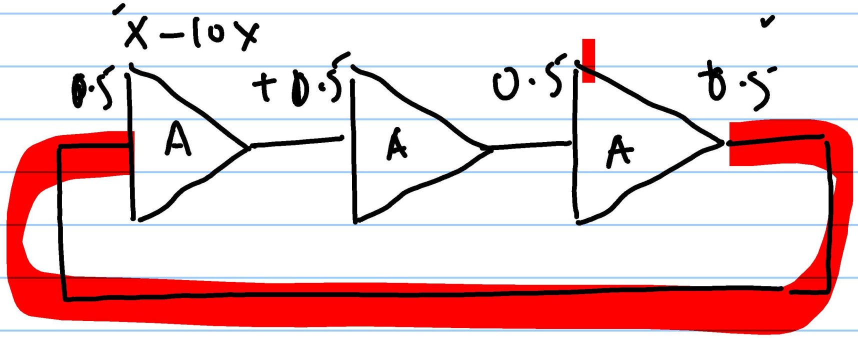
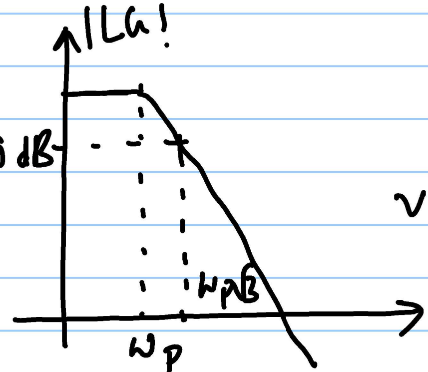
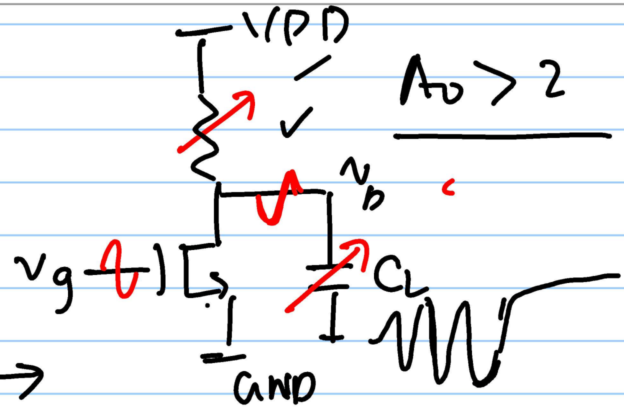
Lecture # 20

Note Title — 12-09-2018

Small-swing oscillators.



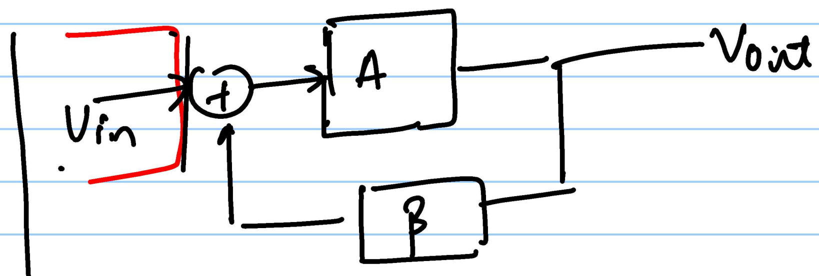




$A_o > 2$

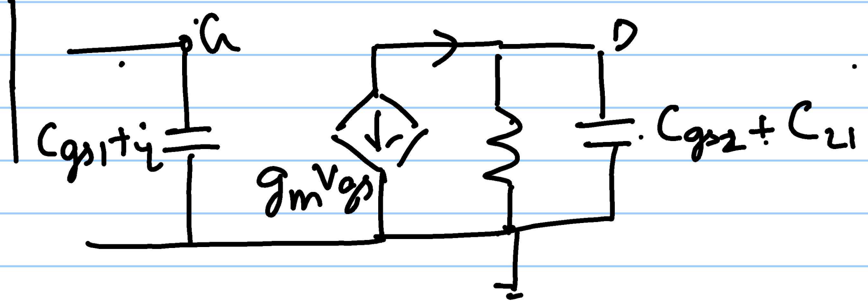
$$A(s) = \frac{-A_o}{(1+s/\omega_p)}$$

$$LG = \left[\frac{-A_o}{1+s/\omega_p}\right]^3$$



Condition for sustained oscillations:

$$\left.\begin{array}{l} |LG(\omega_{osc})| = 1 \\ \angle LG(\omega_{osc}) = 2n\pi \end{array}\right\} \quad \begin{array}{l} \omega_{osc} = \omega_p\sqrt{3} \\ A_o = 2 \end{array}$$



$$\frac{LG}{1+LG} = \frac{-A_0^3 / (1+s/\omega_p)^3}{1 - \frac{(-A_0^3)}{(1+s/\omega_p)^3}}$$

