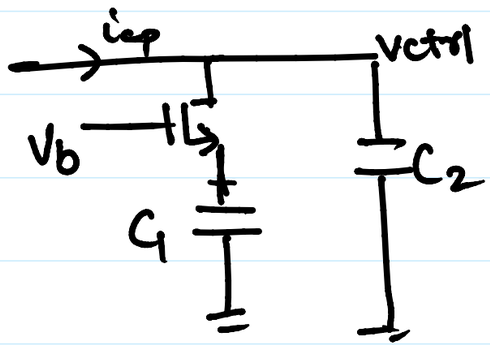
a) R needs to be fixed (independent of PVT variation)
   — compensate for variation

b) Wide-range PLLs — Want to change R



Resistor bank to vary R.

Active Resistor

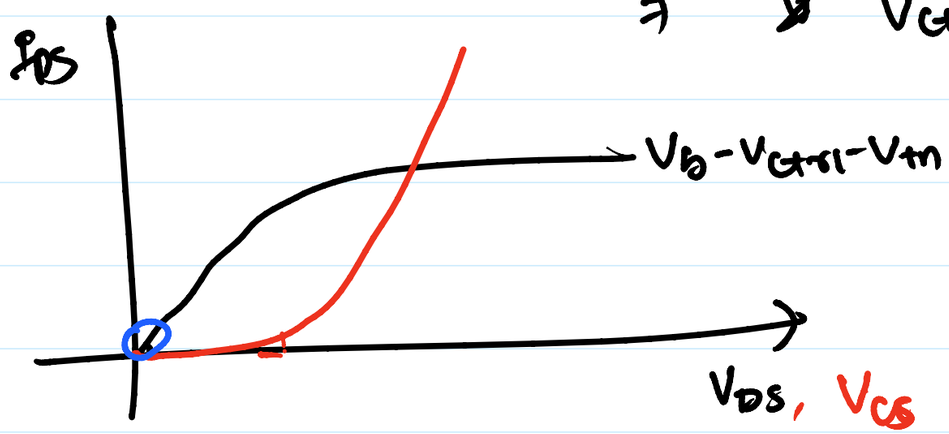


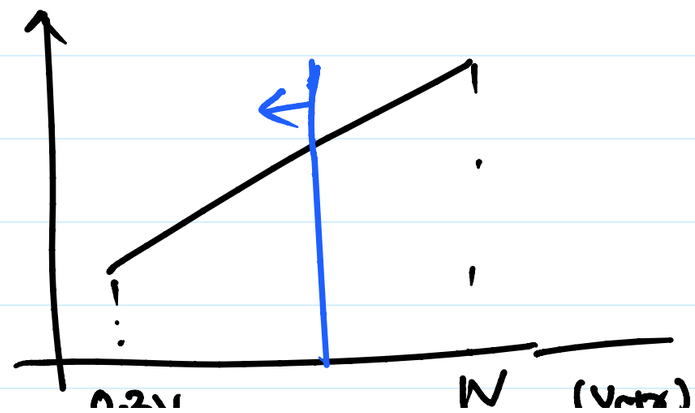
$$R_{ON} = \frac{1}{\mu C_{ox} \frac{W}{L} \left(V_G - V_S - V_{tn} - V_{DS}\right)}$$

