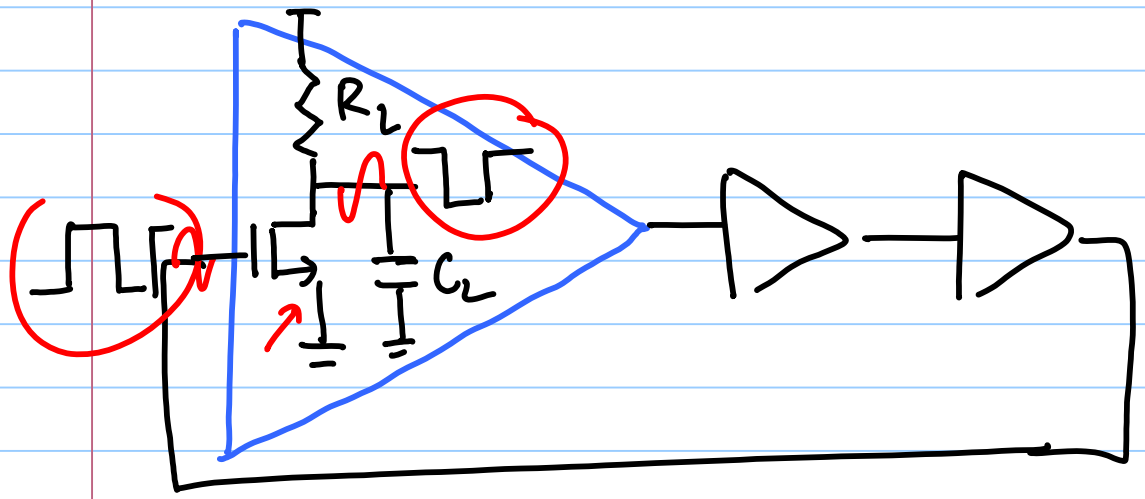
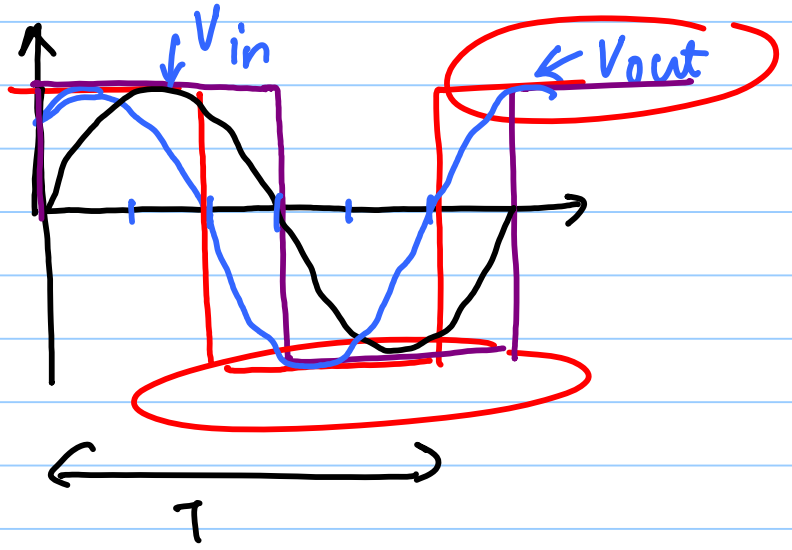
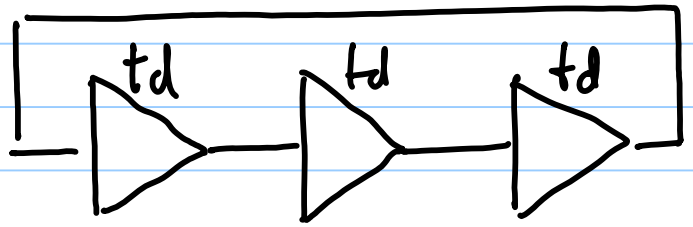
Lecture # 21

