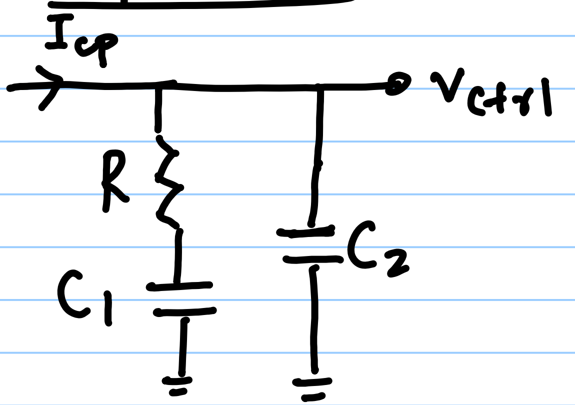
Note Title 17-10-2017

Lecture # 40

Loop-filter



- R, C
- $\Delta R, \Delta C$
- Noise Contribution
- Min. area

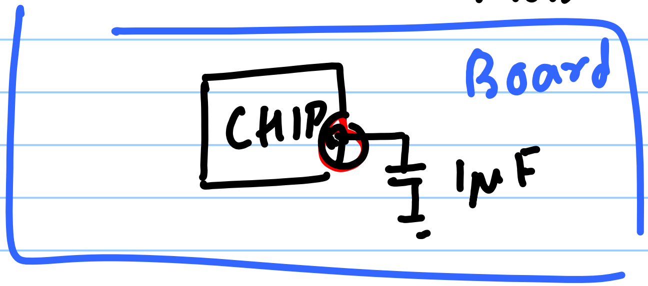
Eg: $\Phi_m = 70^\circ$, $\omega_u = 0.01\,MHz$, $R = 5\,k\Omega$, $C_1 = 18.052\,nF$

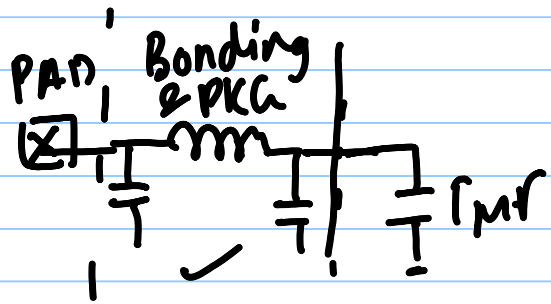
Mim-cap $2\,fF/\mu m^2$

Mos cap $10\,fF/\mu m^2$

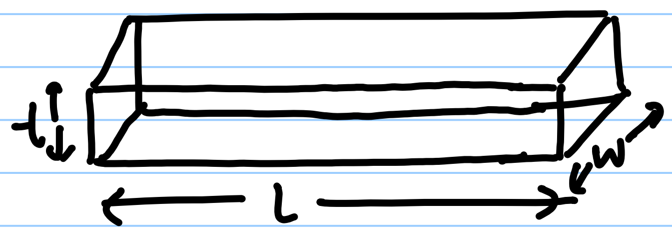
$$\frac{18.052 \times 10^{-9}}{2 \times 10^{-15}} = 9 \times 10^{6}\,\mu m^2$$

$300\,\mu m \times 300\,\mu m$





Resistor



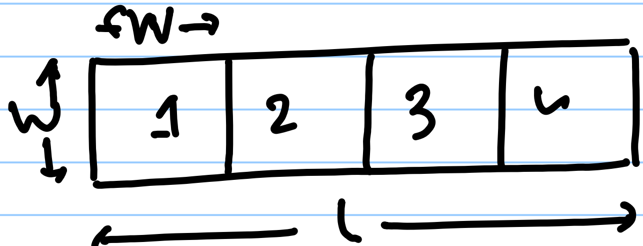
$$R = \rho \frac{L}{A} = \rho \frac{L}{W \times t}$$

