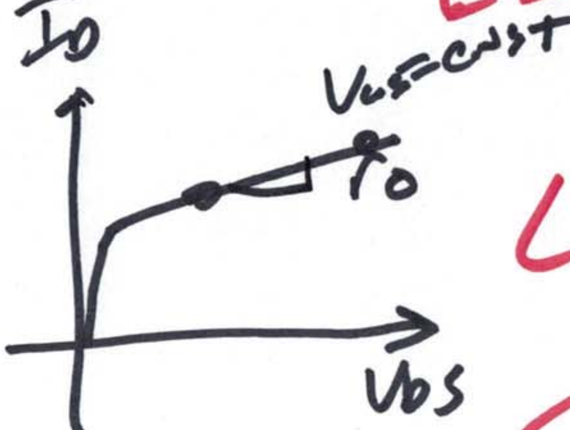
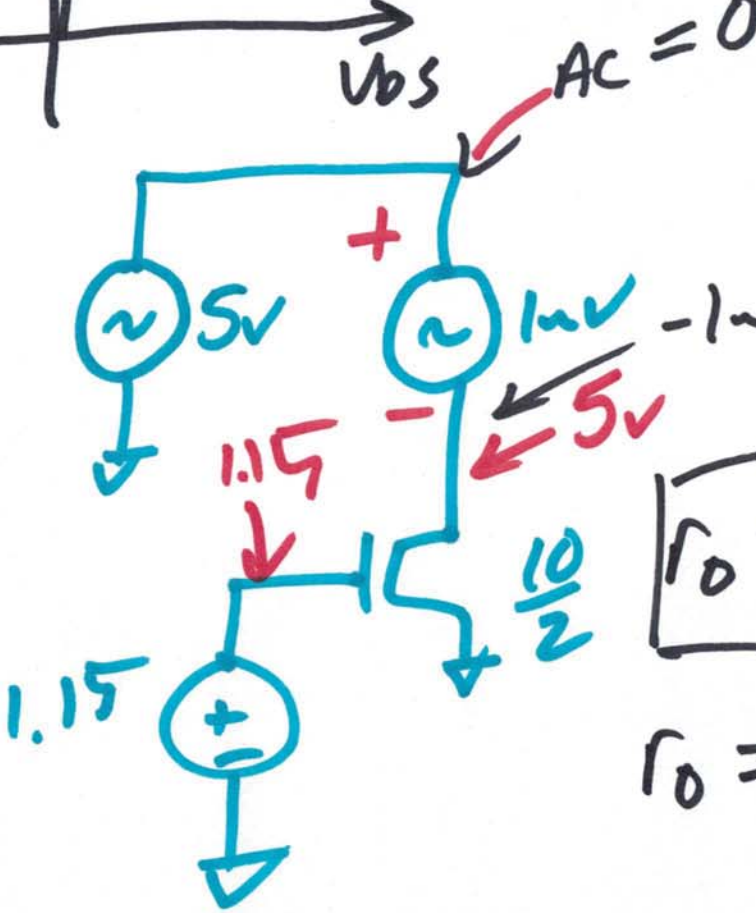
EE420/ECG 620 Analog IC Design

