Lecture 7 EE 420/ECG 620

Feb. 6, 2014 * Extra *

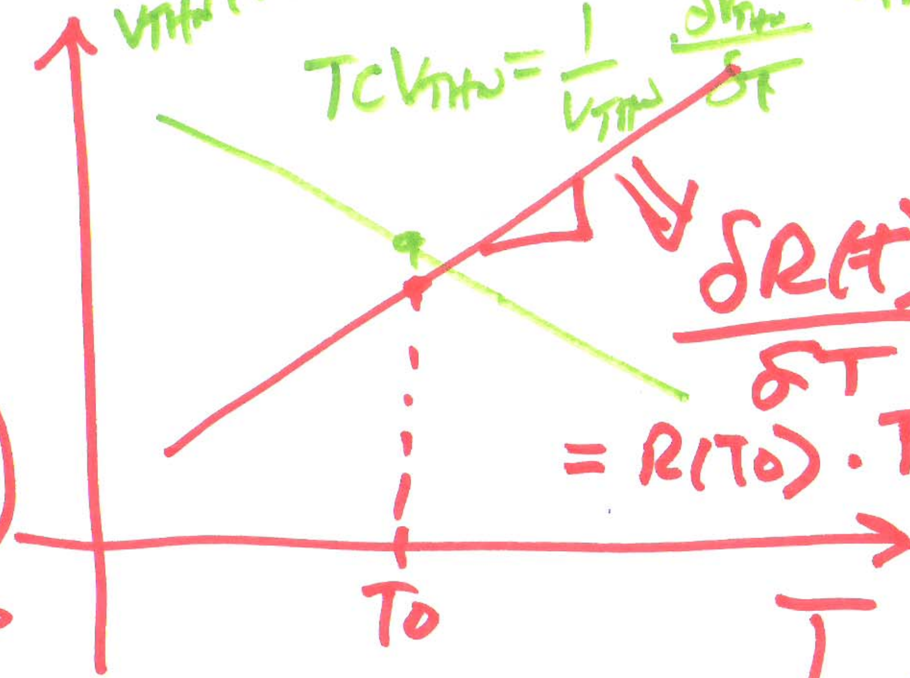
TEMP co. resistn

$$TCR = \frac{1}{R(T_0)} \cdot \frac{\delta R(T)}{\delta T}$$

R(T)

$$V_{THN}(T) = V_{THN}(T_0)\left(1 + TC_{V_{THN}}(T - T_0)\right)$$

$$TC_{V_{THN}} = \frac{1}{V_{THN}} \frac{\delta V_{THN}}{\delta T}$$



$$\Rightarrow \frac{\delta R(T)}{\delta T} = R(T_0) \cdot TCR$$

$$R(T) = R(T_0) \cdot \left(1 + \cancel{TCR}\,TCR1\,(T - T_0)\right)$$

$$= 2{,}000 \frac{\cancel{ppm}\ 10^{-6}}{C^\circ} = 2{,}000 \cdot 10^{-6} = 2 \cdot 10^{3} \cdot 10^{-6}$$

$$= 0.002$$

$$R(T) = R(T_0)\left(1 + TCR1(T - T_0) + TCR2(T - T_0)^2\right)$$

$$T \nearrow \quad V_{THN} \searrow \qquad I_D = \mu_n C_{ox} \frac{W}{L}(V_{GS} - V_{THN})^2$$

$$KP = \mu_n C_{ox}$$

$$\mu_n(T) = \left(\frac{T_0}{T}\right)^{1.5} \cdot \mu_n(T_0)$$

$$\frac{\delta \mu_n(T)}{\delta T} = \frac{\delta \left(\frac{T}{T_0}\right)^{-1.5} \mu_n(T_0)}{\delta T}$$

$$\frac{1}{\mu_n}\frac{\delta \mu_n}{\delta T} = \frac{-1.5}{T} \qquad = -1.5\left(\frac{T}{T_0}\right)^{-2.5} \cdot \frac{\mu_n(T_0)}{T_0}$$

$$= -1.5 \cdot \frac{T^{-2.5}}{T_0^{-1.5}} \mu_n$$

2)

