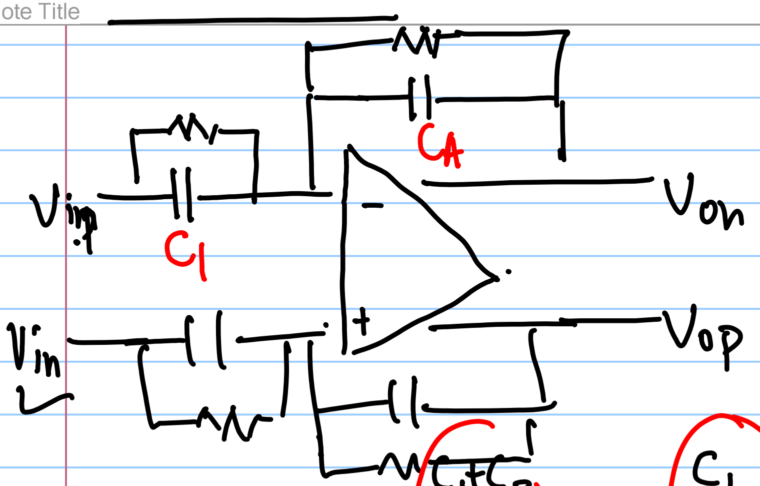
Note Title 22-04-2019

lecture # 45



$$\frac{V_{out}}{V_{in}} = -\frac{\frac{C_1+C_2}{C_A}z - \frac{C_1}{C_A}}{\left(1+\frac{C_3}{C_A}\right)z - 1}$$

$$w_a = \frac{2}{T}\tan\left(\frac{w_d T}{2}\right)$$

$$\approx \frac{2}{T}\frac{w_d . T}{2} = w_d$$

Continuous & Discrete filter

$$s = \frac{2}{T}\frac{z-1}{z+1} \qquad \frac{z-1}{z+1} = \frac{sT}{2}$$

$$H_d(z) = H_a(s)\Big|_{s=\frac{2}{T}\frac{z-1}{z+1}}$$

$$s = \frac{2}{T}\frac{e^{jw_dT}-1}{e^{jw_dT}+1}$$

$$= \frac{2j}{T}\frac{\left(e^{jw_dT/2}-e^{-jw_dT/2}\right)/2j}{\left(e^{jw_dT/2}+e^{-jw_dT/2}\right)/2}$$

$$= \frac{2j}{T}\tan\left(\frac{w_d T}{2}\right)$$

$$jw_a = \frac{2j}{T}\tan\left(\frac{w_d T}{2}\right)$$

$$w_d = \frac{2}{T} \tan^{-1}\left(\frac{w_a . T}{2}\right)$$

Eg: $\underbrace{f_{-3dB}}$ $= \underbrace{f_s/20}_{\downarrow\ z_p}$, $A_{DC} = 1$, $\underbrace{z_z} = -1 = e^{jw_dT}$

$$w_d = \frac{2\pi f_s}{20} \xrightarrow{|H_d(z)|} \frac{1}{\sqrt{2}} . A_{DC}$$

$$w_d \longleftrightarrow \underline{w_a}$$

$$\frac{w_a T}{2} = \tan\left(\frac{w_d . T}{2}\right) = \tan\left(\frac{\cancel{2}\pi \cancel{f_s}}{20} . \frac{1}{\cancel{2f_s}}\right)$$

$$= \underbrace{\tan\left(\frac{\pi}{20}\right)} = 0.1583$$

$$H_a(s) = \frac{1}{1 + s/w_p}$$

$$H_d(z) = \frac{A_{DC}\,(z + z_z)}{(z + \underbrace{z_p})}$$

$z_z = -1$

$z + z_p = 0$

$$|H_d(z)|_{z = e^{j\underbrace{\frac{2\pi f_s}{20}} . T}} = \frac{1}{\sqrt{2}} . A_{DC}$$