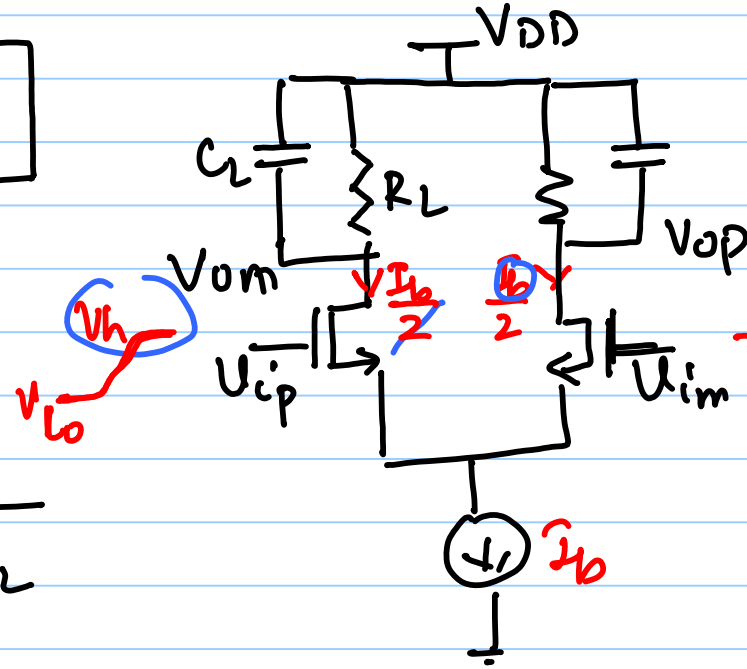
Note Title 09-07-2020

Oscillator







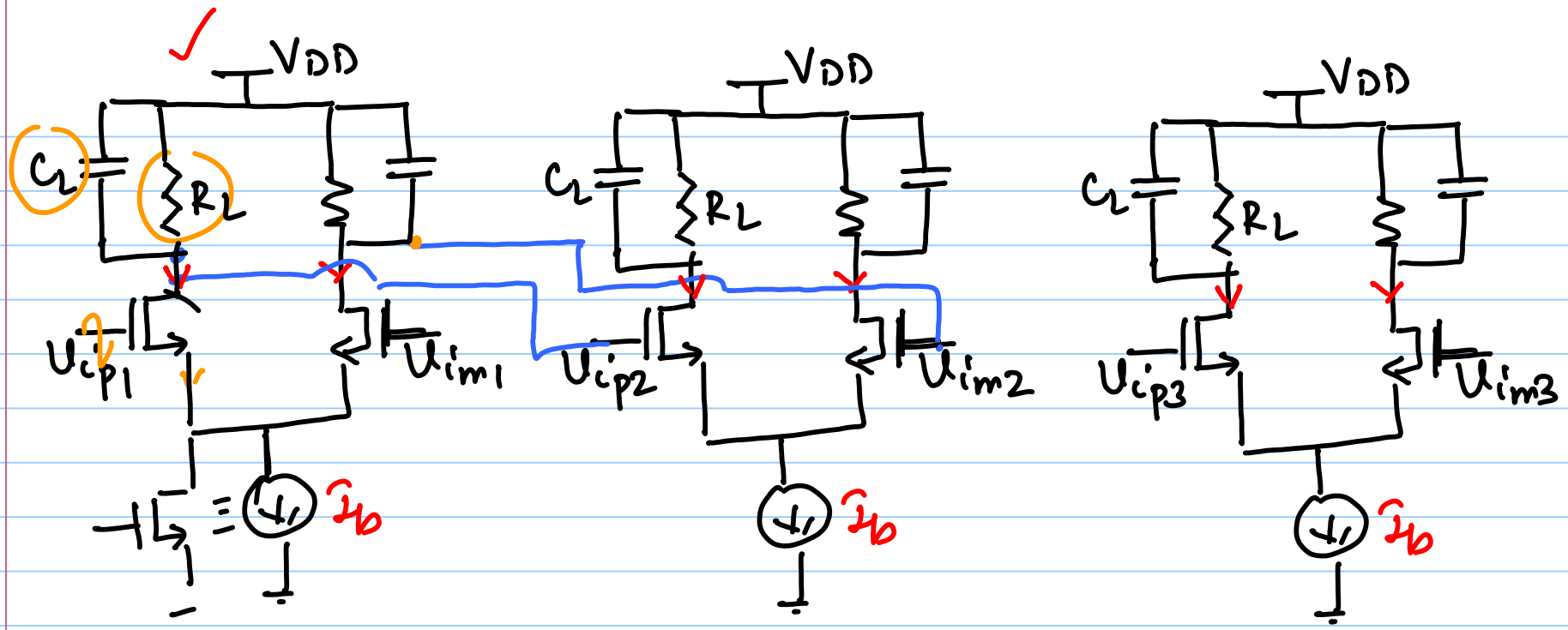


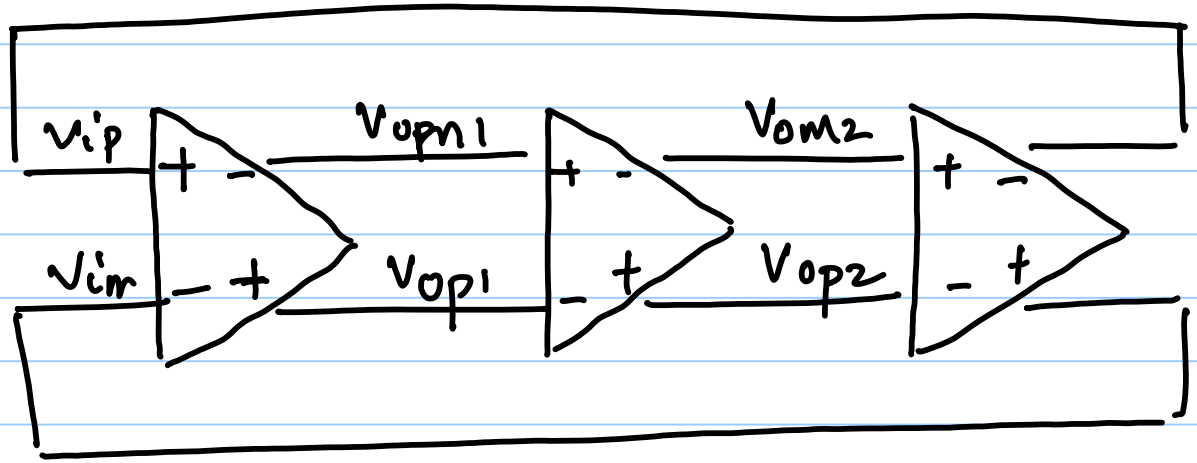
$V_{op} = V_{DD}$

$V_{om} = V_{DD} - I_b R_L$

$V_{op} - V_{om} = I_b R_L$

