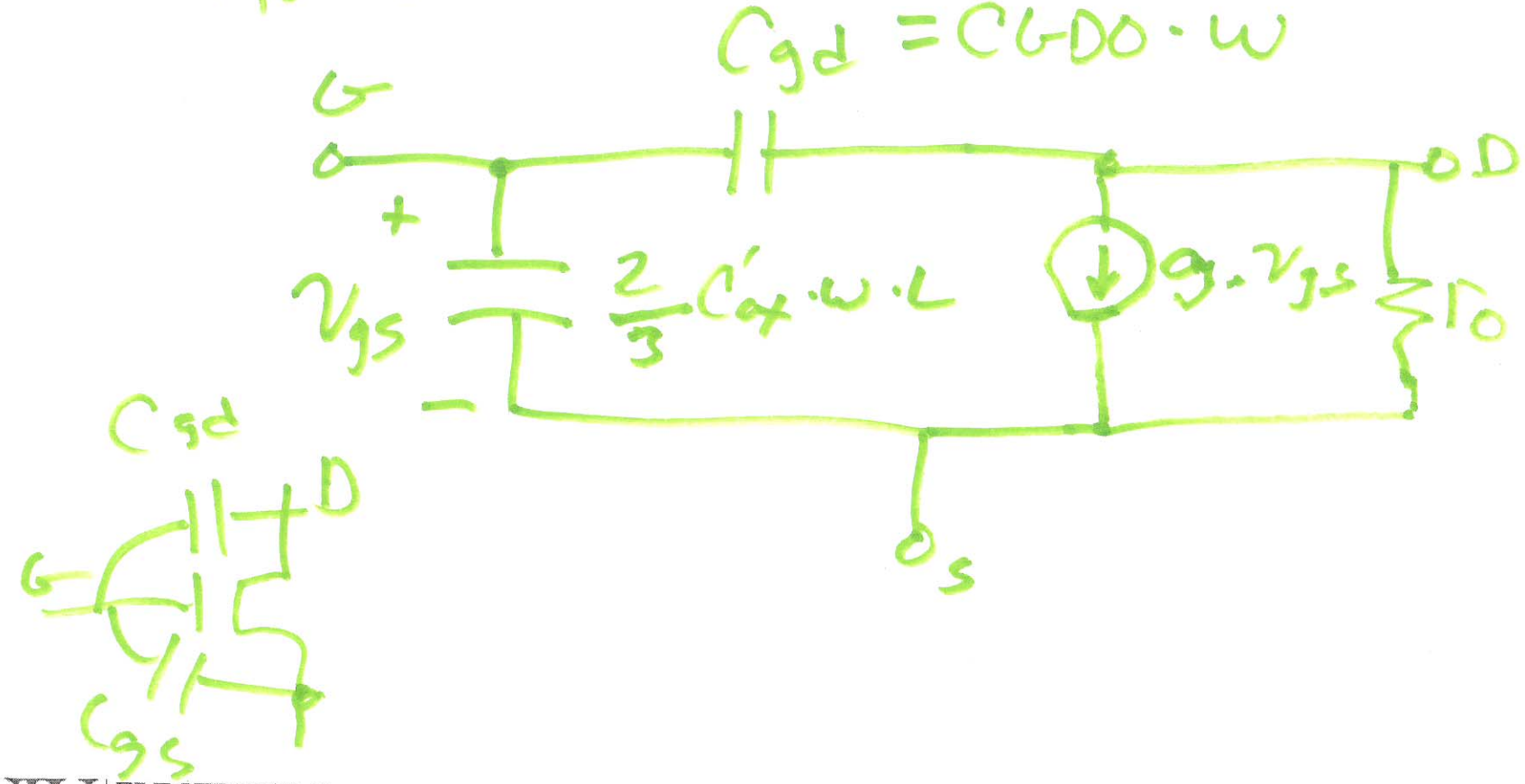
EE 420 ECE 620

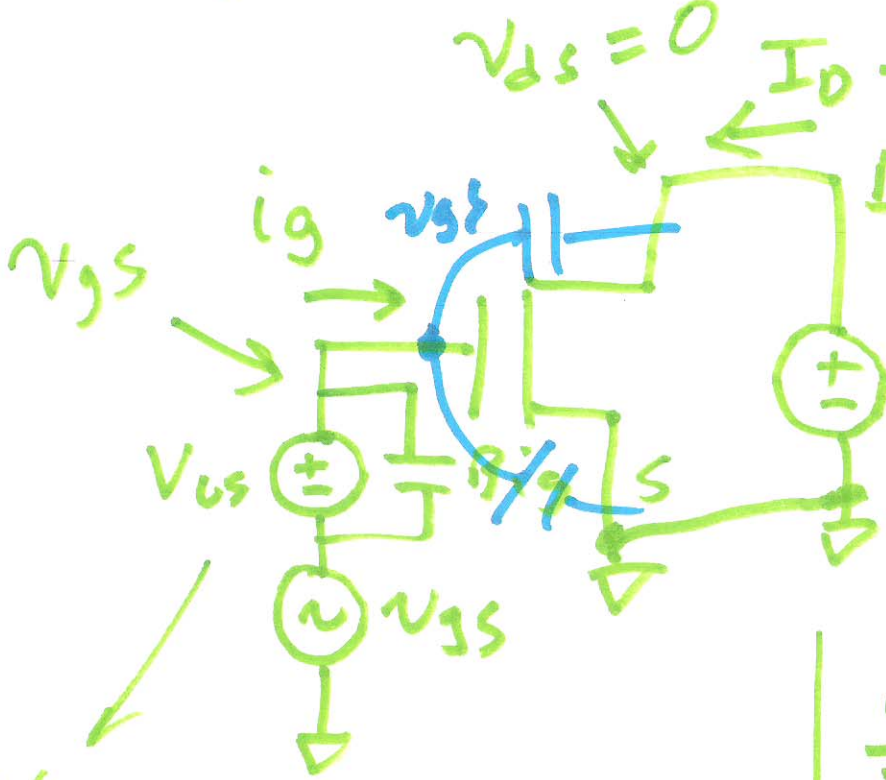
Lecture 6

Feb. 4, 2015

for sat.