Lecture 4, Feb. 3, 2020





$$I_D = \frac{120\mu}{2}\cdot\frac{10}{2}(1.15-.8)^2$$

$$= 300\mu \cdot 0.1225$$

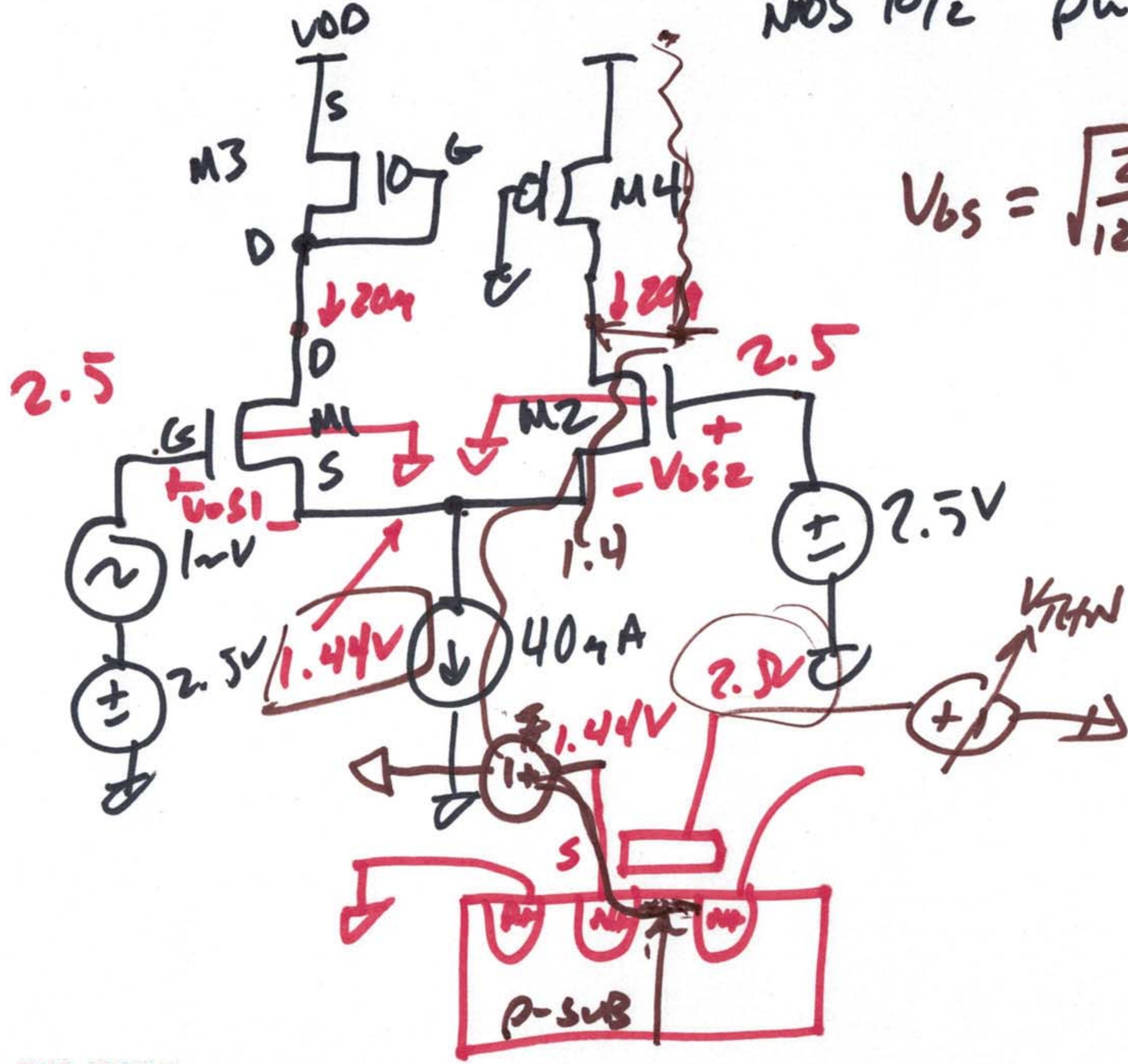
$$I_D = 36.75\mu A$$

$$r_o = 1750k \text{ (sim AC)}$$

$$r_o = \frac{1}{0.01\cdot 36\mu A} = \frac{1}{\lambda I_D} = 2.7M\Omega$$

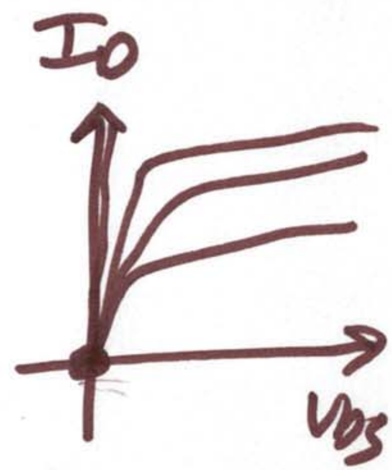
$$r_o = 3.6MEG \text{ (transient)}$$