$$\frac{V_{op} - V_{om}}{V_{ip} - V_{im}} = \frac{-g_m R_L}{1 + sR_L C_L}$$

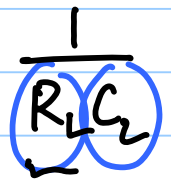


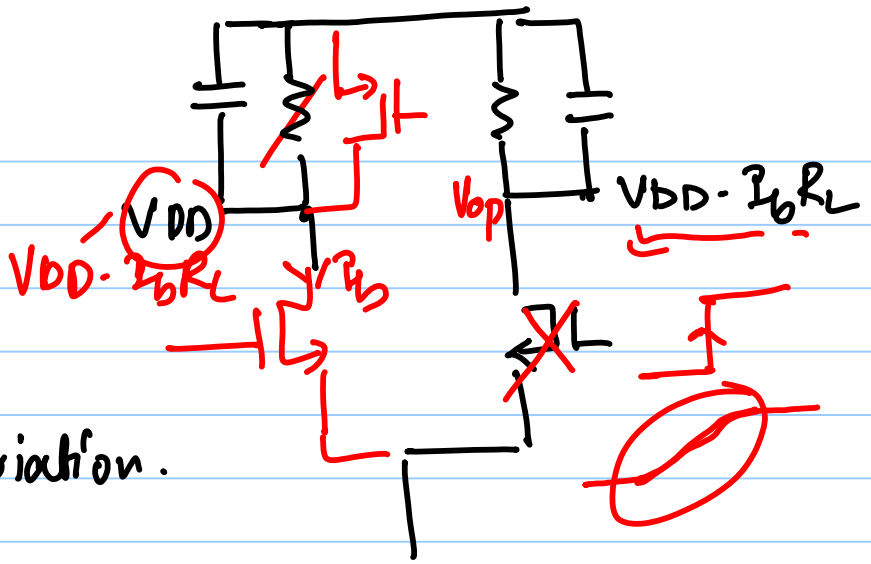


$$H(s) = \frac{-g_m R_L}{1+sR_LC_L} = \frac{-A_0}{1+s/\omega_p} \qquad \text{with} \quad H = \frac{-A_0^3}{(1+s/\omega_p)^3}$$