$$= \frac{-A_0^3}{(1+s/\omega_p)^3 + A_0^3}$$

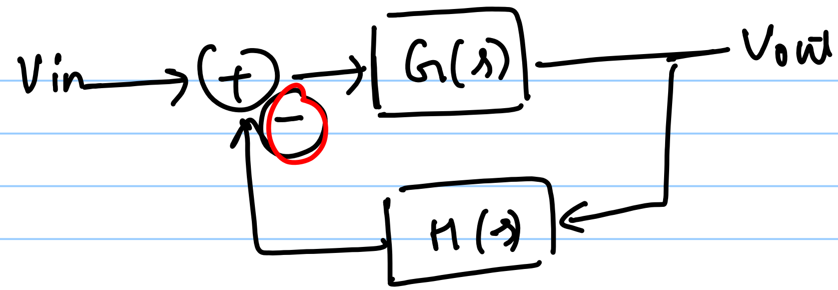
$$\left(1+\frac{s}{\omega_p}\right)^3 + A_0^3 = 0$$

$$\frac{s}{\omega_p} = -1 + A_0 (-1)^{1/3}$$

$$s = \omega_p \left[-1 + A_0 e^{j(\pi/3 + 2k\pi/3)}\right] \quad k = 0, 1, 2$$

$$0, \frac{2\pi}{3}, \frac{4\pi}{3}$$

$$s_1 = \omega_p \left[-1 + A_0 e^{j\pi/3}\right] = \omega_p \left[-1 + A_0 \left(\frac{1}{2} + j\frac{\sqrt{3}}{2}\right)\right]$$



$$\frac{V_{out}}{V_{in}} = \frac{G(s)}{1+G(s)H(s)}$$

$$\left[V_{in} - H(s)V_0\right] G(s) = V_{out}.$$

V_{out}.

$$e^{j(2n\pi +}$$

$$= \omega_p\left[\left(-1+\frac{A}{2}\right) + j\cdot\frac{A\sqrt{3}}{2}\right]$$

$$s_2 = \omega_p\left[-1 + \cancel{A_0}\, e^{j(\pi/3+2\pi/3)}\right]$$

$$= \omega_p\left[-1 + (-A_0)\right]$$

$$s_3 = \omega_p\left[-1 + A_0\, e^{j(\frac{\pi}{3}+4\pi/3)}\right]$$

$$= \omega_p\left[-1 + A_0\left(e^{j(2\pi-\pi/3)}\right)\right]$$

$$= \omega_p\left[-1 + A_0\left(\frac{1}{2} - j\frac{\sqrt{3}}{2}\right)\right]$$

$$= \omega_p\left[\left(-1+\frac{A_0}{2}\right) - j\frac{\sqrt{3}A_0}{2}\right]$$

$$e^{j2\pi/3}$$

$$= \cos(2\pi/3) + j\cdot\sin(2\pi/3)$$

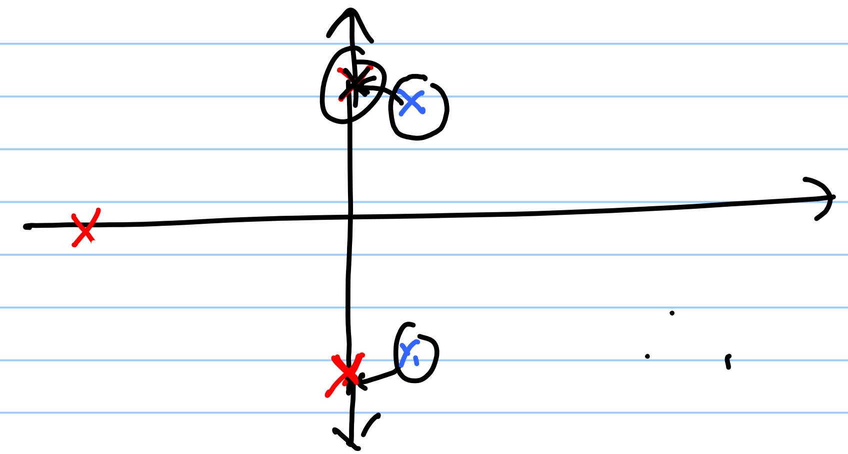
$$= \cos(90^\circ+30^\circ) + j\sin(90+30^\circ)$$

