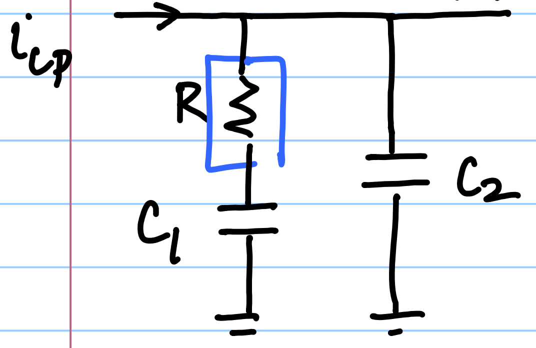
Note Title 03-12-2020

lecture # 41

Loop filter

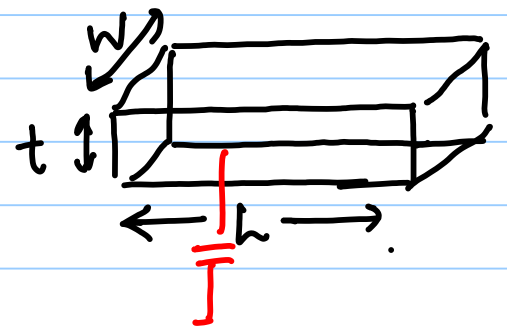


$$\frac{V_{ctrl}}{i_{cp}} = \frac{1}{sC_2} \parallel \left(R + \frac{1}{sC_1}\right)$$

$$= \frac{\frac{1+sRC_1}{sC_1} \times \frac{1}{sC_2}}{\frac{1+sRC_1}{sC_1} + \frac{1}{sC_2}} = \frac{(1+sRC_1)/s^2C_1C_2}{\frac{C_2+sRC_1C_2+C_1}{sC_1C_2}}$$

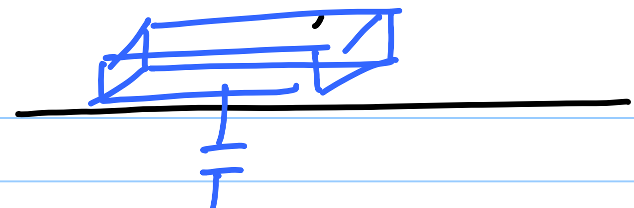
$$= \frac{1}{s(C_1+C_2)} \frac{1+sRC_1}{1+\frac{sRC_1C_2}{C_1+C_2}} \checkmark$$

$$\omega_z = \frac{1}{RC_1} \quad , \quad \omega_p = \frac{1}{\frac{RC_1C_2}{C_1+C_2}}$$



$$R = \rho \frac{L}{W \times t} = \frac{\rho}{\underset{\sim}{t}} \frac{L}{W} = \underset{(\Omega/\square)}{R_{sh}} \frac{L}{W}$$

$1k\Omega$, $R_{sh} = 100\ \Omega/\square \Rightarrow \frac{L}{W} = 10$



#1 $W = 0.2\mu m,\ L = 2\ \mu m$ ✓

#2 $W = 2\ \mu m,\ L = 20\ \mu m$ ✓

$$R = R_{sh}\frac{L}{W}$$

$$\Delta R = \Delta R_{sh}\cdot\frac{L}{W} + R_{sh}\cdot\frac{\Delta L}{W} - R_{sh}\frac{L}{W^2}(\Delta W)$$

$$R = f(R_{sh}, L, W)$$

$$\Delta R = \frac{\partial f}{\partial R_{sh}}\cdot\Delta R_{sh} + \frac{\partial f}{\partial L}\cdot\Delta L + \frac{\partial f}{\partial W}\cdot\Delta W$$