Output swing = $I_b \cdot R_L$

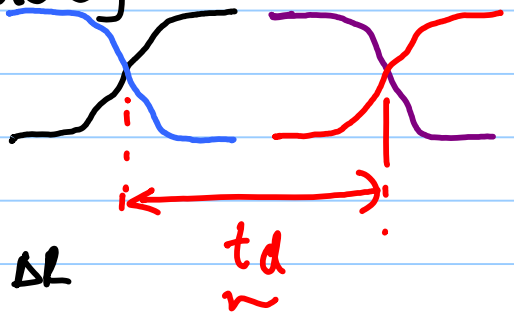
Oscillator frequency $\propto \frac{1}{R_L C_L}$

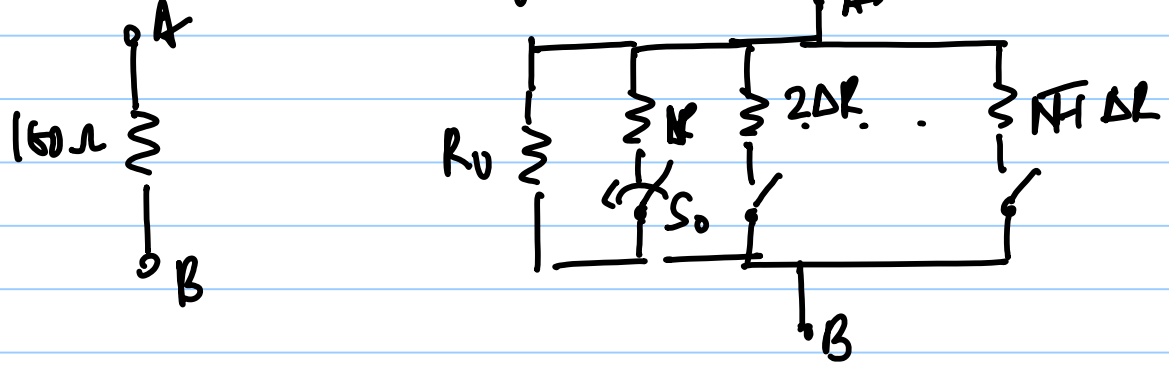




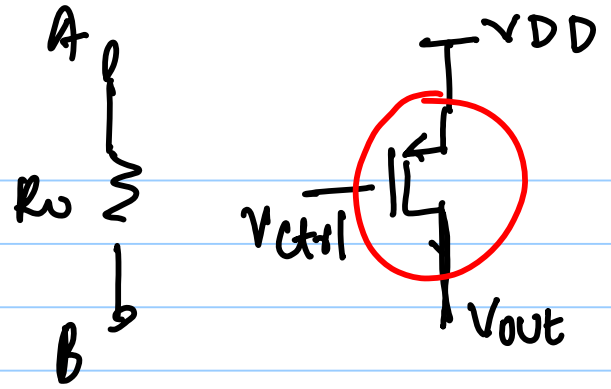
- if frequency varies due to PVT variation.
  - bring it back to desired

- if I need to change to a new frequency
  then I need frequency tuning.





$$\frac{1}{R} = \frac{1}{R_0} + \frac{S_0}{\Delta R} + \dots$$



$V_{SG} - |V_{TP}| > 0$

$V_{SD} < V_{SG} - |V_{TP}|$ Linear Region.

$VDD - V_{out} < V_{DD} - V_{Ctrl} - |V_{TP}|$

$V_{Ctrl} < V_{out} - |V_{TP}|$ ✓

$$I_{SD} = \mu_p C_{ox} \frac{W}{L} \left[(V_{SG} - |V_{TP}|) V_{SD} - \frac{V_{SD}^2}{2} \right]$$

$$g_{ds} = \frac{\partial I_{SD}}{\partial V_{SD}} = \mu_p C_{ox} \frac{W}{L} \left[(V_{SG} - |V_{TP}|) - V_{SD} \right]$$

$$R = \frac{1}{\mu_p C_{ox} \frac{W}{L} \left((V_{SG} - |V_{TP}|) - V_{SD} \right)}$$

$$\frac{V_{SD}}{I_{SD}} = \frac{1}{\mu_p C_{ox} \frac{W}{L} \left(|V_{SG} - |V_{TP}| | - \frac{V_{SD}}{2} \right)}$$