NMOS 10/2 PMOS 30/2

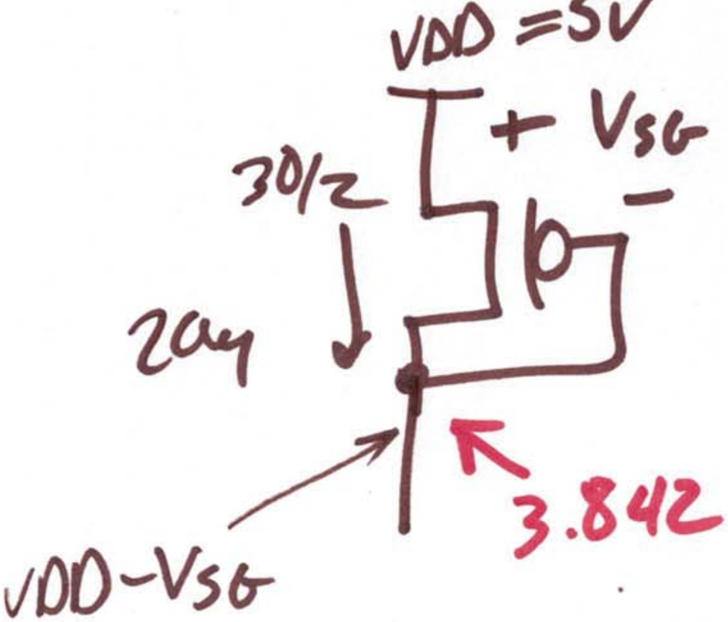


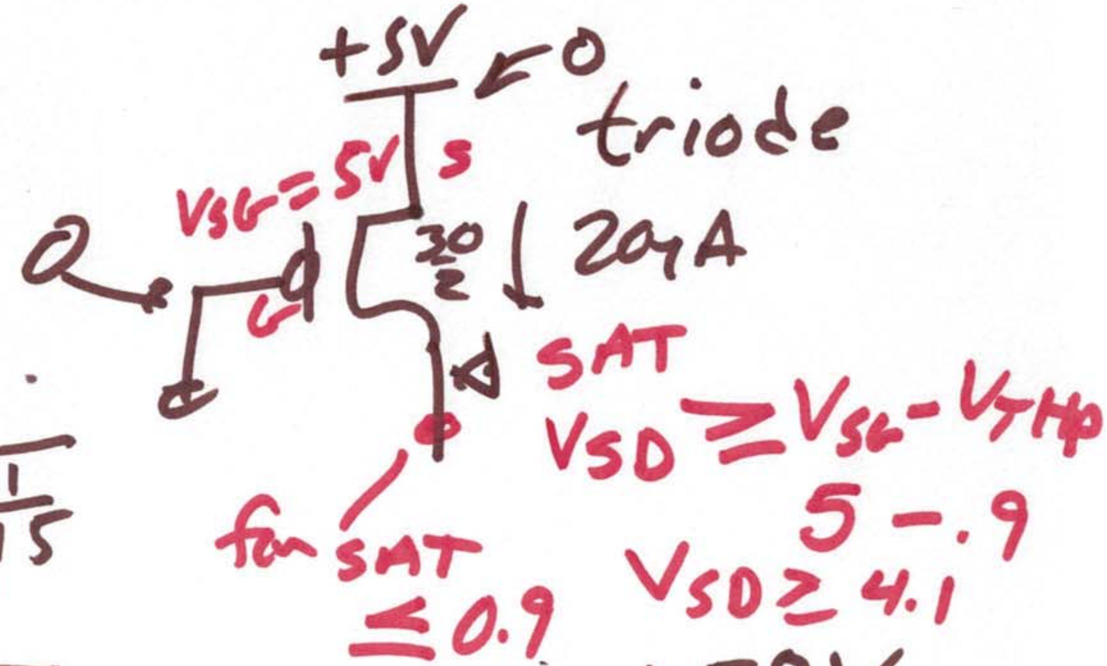
$$V_{GS} = \sqrt{\frac{2\cdot 20\mu}{120\mu\cdot\frac{10}{2}}} + 0.8$$

$$V_{GS} = 1.058V$$



2)





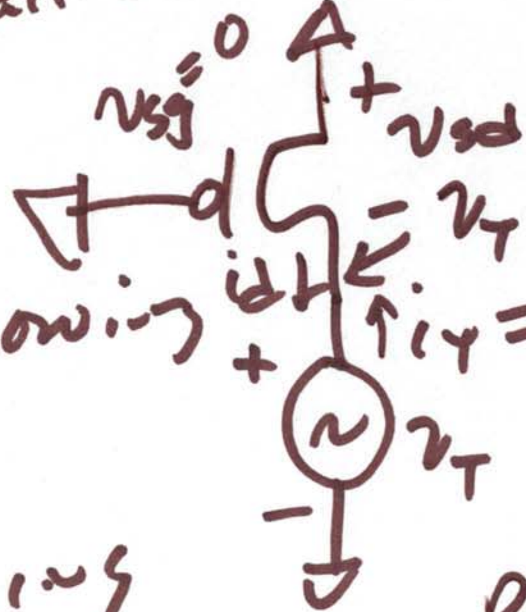
$$V_{SG} = \sqrt{\frac{2 \cdot 20\mu}{40\mu \cdot \frac{30}{2}}} + .9 = 1.158V$$