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

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

TC_1 → ppm/°C

TC_2 → ppm/°C²

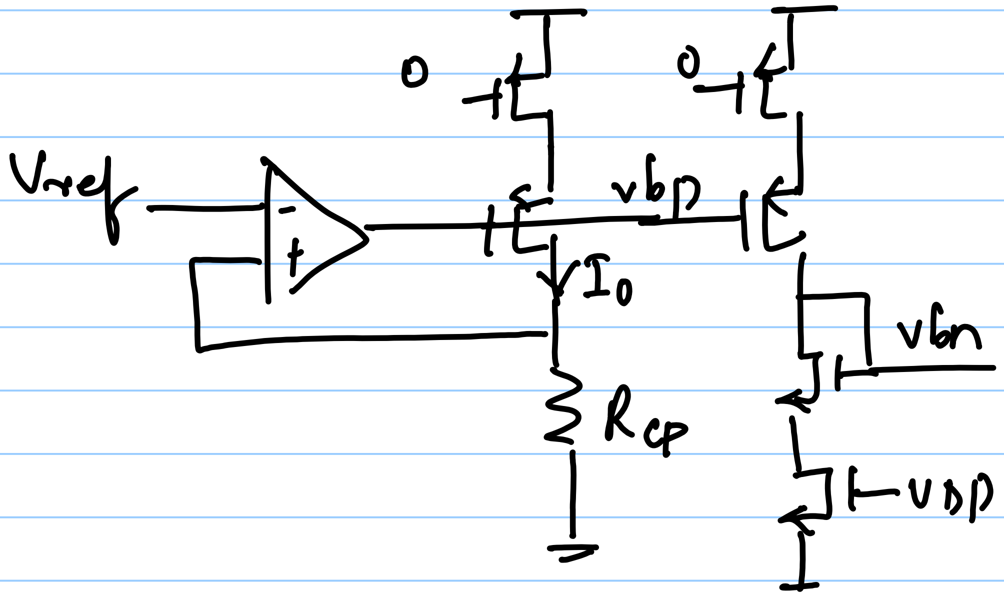
$$L_G = \frac{I_{cp}}{2\pi}\frac{(1+sRC_1)}{s(C_1+C_2)}\frac{1}{\left(1+s\frac{C_1C_2}{C_1+C_2}\right)}\frac{2\pi K_{vco}}{sN} \checkmark$$