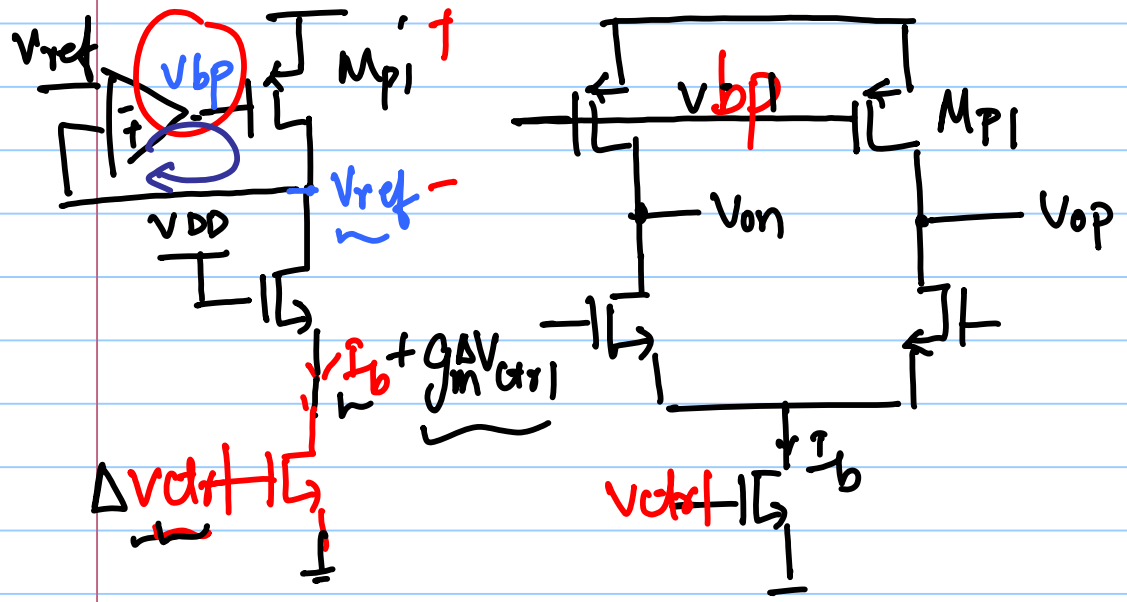
$$R = \frac{1}{\mu_p C_{ox} \frac{W}{L} \left[V_{DD} - V_{ctrl} - |V_{TP}| \right]}$$ ✓

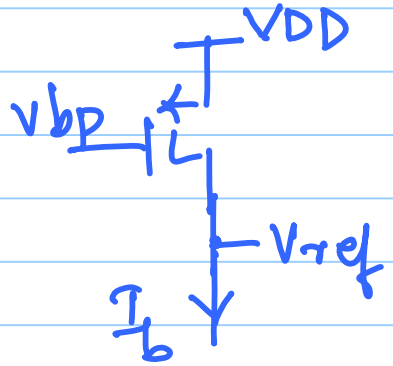
$$f_{osc} \propto \frac{1}{R_L C_L} = \frac{\mu_p C_{ox} \frac{W}{L} \left[V_{DD} - V_{ctrl} - |V_{TP}| \right]}{C_L}$$

$V_{swing} = I_b \uparrow R_L \downarrow$

$\propto R_L$

- Output freq. increases w/ decrease in R_L
- Output swing decreases w/ decrease in R_L