$$\frac{1}{1 + s/w_p}$$

$$Z_p = \frac{1+sT/2}{1-sT/2} = 0.7267$$

$$H_d(z) = \frac{A_{DC}\,(z-1)}{(z-0.7267)}$$ ✓

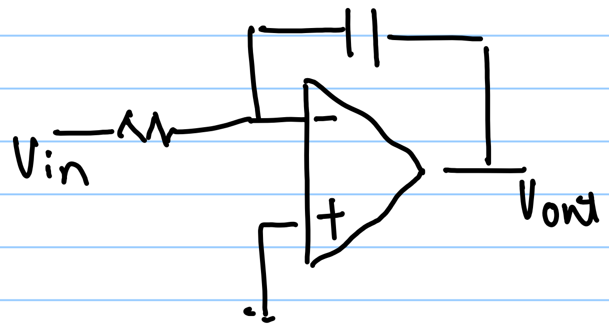
$$z = e^{j\omega T}$$

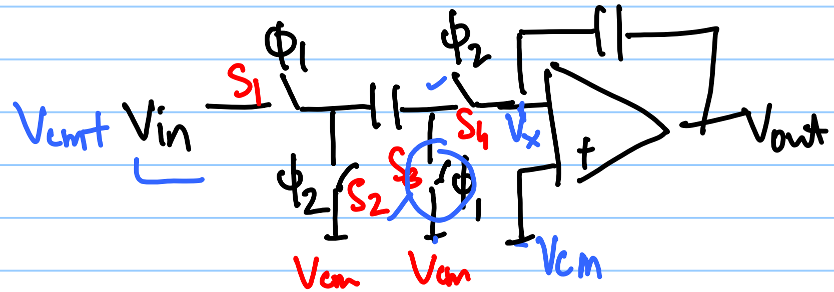
$$z = e^{sT}$$

$$s = \frac{1}{T}\ln(z)$$

$$= \frac{2}{T}\left[\frac{z-1}{z+1} + \frac{1}{3}\left(\frac{z-1}{z+1}\right)^2 + \cdots\right]$$

$$\approx \quad \downarrow$$



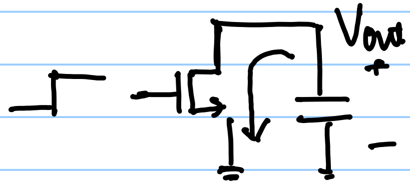


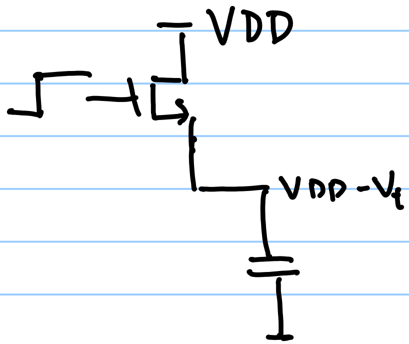
S_1 :

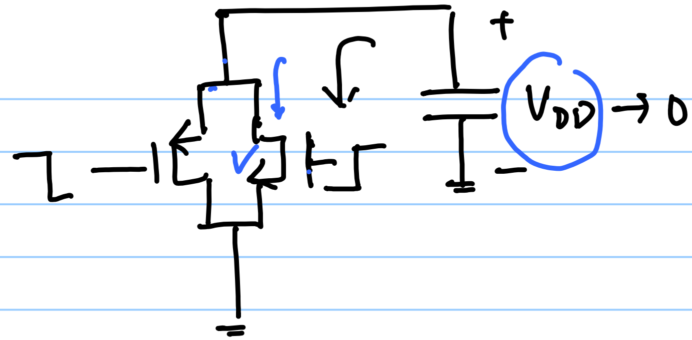
S_2 :

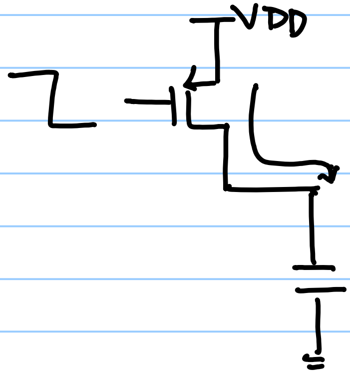
S_3 :

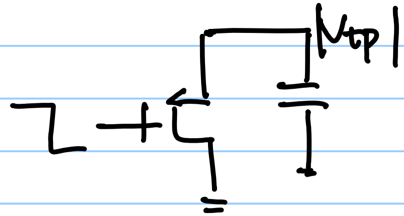
S_4 :