$1\mu m \rightarrow VDD = 5$ N-well

$V_{THN} = 0.8$ $V_{THP} = 0.9$

$KP_N = 120 \frac{\mu A}{V}$ $KP_P = 40 \mu A/V$

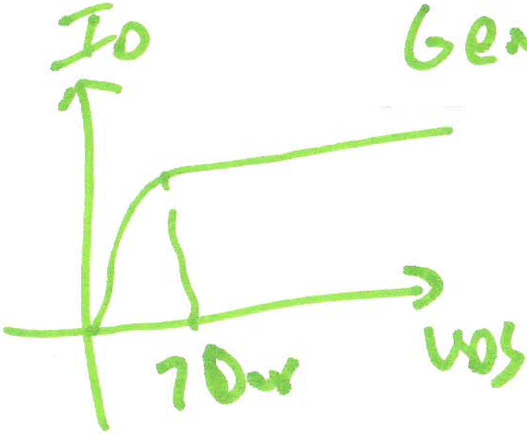
$50nm = 0.05 \mu m$ $VDD = 1$

$V_{THN} = V_{THP} = 280mV$

General design $\rightarrow V_{ov} \approx 5\%$ VDD

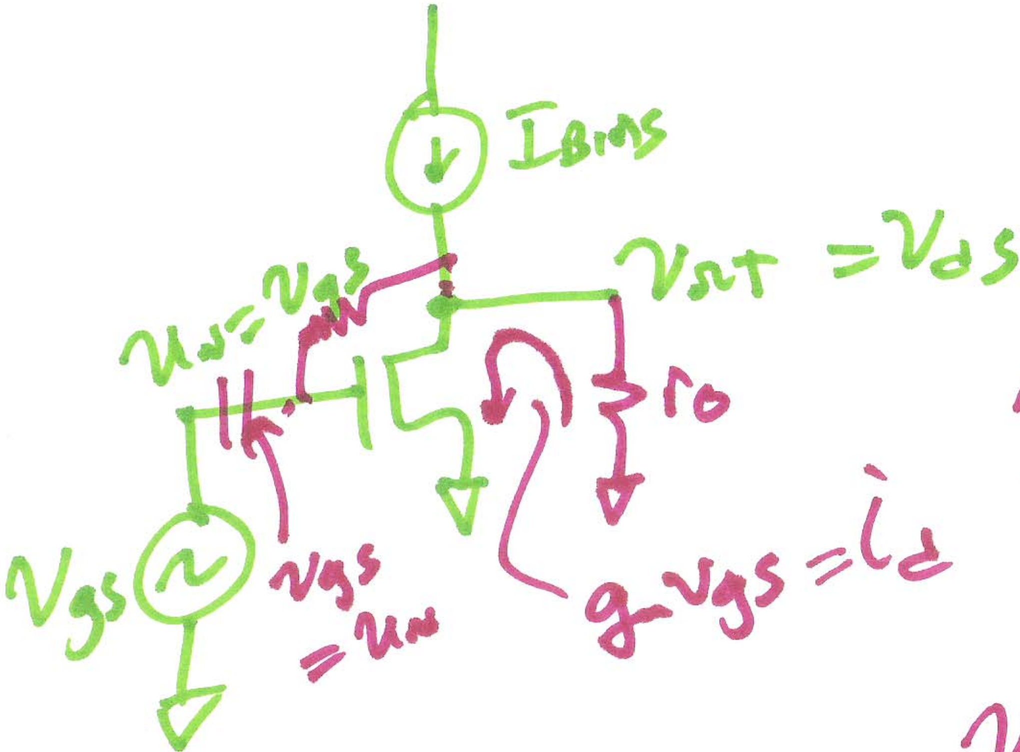
50mV

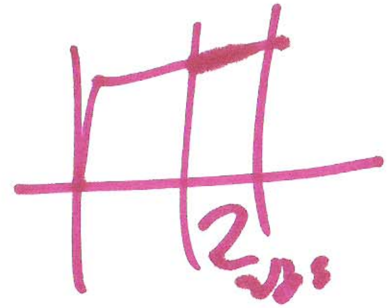
70mV



V_{GS}
V_{SG} $\approx 350mV$

$V_{DS,sat} = 70mV = V_{ovn}$





$$\frac{v_{out}}{v_{in}} = \frac{-i_d \cdot r_o}{v_{gs}} = \frac{-g_m \cancel{v_{gs}} r_o}{\cancel{v_{gs}}}$$

$$\frac{v_{out}}{v_{in}} = -g_m r_o$$

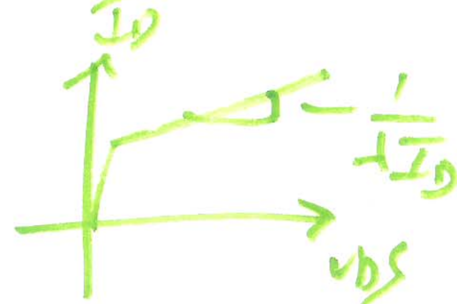
BIASING NOT shown

$I_D \uparrow$ $g_m r_o \downarrow$

$$g_m r_o = \frac{\sqrt{2\beta \cdot \cancel{I_D}}}{\lambda \sqrt{I_D}}$$

$$g_m = KP\cdot\frac{W}{L}\left(V_{GS}-V_{THN}\right)$$

$$= \sqrt{2KP\cdot\frac{W}{L}I_D}$$



$V_{DS}\nearrow \qquad I_D\nearrow$

$$I_D(V_{DS},V_{GS}) = \underbrace{\frac{KP}{2}\cdot\frac{W}{L}\left(V_{GS}-V_{THN}\right)^2}_{I_{D,SAT}}\left(1+\lambda\left(V_{DS}-V_{DS,SAT}\right)\right)$$