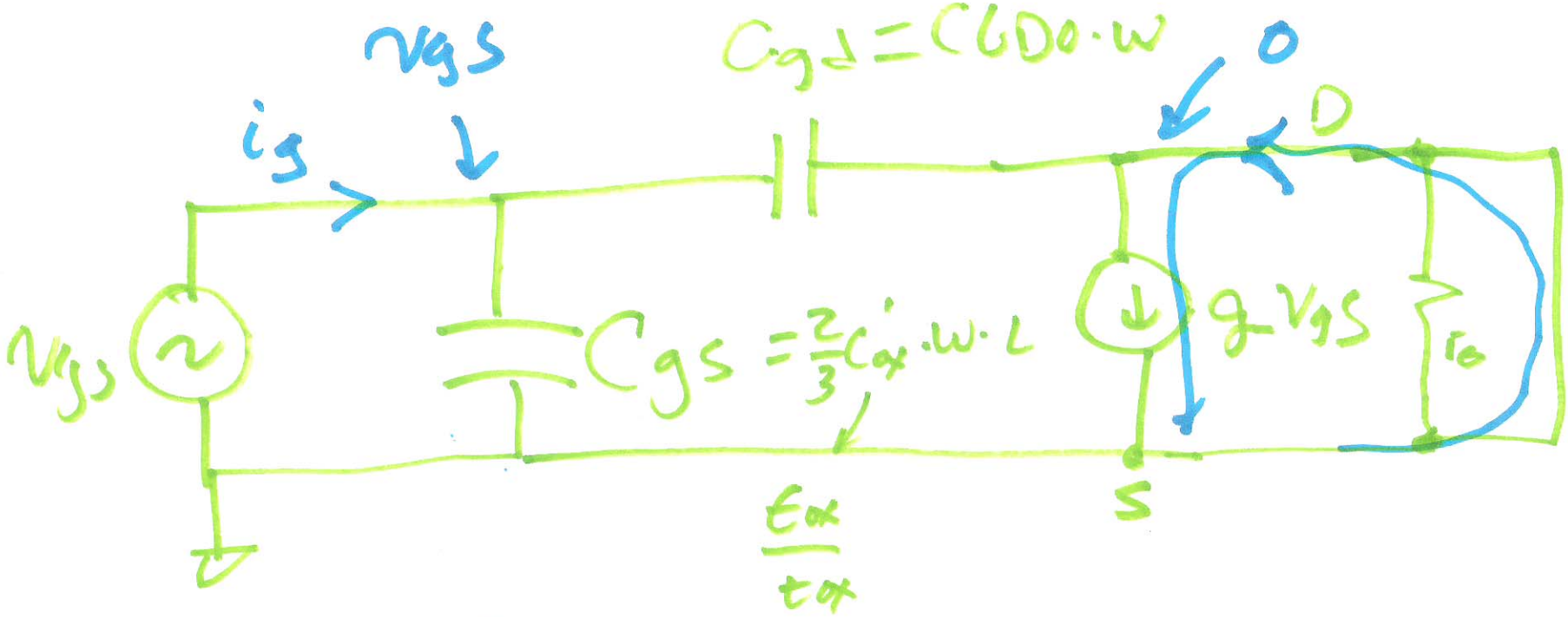
transition frequency



$$\left|\frac{i_d}{i_g}\right| = 1$$

$f = f_T$

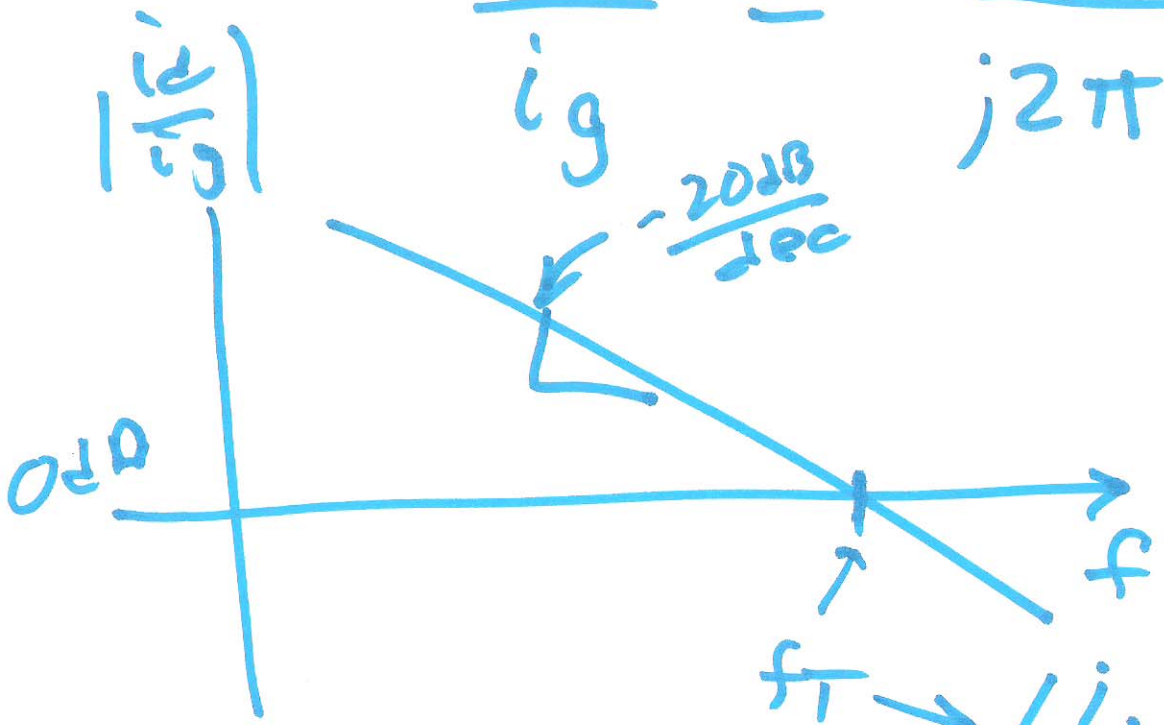
AC ckt



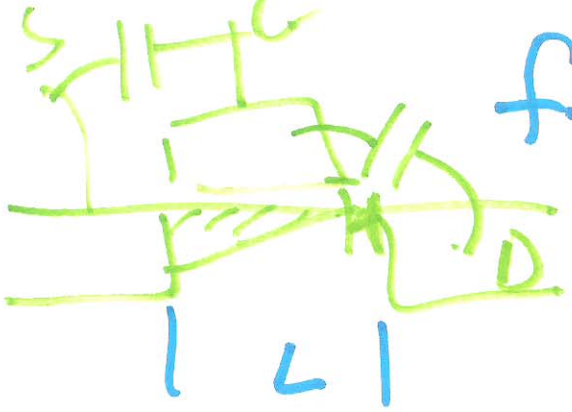
$$i_g = \frac{v_{gs}}{\frac{1}{j\omega}(C_{gd} + C_{gs})}, \quad i_d = g_m v_{gs}$$

$$\frac{i_d}{i_g} = \frac{g_m \cancel{v_{gs}}}{\cancel{v_{gs}} \cdot jw(C_{gd}+C_{gs})}$$

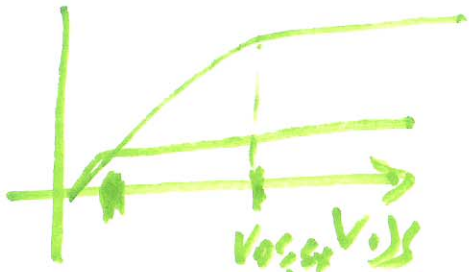
$$\frac{i_d}{i_g} = \frac{g_m}{j2\pi f \cdot (C_{gd}+C_{gs})}$$



$$f_T = \frac{g_m}{2\pi(C_{gd}+C_{gs})}$$



$$f_T = \frac{g_m}{2\pi(C_{gs}+C_{gd})}$$



$$\approx \left| \frac{\mu_n C_{ox}\cdot\frac{W}{L}\left(V_{GS}-V_{THN}\right)}{2\pi\left(\frac{2}{3}C_{ox}\cdot W\cdot L\right)} \right.$$

$V_{DS,sat} = V_{OVN}$ Excess gate voltage

$C_{gs} >> C_{gd}$.