$$= -\frac{1}{2} + j\cdot\frac{\sqrt{3}}{2}$$

$$(-1)^{1/3} = \left(e^{j\pi}\right)^{1/3}$$

$$= \left[e^{j(\pi+2n\pi)}\right]^{1/3}$$

$$= e^{j(\pi/3+2n\pi/3)}$$



$$\omega_{osc} = \sqrt{3}\,\omega_p = \frac{\sqrt{3}}{RC}$$

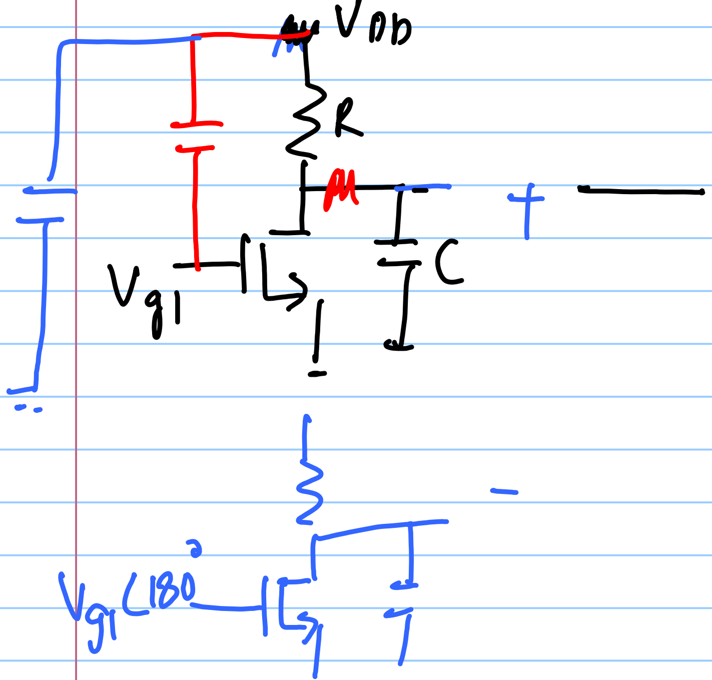
$$R = (R_o \| r_{ds})$$

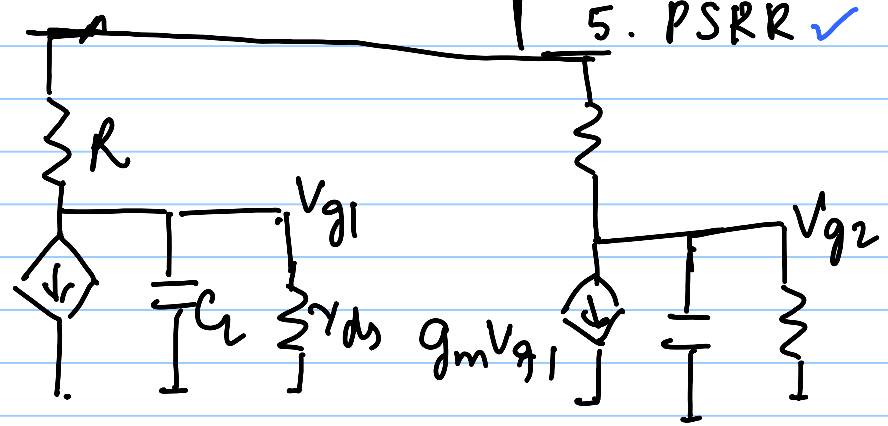
$$A_o = g_m(R_o \| r_{ds}) = 2$$

Vout

Oscillator

1. Amplitude
2. Frequency — Stability / Tunability.
3. Power consumption.
4. Phase noise
5. PSRR

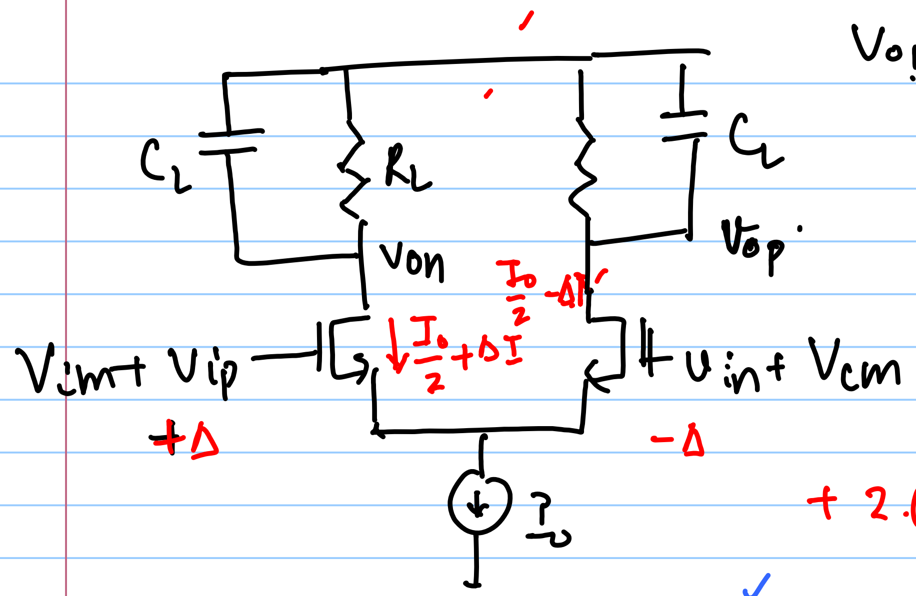




$V_{on} = V_{DD} - I_o . R_L$

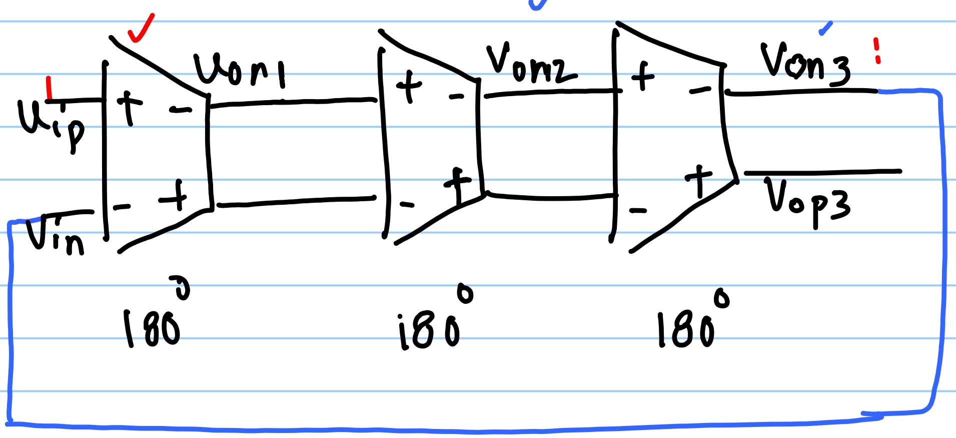