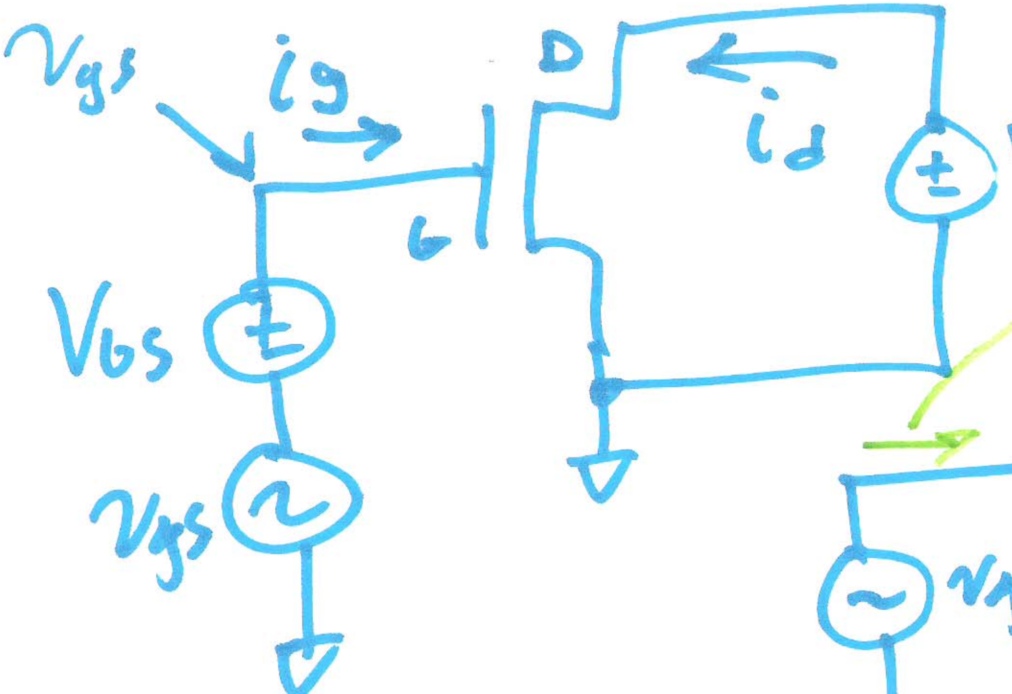
Show how to derive f_T

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

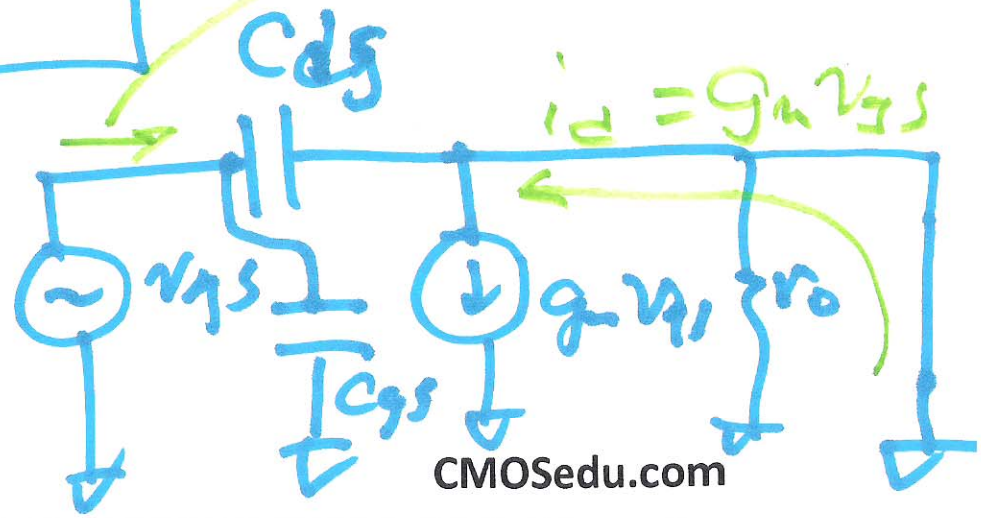
plot $\left|\frac{i_d}{i_g}\right|$ v. f