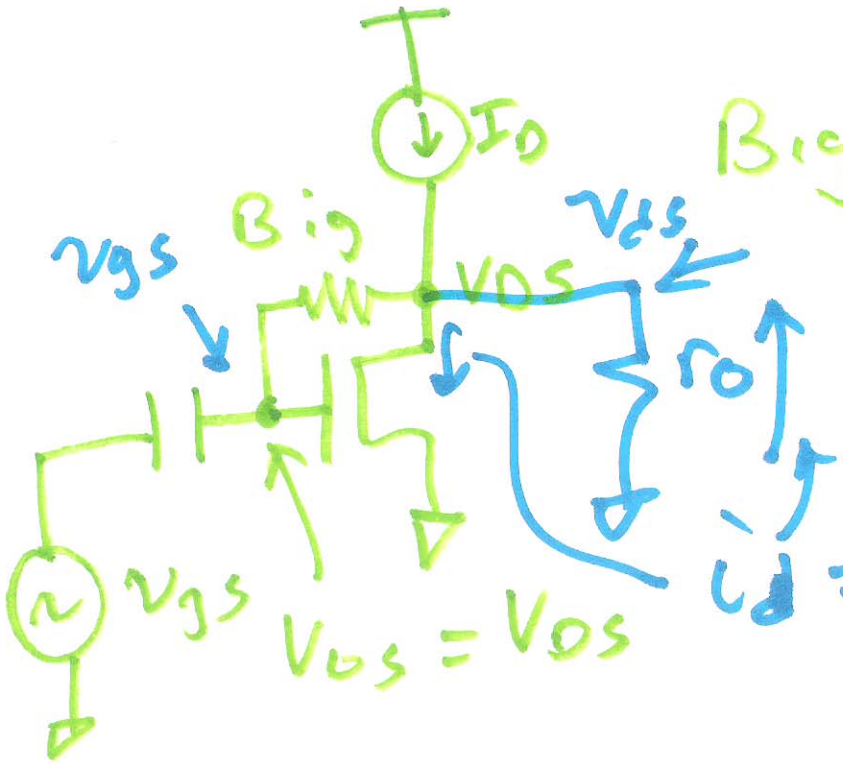
$I \rightarrow \frac{1}{T}C$

$\frac{dV}{dt} = \frac{I}{C}$

inherent speed not dep. on W!

$f_T \propto \frac{1}{L^2}$ $f_T \uparrow$ $L \downarrow$

$f_T \propto V_{OVN}$ $V_{GS} \uparrow$ $f_T \uparrow$



Big $R >> r_o$

$$I_D = \frac{K_P}{2}\cdot\frac{W}{L}\left(V_{GS}-V_{TH}\right)^2$$

$$v_{ds} = -i_d \cdot r_o$$

$$v_{ds} = -g_m v_{gs}\cdot r_o$$

$$\rightarrow \frac{v_{ds}}{v_{gs}} = -g_m r_o$$

Open CKT gain

$$\left|\frac{v_{ds}}{v_{gs}}\right| = \frac{\sqrt{2\cdot K_P\frac{W}{L}\cdot I_D}}{\lambda I_D} = \frac{\sqrt{2\mu_n C_{ox}\frac{W}{L}}}{\lambda\sqrt{I_D}} \propto \frac{C}{V_{GS}-V_{TH}}$$

$\lambda \downarrow$

$I_D \uparrow$ GAIN $\downarrow$ $\leftarrow \frac{L}{L}$ $V_{GS} \uparrow$ GAIN $\downarrow$

$$GAIN \propto \frac{\sqrt{\frac{1}{L}}}{\frac{1}{L}} = \sqrt{L}$$

$L \uparrow$ GAIN $\uparrow$

GAIN · f_T (GFT product)

$$GFT = g_m r_o \cdot \frac{g_m}{2\pi C_{gs}}$$

$$= \frac{g_m^2}{\lambda I_D \cdot 2\pi \cdot \frac{2}{3} C_{ox}' \cdot W \cdot L}$$

$$g_m^2 = \left(\sqrt{2 \cdot KP \cdot \frac{W}{L} I_D}\right)^2 = 2KP \cdot \frac{W}{L} \cdot I_D$$

GAIN. BW

$$\rightarrow GFT = \frac{2 g_m C_{ox}' \cdot \frac{W}{L}}{\lambda \cdot 2\pi \cdot \frac{2}{3} C_{ox}' \cdot W \cdot L}$$

$$GFT \propto \frac{g_m}{L}$$

Thermal Voltage

$$V_T = \frac{kT}{q}$$

$T \uparrow \quad V_T \uparrow$

Threshold voltage

$T \uparrow \quad V_{THN} \downarrow$