$$V_b - V_{Ctrl} - V_{tn} \geq 0$$

$$\Rightarrow \quad V_{Ctrl} \leq V_b - V_{tn}$$

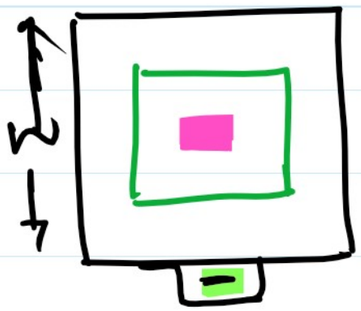
$\Rightarrow$ Limits oscillation freq

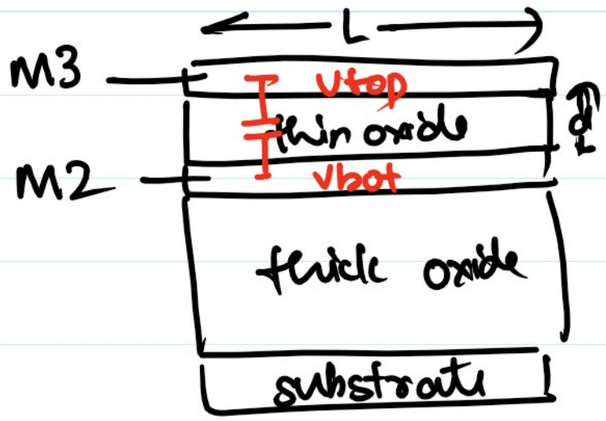


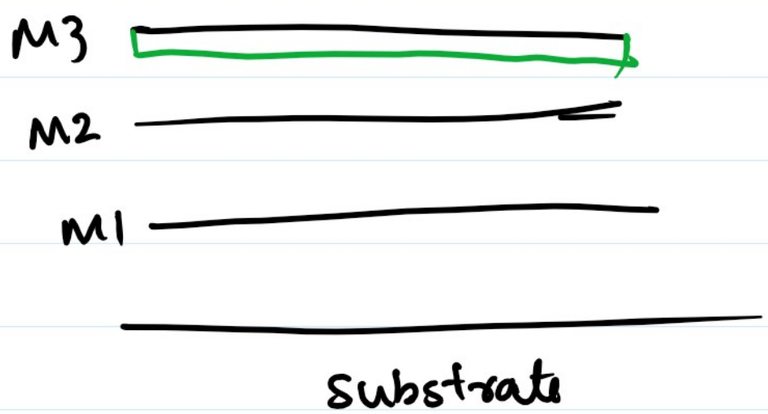


Passive Capacitor

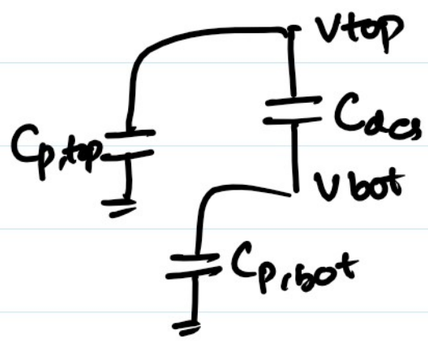
a) Parallel plate capacitor

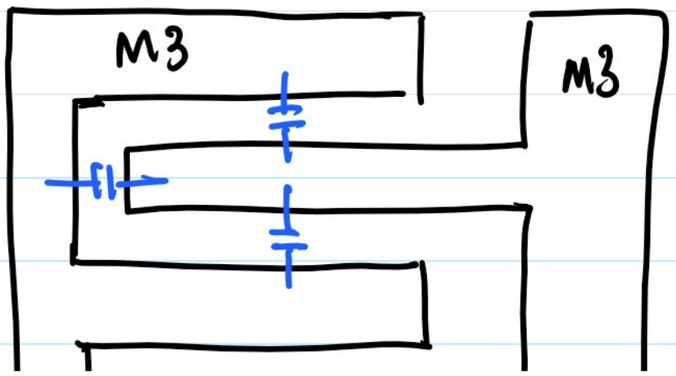


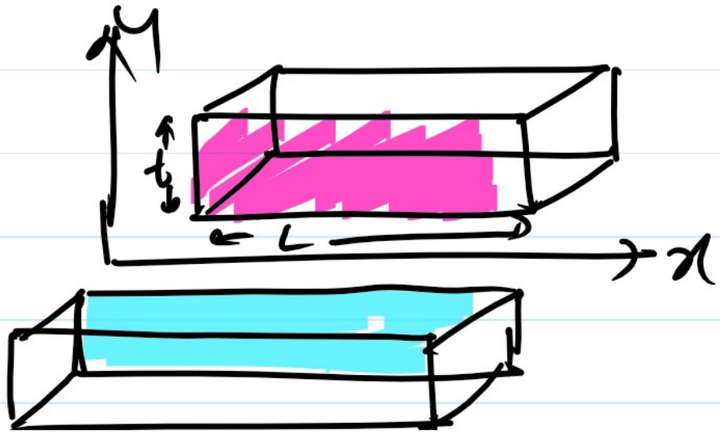


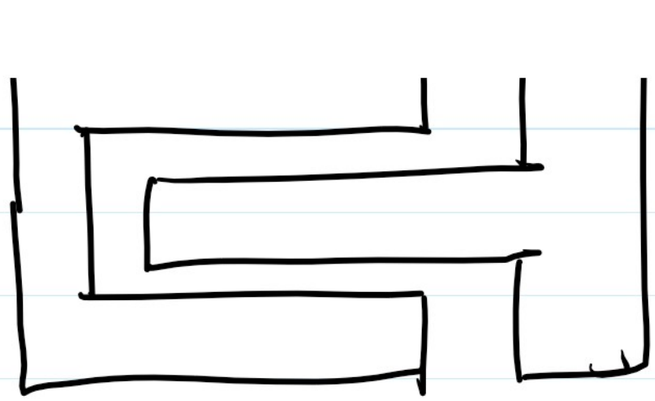


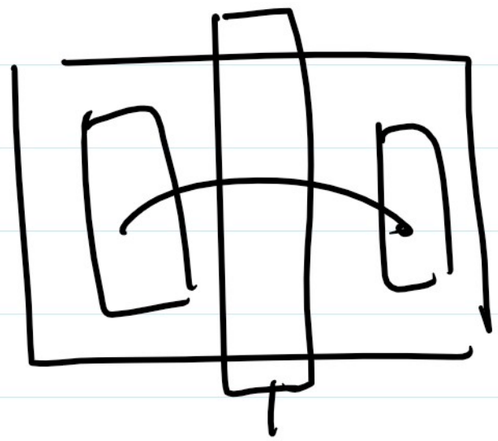
$$C = \epsilon \frac{A}{d}$$

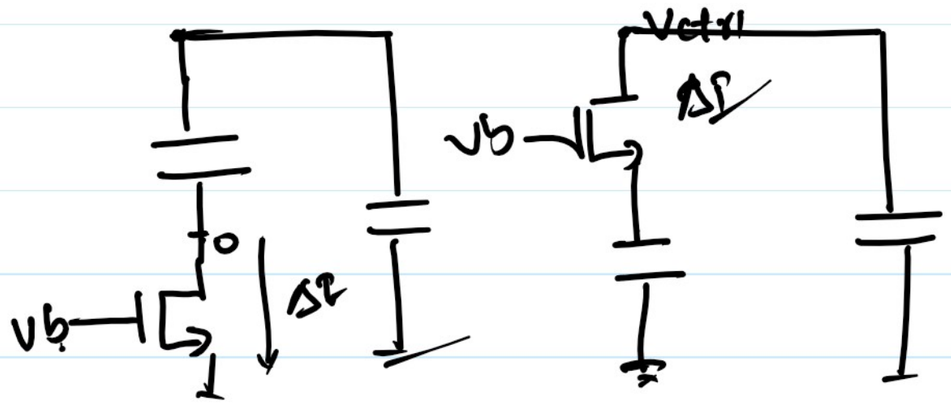











Vctrl
Vb
ΔV
Vb
ΔV