$\sqrt{\frac{1}{15}}$

AC Small-Signal

R_{CH}

Not showing DC biasing

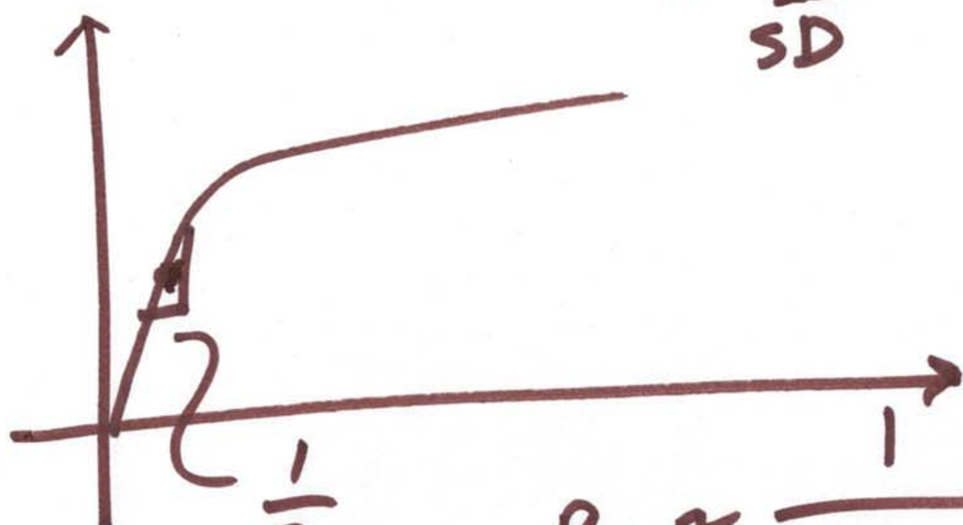


triode

$$I_D = KP \cdot \frac{W}{L} \cdot \left((V_{GS} - V_{THN}) \cdot V_{DS} - \frac{V_{DS}^2}{2} \right)$$

$$R_{CH}^{-1} = \frac{\delta i_D}{\delta v_{SD}} = KP \cdot \frac{W}{L} \left((V_{GS} - V_{THN}) - v_{DS} \right) \cdot \frac{\delta v_{DS}}{\delta v_{SD}}$$

$V_{DS} \ll v_{ds}$



$\frac{1}{R_{CH}}$

$$R_{CH} \approx \frac{1}{KP \cdot \frac{W}{L} (V_{GS} - V_{THN}) + V_{DS}}$$

$$R_{CH}^{-1} = \frac{\delta i_D}{\delta v_{DS}} = \frac{-\delta i_Y}{-\delta v_Y} =$$

$$R_{CH}^{-1} = \frac{\delta i_d}{\delta v_{DS}} = \frac{\delta}{\delta v_{DS}}\left(KP \cdot \frac{W}{L}\left(\left(V_{GS} + v_{gs} - V_{THN}\right)^2 \cdot v_{DS} - \frac{v_{DS}^2}{2}\right)\right)$$

$v_{gs} \to 0$

$V_{DS} \ll v_{ds}$

$V_{DS} + v_{ds} \approx V_{DS}$

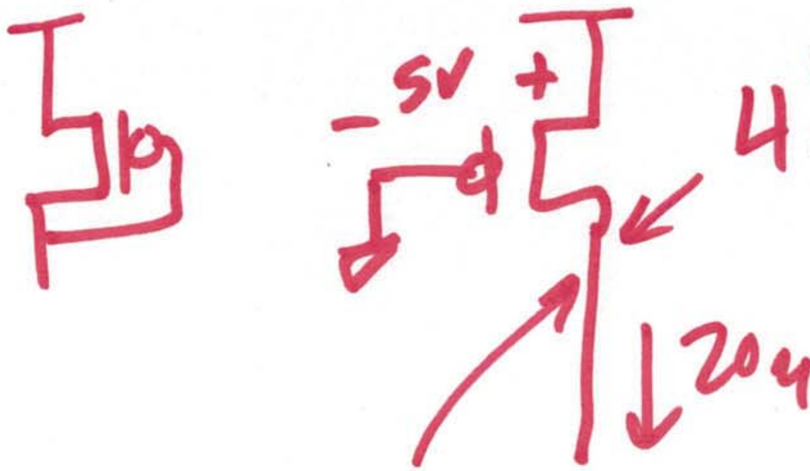
$= V_{DS,SAT}$

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

$V_{DS} \to 0$

V_{DS} is small

$$R_{CH} \approx \frac{1}{KP \cdot \frac{W}{L}\left(V_{GS} - V_{THN}\right)}$$



$$R_{CH} = \frac{1}{KP\cdot\frac{W}{L}(V_{SG}-V_{THP})}$$

V_{SD}

$$20u = 40u\cdot\frac{30}{2}\left((5-.9)V_{SD} - \frac{V_{SD}^2}{2}\right), \quad \frac{V_{SD}^2}{2} \approx 0$$

$$V_{SD} = \frac{1}{30\cdot 4.1} = 8.1mV$$