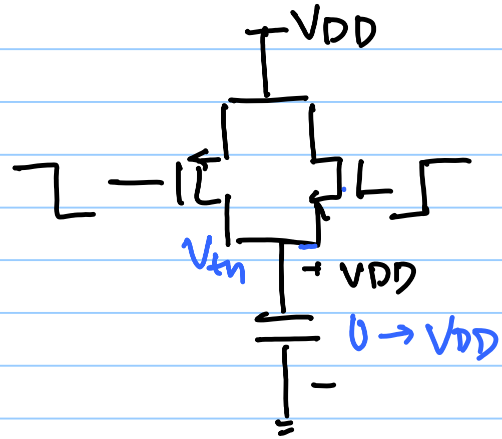

Vout
+
−

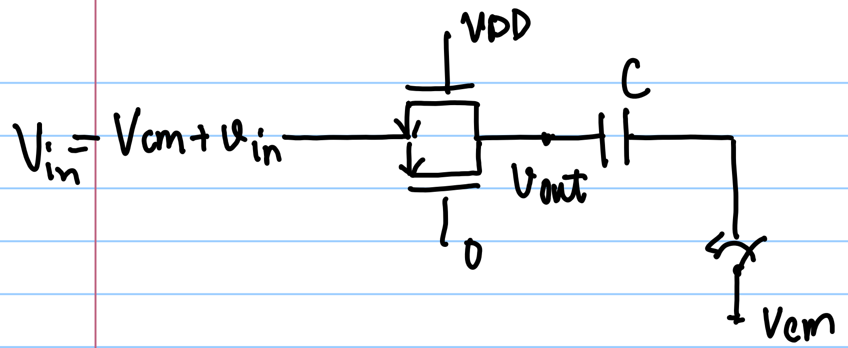

VDD
VDD-Vt


+
VDD → 0
−


VDD


|Vtp|


VDD
Vtn
+ VDD
0 → VDD
−



$v_{in} = a\sin(\omega_0 t)$

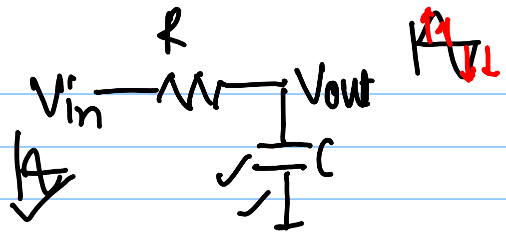
$$I = \mu_p C_{ox}\left(\frac{W}{L}\right)_p \left[(V_{in} - 0 - |V_{TP}|)(V_{in} - V_{out}) - \frac{(V_{in} - V_{out})^2}{2} \right]$$

$$+ \mu_n C_{ox}\left(\frac{W}{L}\right)_n \left[(V_{DD} - V_{tn} - V_{out})(V_{in} - V_{out}) - \frac{(V_{in} - V_{out})^2}{2} \right]$$

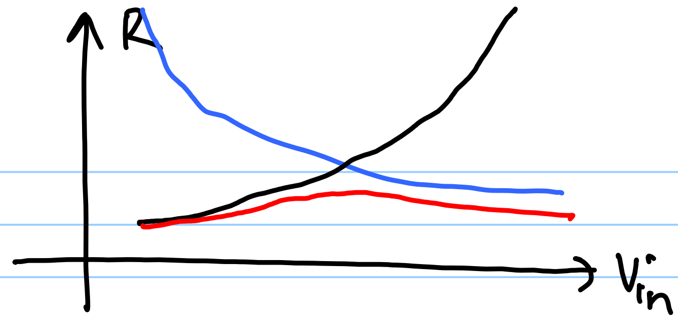
$$= C\frac{dV_{out}}{dt}$$

$$C_{ox}\left[\underbrace{\left\{ \mu_p\left(\frac{W}{L}\right)_p (V_{in} - |V_{Tp}|) + \mu_n\left(\frac{W}{L}\right)_n (V_{DD} - V_{tn} - V_{out}) \right\}} (V_{in} - V_{out}) \checkmark = \frac{V_{in} - V_{out}}{R} \right.$$

$$\left. - \mu_p\left(\frac{W}{L}\right)_p \frac{(V_{in} - V_{out})^2}{2} - \mu_n\left(\frac{W}{L}\right)_n \frac{(V_{in} - V_{out})^2}{2} \right] = C\frac{dV_{out}}{dt} \checkmark$$



$$\frac{V_{in}-V_{out}}{R} = C\frac{dV_{out}}{dt}$$



$$R_{eff} = \frac{1}{C_{ox}\left[\mu_p\left(\frac{W}{L}\right)_p\left(V_{in}-|V_{tp}|\right)+\mu_n\left(\frac{W}{L}\right)_n\left(V_{DD}-V_{tn}-V_{out}\right)\right]} \approx \frac{1}{\mu\left(\frac{W}{L}\right)C_{ox}\times\left[V_{DD}-V_{tn}-|V_{tp}|\right]}$$

V_{in}

$V_{in} \approx V_{out}$

$$\mu_p\left(\frac{W}{L}\right)_p = \mu_n\left(\frac{W}{L}\right)_n$$