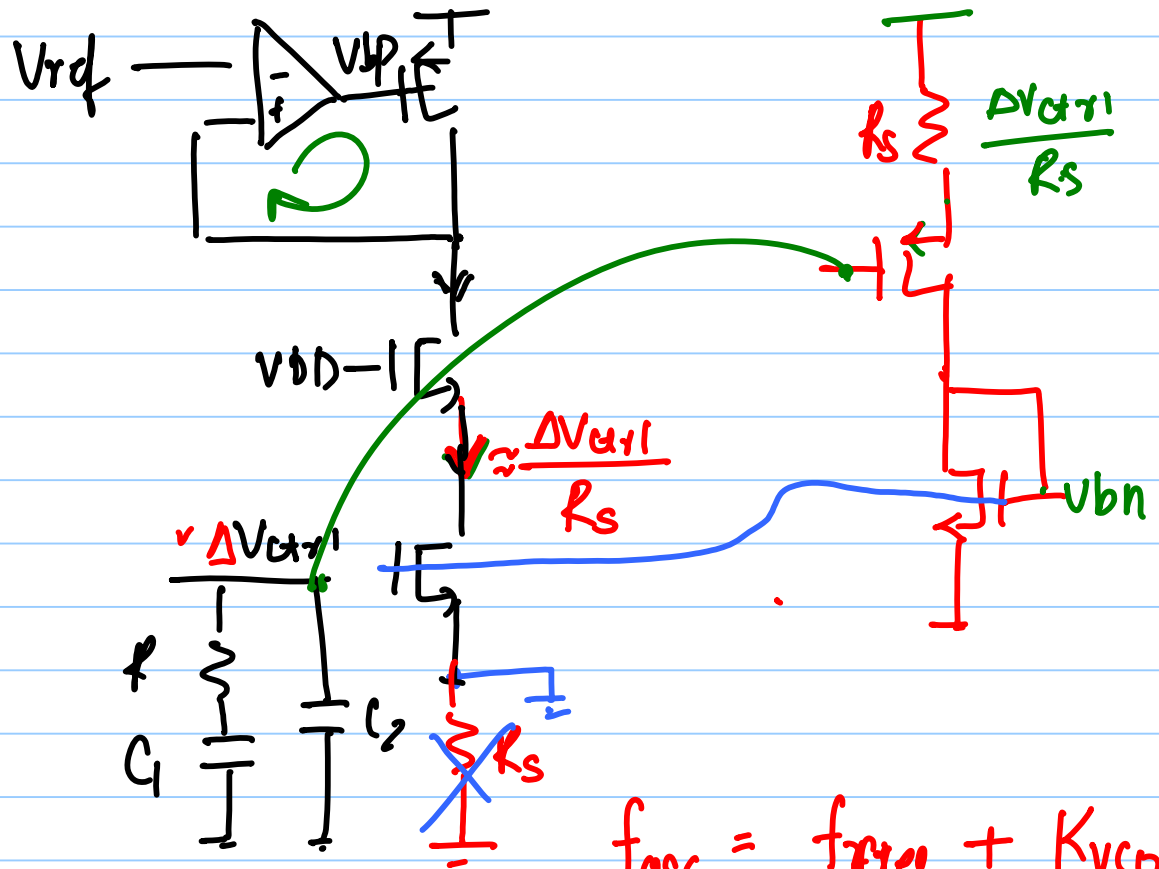


- Voltage drop across resistor when all current is diverted to one side, $V_{DD} - V_{out} = V_{DD} - V_{ref}$

- $f_{osc} \propto \frac{1}{RC}$

$$= \frac{I_{Ctrl}}{(V_{DD} - V_{ref})\,C}$$

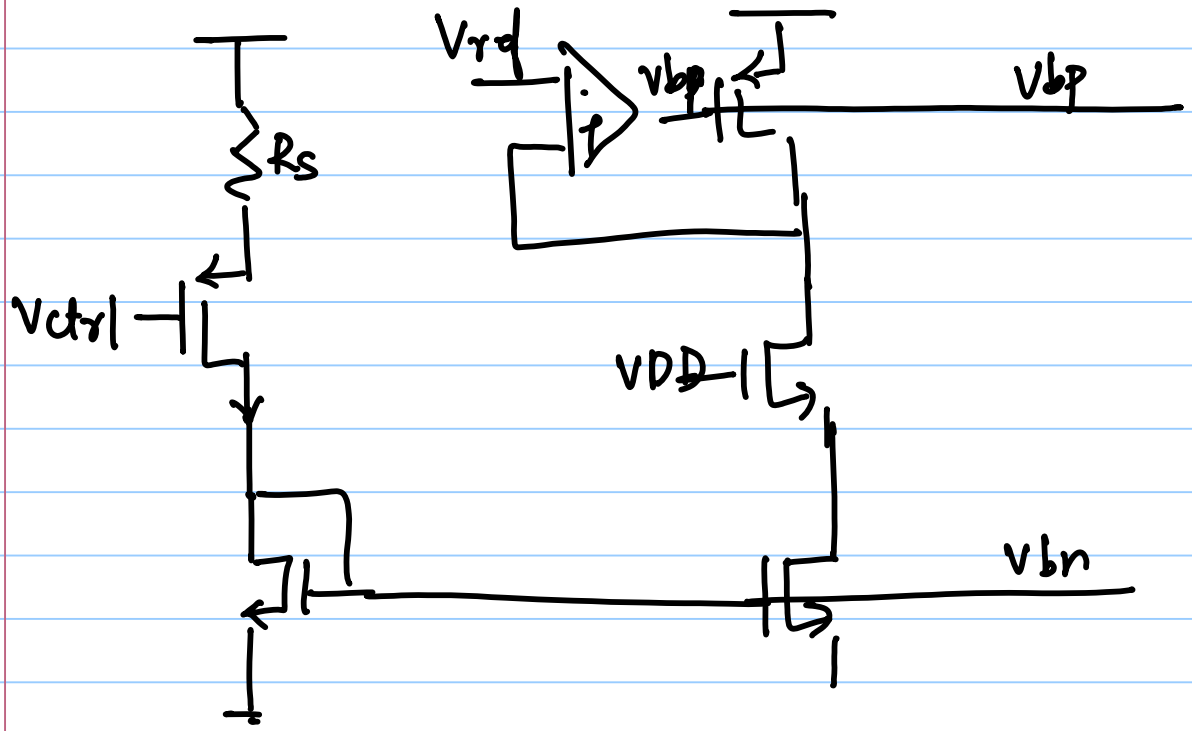
$$= \frac{g_m \Delta V_{Ctrl}}{(V_{DD} - V_{ref})\,C}$$