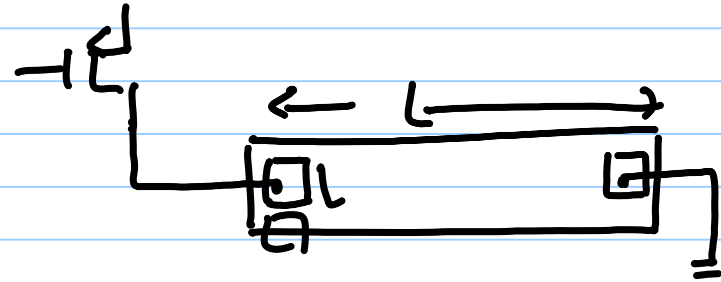
ρ: resistivity of material

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

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

R_{SH}: sheet resistance





Metal

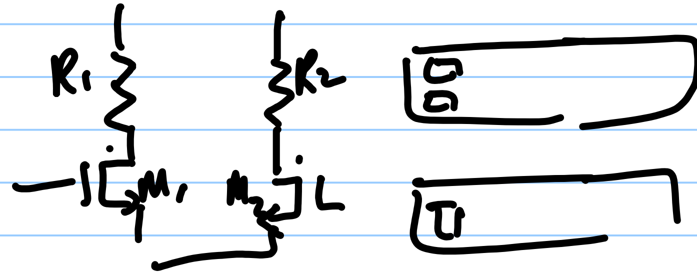
Al: $\rho = 1.7 \times 10^{-6}$ [Ω-cm]

Cu: $\rho = 2.7 \times 10^{-6}$ [Ω-cm]

SiO_2: $\rho = 10^{14}$ [Ω-cm]

n-type: $\rho = 0.25$ [Ω-cm]

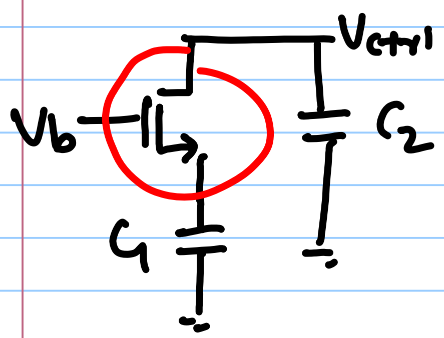
$R = R_{poly} + 2R_{contact}$



$$R = \frac{\rho}{t} \cdot \frac{L}{W}$$ $\pm 30\%$

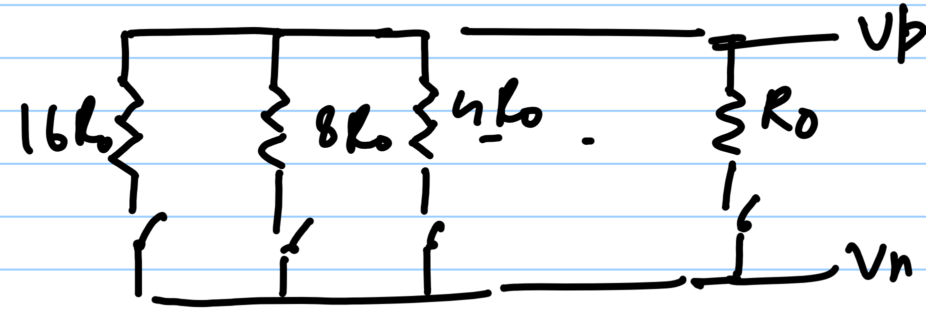
$$\frac{\Delta R}{R} = \frac{\Delta R_{SH}}{R_{SH}} + \frac{\Delta L}{L} + \frac{\Delta W}{W}$$

Non-linear resistor



$V_b - V_{ctrl} - V_t > 0$

$V_{ctrl} < V_b - V_t$



Temp.

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

TC_1 : Temp. coeff. [ppm/°C]

T_0: 298 K.

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

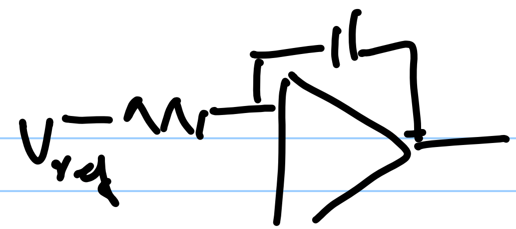
VC_1 : [ppm/V]