$V_{op} = V_{DD}$

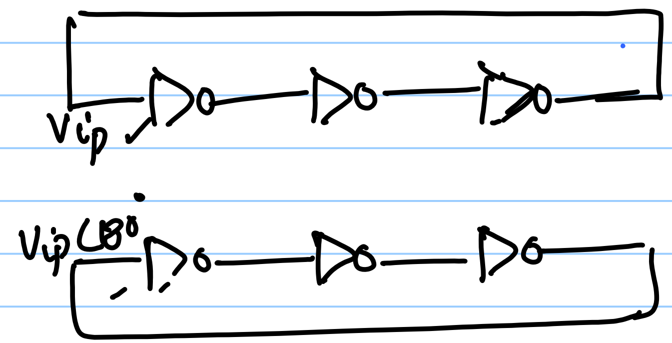
$$\frac{V_{out}(s)}{V_{in}(s)} = \frac{V_{op} - V_{on}}{V_{ip} - V_{in}} = \frac{g_m R_L}{1 + s C_L R_L}$$



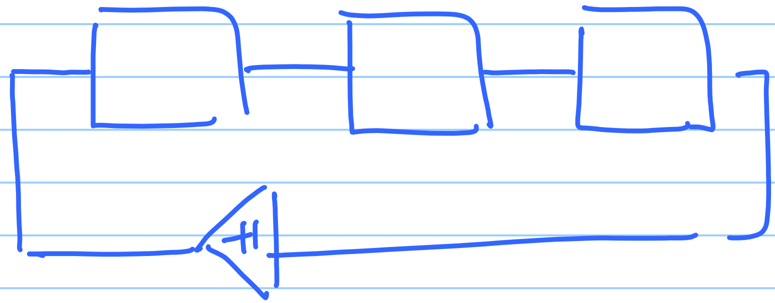
$$\omega_p : \frac{1}{R_L C_L} \qquad \omega_{osc} = \sqrt{3}\,\omega_p$$

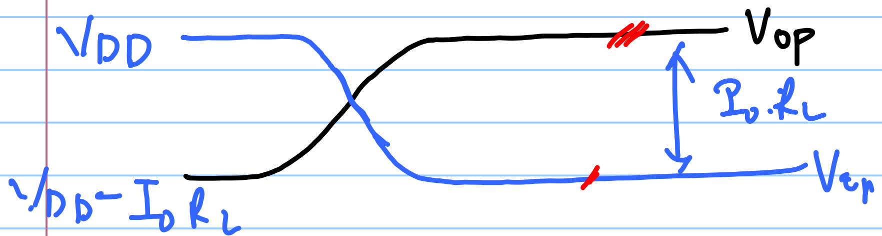
$$+\ 2.(\Delta I).R_L\Big|_{max} = 2\ \frac{I_o}{2} . R_L$$





$$A(s) = \frac{A_0}{1 + s/\omega_p}$$





$$V_{out,max} = |V_{op} - V_{on}|_{max}$$

$$= g_m R_L \, \underbrace{|V_{ip} - V_{in}|_{max}}_{2} \checkmark$$

$$= 2 g_m R_L$$