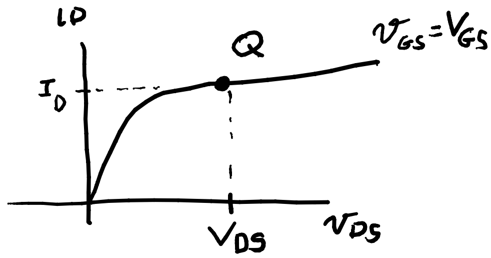
EE303
02/23/10

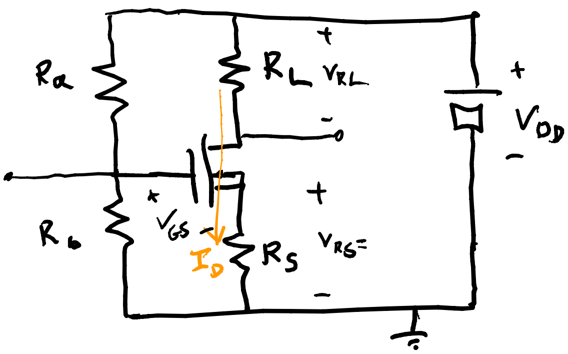
Homework due today now
due next period

Biasing: (@DC)

MOS ~ n-channel

small signal gain $\approx g_m R_L$





bias in saturation

$i_D = \frac{KP}{2}\frac{W}{L}(v_{GS} - V_{TO})^2 (1 + \lambda v_{DS})$

ignore @ start

assume $KP = 2 \times 10^{-5}\, A/V^2$, $W/L = 20$, $V_{TO} = 1.2V$, $\lambda = 10 \times 10^{-3} \frac{1}{V}$

$k = \frac{KP}{2}\frac{W}{L} = \frac{2}{2} \times 10^{-5} \times 20 = 2 \times 10^{-4}$

choose $V_{GS} = 3.2V$, $V_{GS} - V_{TO} = 2$, $(V_{GS} - V_{TO})^2 = 4$

$I_D = k(V_{GS} - V_{TO})^2 = 2 \times 10^{-4} \times 4 = 0.8 \times 10^{-3} = 0.8mA$

$R_S = 1k\Omega = 10^3 \Omega$, $V_{RS} = R_S \times I_D = 10^3 \times 0.8 \times 10^{-3} = 0.8V$

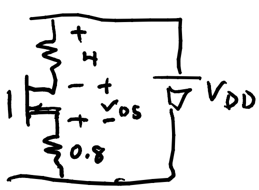
$V_{R_L} = R_L \cdot I_D$; fix R_L from the gain:

$$g_m = \frac{\partial i_D}{\partial v_{GS}}\bigg|_Q = \frac{2 I_D}{V_{GS} - V_{TO}} = \frac{2 \times 0.8 \times 10^{-3}}{2} = 0.8 m\mho$$

$A_v \approx g_m R_L$; choose $A_v = \frac{v_o}{v_i}$ for small signal $= 4$

$$\Rightarrow g_m R_L = 4;\ R_L = \frac{4}{0.8 \times 10^{-3}} = \frac{4}{0.8} \times 10^3 = 5k\Omega$$

$V_{R_L} = R_L I_D = 5 \times 10^3 \times 0.8 \times 10^{-3} = 4V$



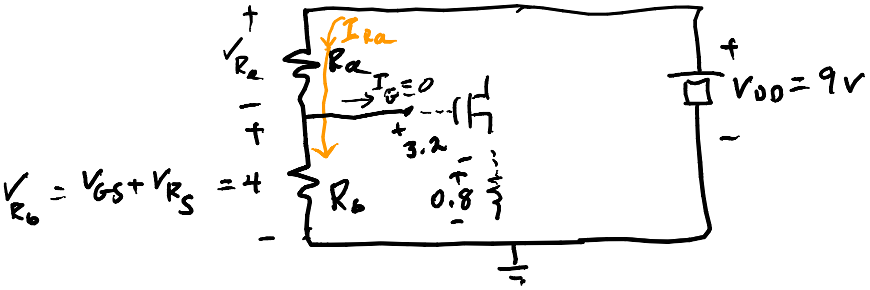
for M in saturation

need $V_{DS} > V_{GS} - V_{TO} = 2$

$V_{DS} = V_{DD} - 4 - 0.8 = V_{DD} - 4.8 > 2$

$V_{DD} > 6.8$

choose $V_{DD} = 9V$; need $V_{GS} = 3.2$ so now design R_a, R_b



$V_{R_b} = R_b \cdot I_{R_a} = 4$
$V_{R_A} = R_a \cdot I_{R_a} = V_{DD} - V_{R_a} = 9 - 4 = 5$ $\Bigg\}$ $\frac{4}{5} = \frac{R_b I_{Ra}}{R_a I_{Ra}} = \frac{R_b}{R_a}$