R_{nom} . $\pm 25\%$

R_{bank} $\pm 2\%$

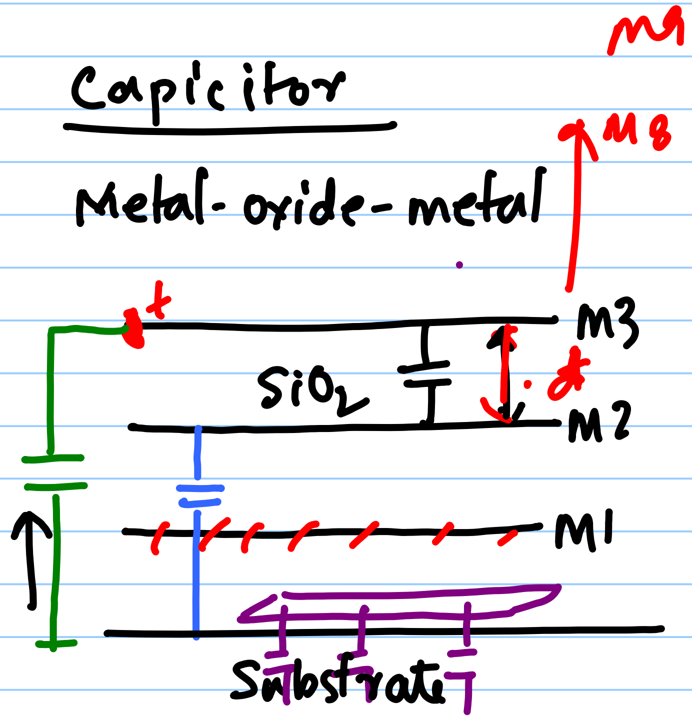
$$\frac{R_{max}}{P} < R_{nom} \pm 2\%$$

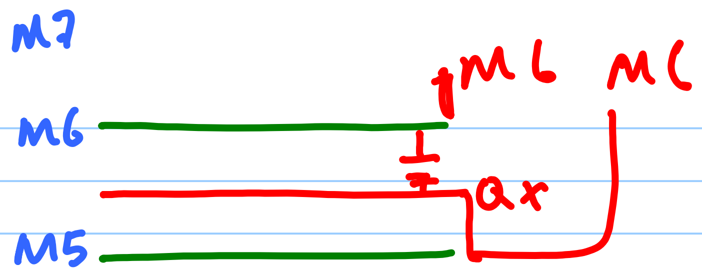
R_{min}

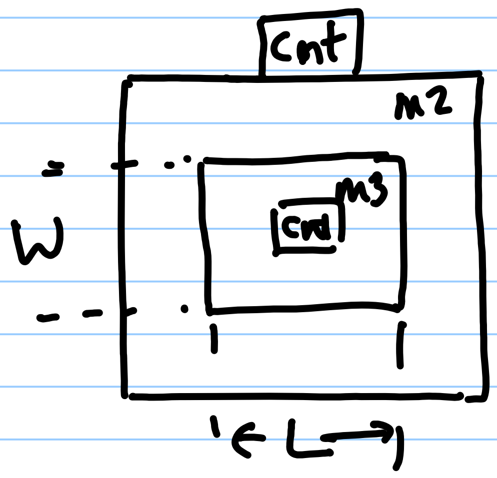


Capicitor

Metal-oxide-metal

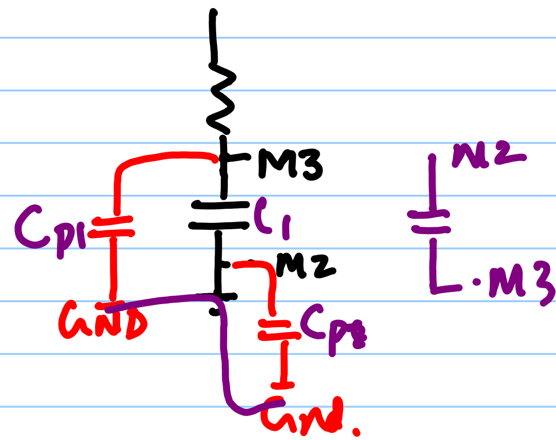




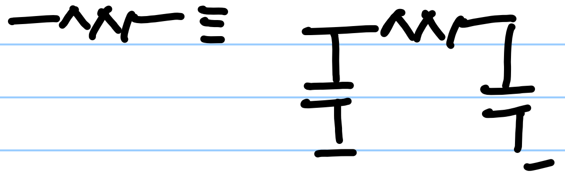


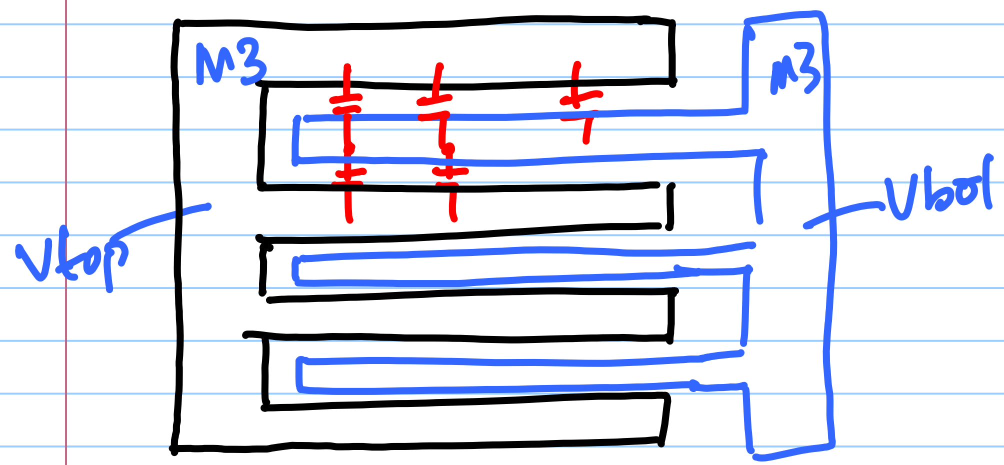
2 fF/µm² ✓

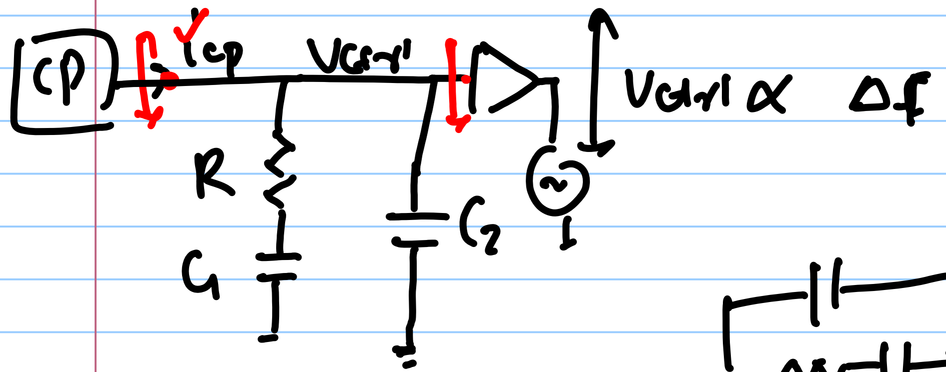
$$C = \frac{\epsilon \cdot A}{d}$$

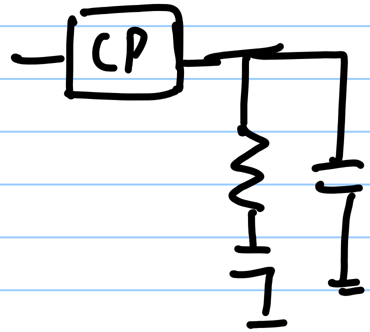