$$\omega_u \approx \frac{I_{cp}\cdot R\, K_{vco}}{N}\frac{C_1}{C_1+C_2}$$

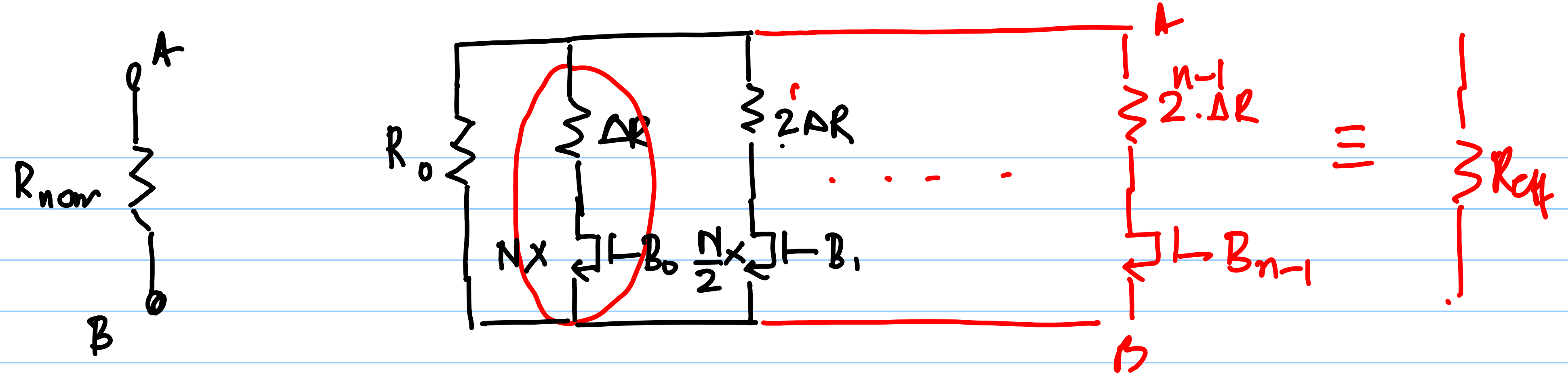
$$|L_G(\omega_u)| = 1$$

$$\frac{I_{cp}\,\omega_u R C_1}{\omega_u^2(C_1+C_2)}\frac{K_{vco}}{N} = 1$$

$$I_{cp} \propto \frac{1}{R}$$



$$I_0 = \frac{V_{ref}}{R}$$



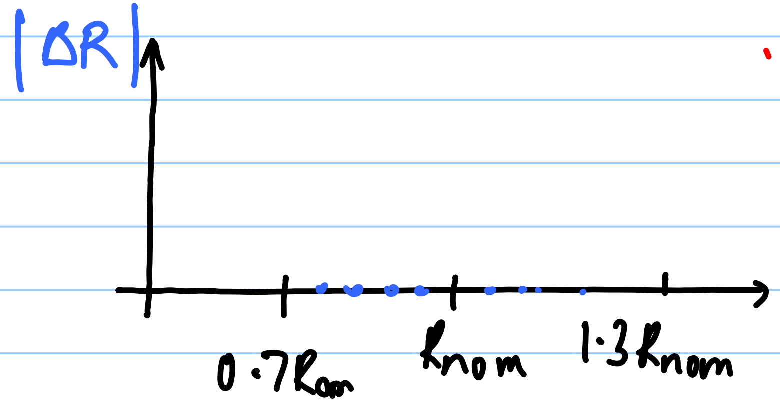
$$\frac{1}{R_{eff}} = \frac{1}{R_0} + \frac{B_0}{\Delta R} + \frac{B_1}{2 \cdot \Delta R} + \cdots$$

For max. variation +30%

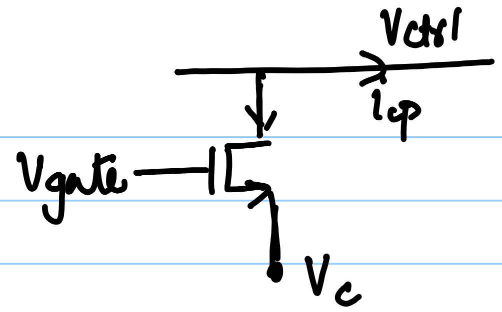
$$\frac{1}{R_{nom}} = \left(\frac{1}{R_{0,max}} + \frac{1}{\Delta R_{max}} + \frac{1}{2 \Delta R_{max}} + \cdots + \frac{1}{2^{(n-1)} \cdot \Delta R_{max}} \right)$$ ✓

For min. variation -30%

$$\frac{1}{R_{nom}} = \frac{1}{R_{0,min}}$$ ✓



$\Delta R = R_{nom} - R_{eff}$



$$I_{DS} = \mu_n C_{ox} \frac{W}{L} \left[\left(V_{gs} - V_{th} - \frac{V_{DS}}{2}\right) V_{DS} \right]$$

$$I_{DS} = \mu_n C_{ox} \frac{W}{L} \left[(V_{gate} - V_c - V_{tn})(V_{ctrl} - V_c) - \frac{(V_{ctrl} - V_c)^2}{2} \right]$$

$$(V_{ctrl} - V_c) < (V_{gate} - V_c) - V_{th}$$

$$V_{ctrl} < V_{gate} - V_{th}$$

Voltage coefficient, $V_c = \frac{1}{R} \cdot \frac{\partial R}{\partial V_{DS}} =$

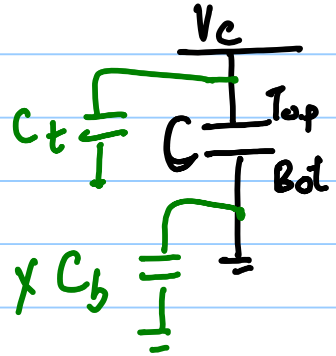
$$R(V) = R(V_0)\left[1 + 10^{-6}\, VC_1 (V - V_0) + 10^{-6}\, VC_2 (V - V_0)^2\right]$$

$$R = \frac{V_{DS}}{I} = \frac{1}{\mu_n C_{ox} \frac{W}{L} \left(V_{gs} - V_{th} - \frac{V_{DS}}{2}\right)}$$