$\therefore \quad R_b = \frac{4}{5} R_a$ choose R_a, say $R_a = 1 \text{ Meg}\,\Omega = 10^6$

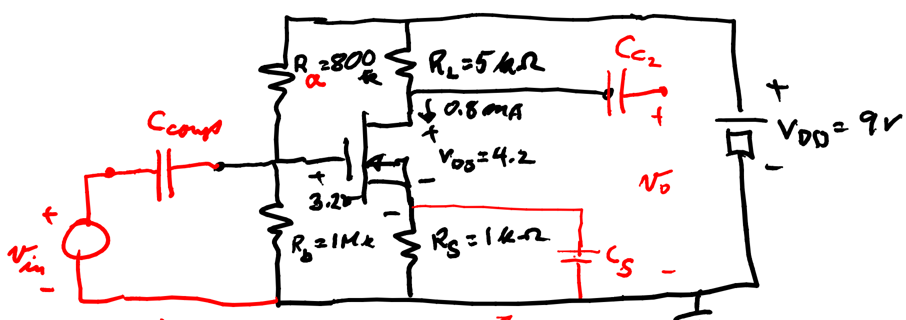
$R_b = \frac{4}{5} \text{Meg}\,\Omega = 800\ k\Omega$

Effect of the Early voltage $\frac{1}{\lambda}$

$\lambda V_{DS} = 10 \times 10^{-3} \times 4.2$, $V_{DS} = V_{DD} - 4.8 = 9 - 4.8$
$= 4.2 \times 10^{-2}$ $= 4.2\,V$
$= 0.042$

gives an increase of I_D by 0.042

Best to go into Spice & do parametric runs to adjust to desired.



does not destroy the bias

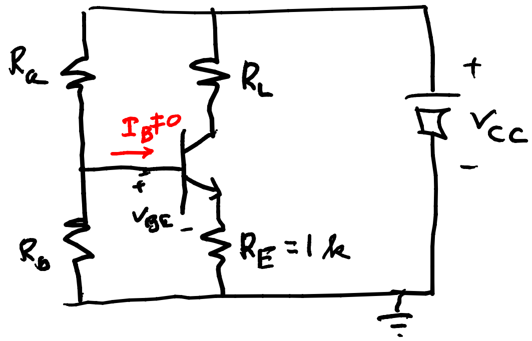
R_S stabilizes w r t changes in I_D

i_c, C, v_c $\quad i_c = C \frac{dv_c}{dt}$ for bias $\frac{dv_c}{dt} = 0$ as @ DC

for bias $i_c = 0 \Rightarrow$ an open circuit for bias

for sine waves $I_c = j\omega C V_c$ acts as a short for high enough frequencies

Biasing for BJT: npn



bias in forward active region $\Rightarrow V_{BE} \simeq 0.7V$

$A_v \approx g_m R_L$; $g_m = \frac{I_C}{V_T}$ assume $I_C = 0.8 \times 10^{-3}$ A

$V_T = 0.026 = 26 \times 10^{-3}$

$= \frac{8 \times 10^{-4}}{2.6 \times 10^{-2}} = 3.07 \times 10^{-2} = 30.7 \times 10^{-3}$ ℧

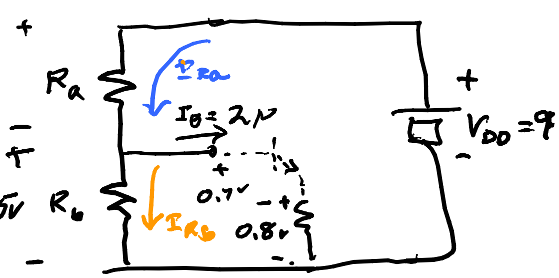
assume $A_v = 4 \Rightarrow R_L = \frac{4}{3.07 \times 10^{-2}} = 1.3 \times 10^{2} = 130\,\Omega$

need I_B, $I_C = \beta I_B$ assume $\beta = 400$ close 2 Q2N3904 (↑ Spice)

$I_B = \frac{0.8 \times 10^{-3}}{400} = \frac{8 \times 10^{-4}}{4 \times 10^{2}} = 2 \times 10^{-6} = 2\mu A$

to choose R_a & R_b choose $V_{DD} = 9V$

$V_{Ra} = V_{DD} - V_{Rb}$
$= 9 - 1.5$
$= 7.5$



$I_{Ra} = I_B + I_{Rb}$

$= 2 \times 10^{-6} + \frac{1.5}{R_b}$

$\Downarrow$

$= \frac{7.5}{R_a}$

Choose $R_b = 1$ Meg $\Rightarrow \frac{7.5}{R_a} = (2 + 1.5) \times 10^{-6} = 3.5 \times 10^{-6}$

$\Rightarrow R_a = \frac{7.5}{3.5} \times 10^{6} = 2.14$ MegΩ