$$f_{osc} = f_{free} + K_{VCO} \cdot V_{ctrl}$$

$$= f_{free} + K_{VCO} \left(V_{ctrl}(0) + \Delta V_{ctrl} \right)$$

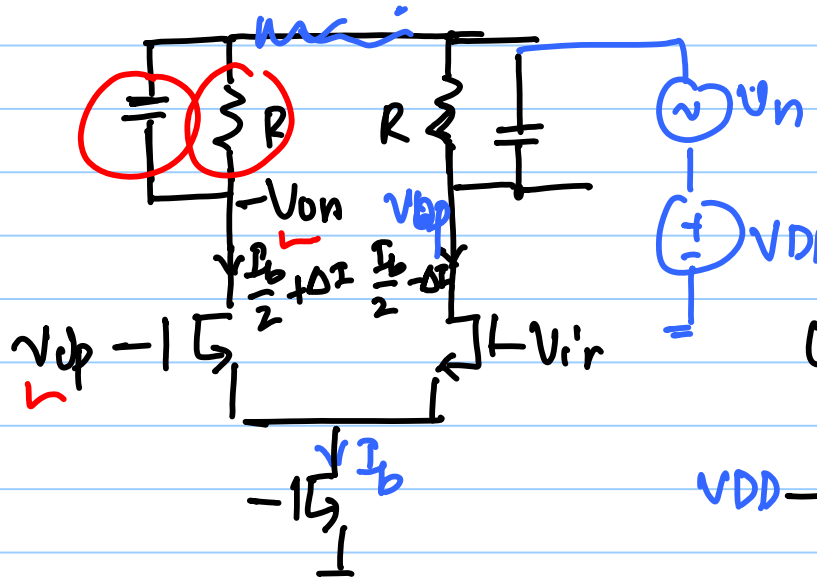
$$\frac{V_{bp}}{V_{ctrl}}$$



- Amplitude
- Tuneable frequency.
- Linear voltage-to-frequency conversion.

$$I_{Ctrl} \approx \frac{V_{Ctrl}}{R_S}$$

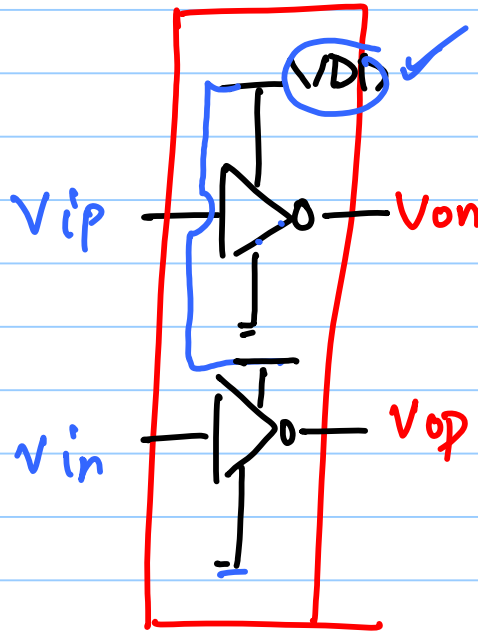
$$f_{OSC} \propto \frac{I_{Ctrl}}{(V_{DD}-V_{ref})C} = \frac{V_{Ctrl}}{R_S C(V_{DD}-V_{ref})}$$