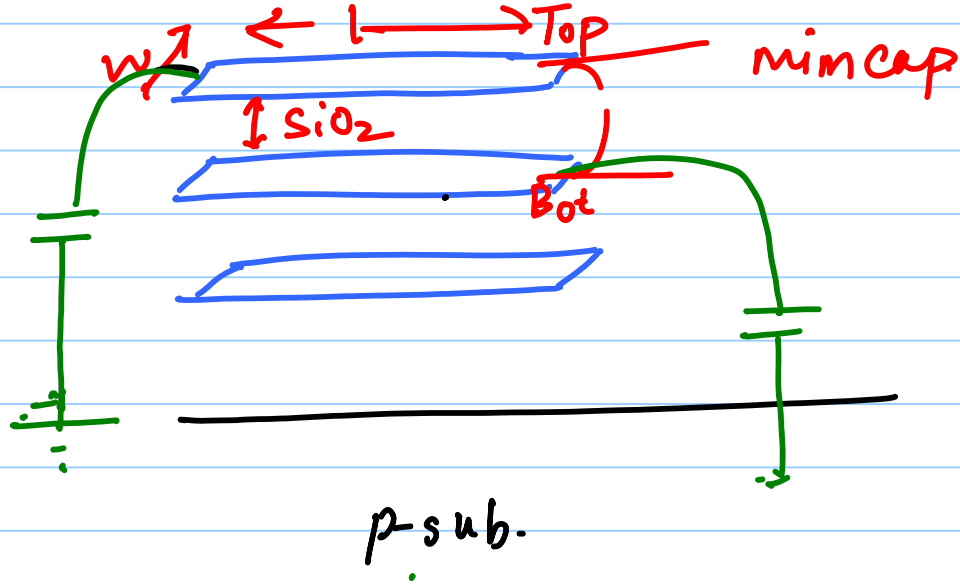
$$\frac{\partial R}{\partial V_{DS}} = \frac{1}{\mu_n C_{ox} \frac{W}{L}} \frac{-1}{\left(V_{gs} - V_{th} - \frac{V_{DS}}{2}\right)^2} \times \frac{-1}{2}$$

$$\frac{1}{R}\frac{\partial R}{\partial V_{DS}} = \frac{1}{2\left(V_{gs}-V_{th}-\frac{V_{DS}}{2}\right)}$$

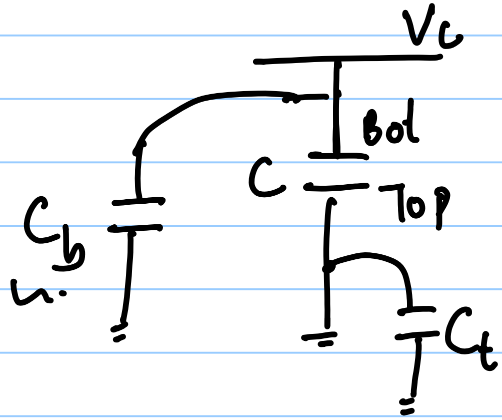
Capacitors

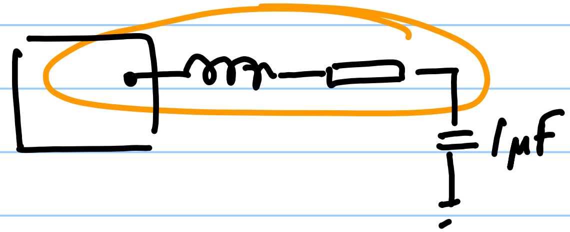


$$C = \frac{\epsilon_{ox}}{t_{ox}} WL$$ ✓



$C_b > C_t$





$1\text{–}2\ fF/\mu m^2$