Show schematic

AC V = 0



$$i_g = \frac{v_{gs}}{1/j\omega(C_{gd}+C_{gs})}$$



$$\frac{i_d}{i_g} = \frac{g_m \cancel{v_{gs}}}{j \cdot 2\pi f \cdot (C_{gd} + C_{gs}) \cdot \cancel{v_{gs}}}$$

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

$$\left|\frac{i_d}{i_g}\right| \approx \frac{g_m}{2\pi f C_{gs}} \rightarrow C'_{ox} \cdot W \cdot L \cdot \frac{2}{3}$$

$$C'_{ox} = \frac{\varepsilon_{ox}}{t_{ox}}$$

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

$$f_T = \frac{u_n \cancel{C_{ox}} \cdot \frac{\cancel{W}}{L} \cdot (V_{GS} - V_{THN})}{2\pi \cancel{C_{ox}} \cdot \cancel{W} \cdot L \cdot \frac{2}{3}}$$

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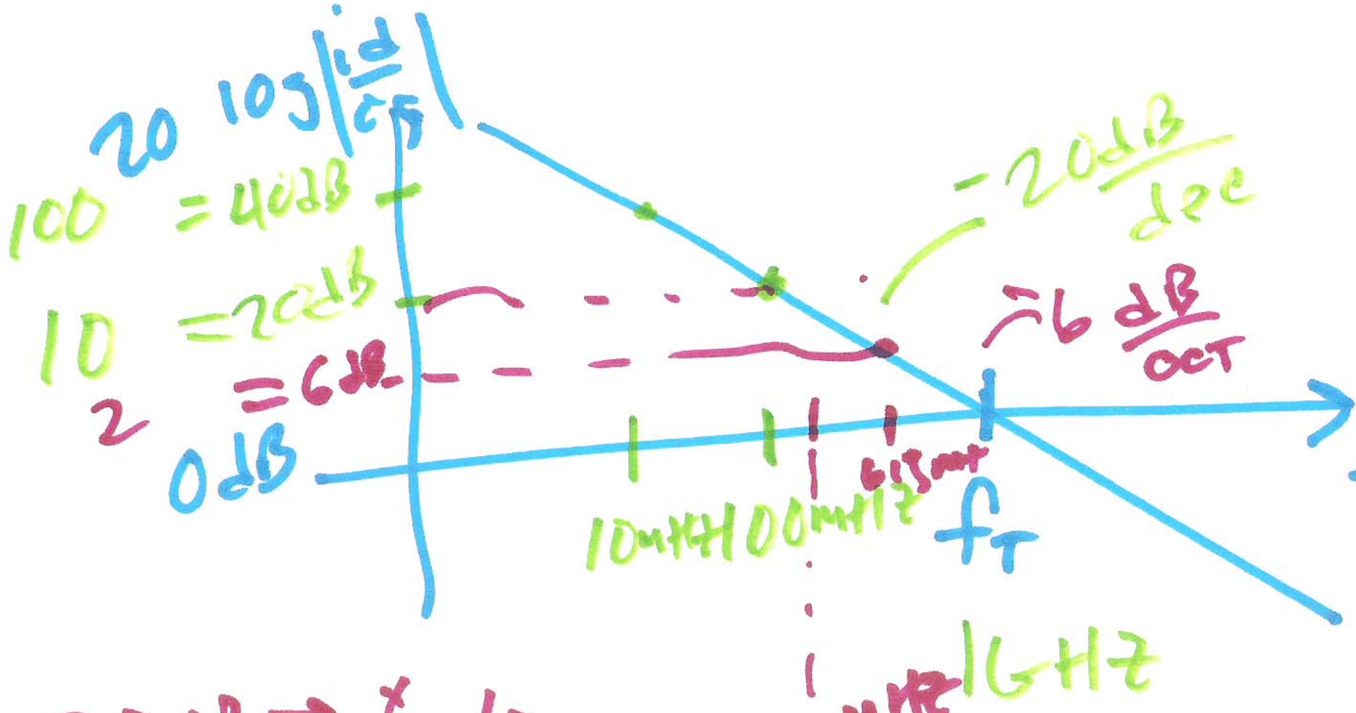

÷2
×2
freq

÷10
×10
freq

1.23GHz

±20dB → ×÷ 10

±14dB ÷× 5

±6dB ×÷ 2

±3dB ÷× $\sqrt{2}$

÷2

×2

34dB

×10 (20dB)

×5 (14dB

×50