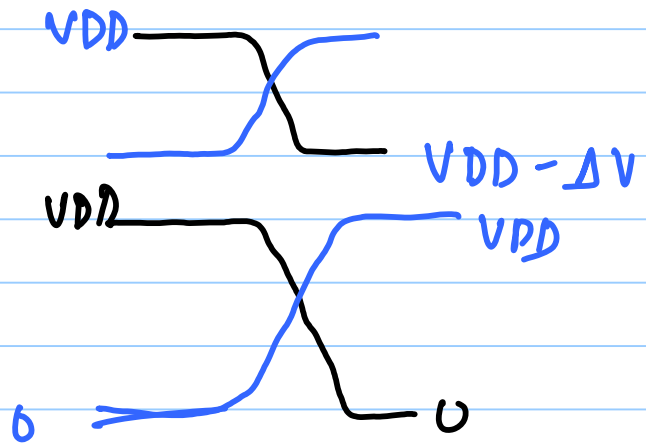


Vip − Vin ⟶ Von − Vop

NOT Gate

Oscillator T / fosc depends on delay (RC)

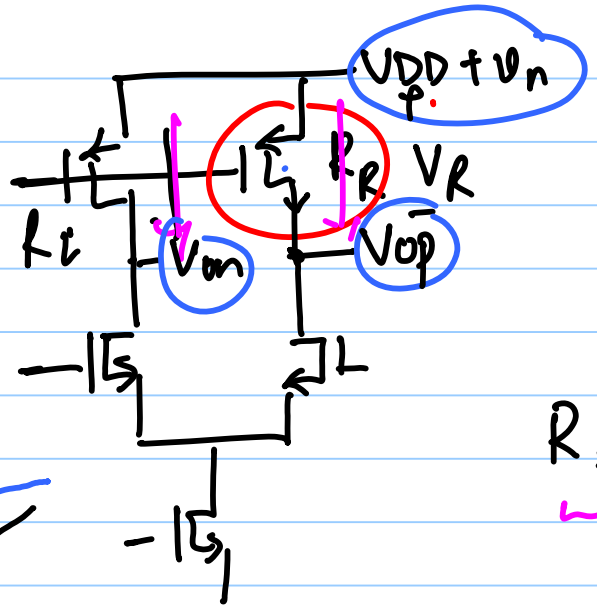




$$V_{op} = \underset{+v_n}{V_{DD}} - \left(\frac{I_b}{2} + \Delta I\right) R$$

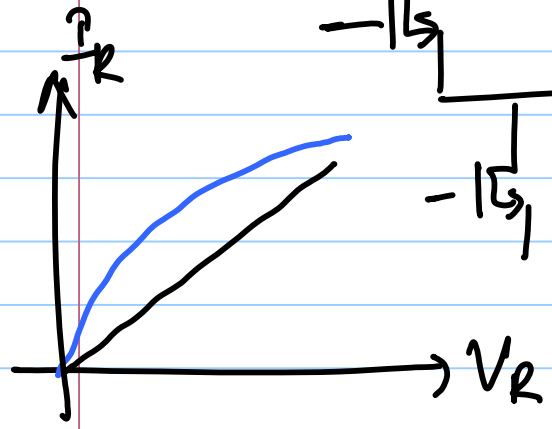
$$V_{on} = \underset{+v_n}{V_{DD}} - \left(\frac{I_b}{2} - \Delta I\right) R$$

$$V_{op} - V_{on} = 2 \cdot \Delta I \cdot R$$



$$V_{op} = V_{DD} + v_n - \left(\frac{I_b}{2} + \Delta I\right)(R_R) \rightarrow (R_0 + \Delta R)$$

$$V_{on} = V_{DD} + v_n - \left(\frac{I_b}{2} - \Delta I\right)(R_L) \quad (R_0 + \Delta R)$$



$$R_R = \frac{1}{\mu_p C_{ox} \frac{W}{L}\left(\{V_{DD} + v_n - V_{th1} - |V_{tp}|\} - (V_{DD} + v_n - V_{op})\right)}$$

$$R_L = \frac{1}{\mu_p C_{ox} \frac{W}{L}\left(\{V_{DD} + v_n - V_{th1} - |V_{tp}|\} - (V_{DD} + v_n - V_{op})\right)}$$