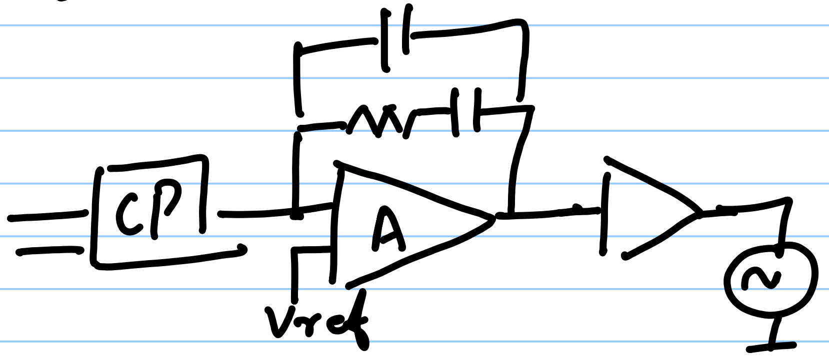
Cp1 + C1











$$V_{ctrl}(s) = I_{cp}\left(R + \frac{1}{sC}\right)$$

$$V_{ctrl}(t) = \underbrace{i_{cp} \cdot R}_{\text{Prop.}} + \underbrace{\frac{1}{C}\int i_{cp} \cdot dt}_{\text{Inte}}$$

$$V_{ctrl}(s) = K_p + \frac{K_I}{s}$$

$$V_{ctrl}(t) = K \cdot i_{cp} \cdot R + \frac{1}{C}\int i_{cp} dt$$

$$V_{ctrl}(s) = K I_{cp} \cdot R + \frac{I_{cp}}{sC} = I_{cp} \left(\frac{sKRC + 1}{sC} \right)$$

$$\omega_z = \frac{1}{KRC}$$