Homework #7 is nominally due today (will accept on 2/25)

Topics Ahead –

Amplifiers – small-signal

Differential amplifiers

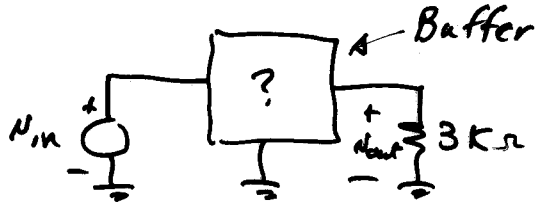
Frequency response ($C \neq \infty$)

Feedback

Design Example

Design a single-transistor amplifier to meet the following specs:

$R_{in} \geq 20 M\Omega$, $A_v \geq 0.85$ with an external load of 3k



1.) Obviously the correct configuration is CC or CD.

Which one?

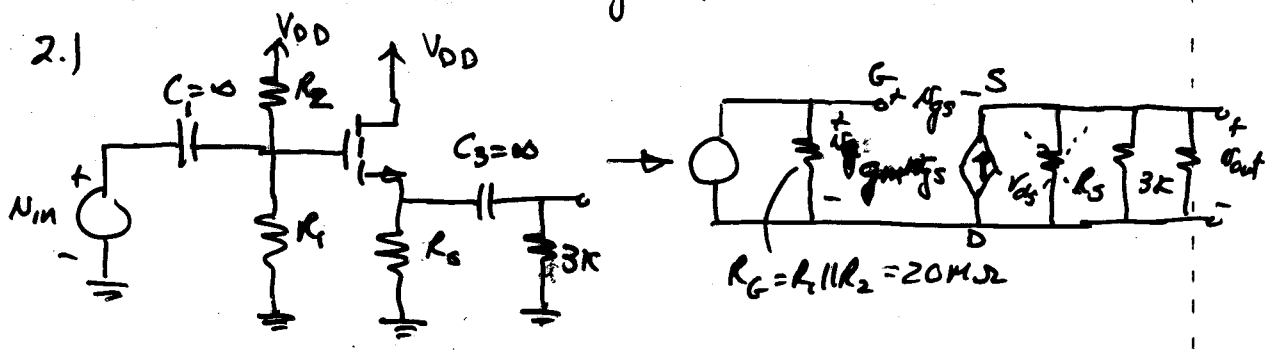
R_{in} is no problem for the MOSFET

$R_{in}(BJT) = (1+\beta)R_L = (1+\beta)3K = 20M\Omega$

$\beta \simeq \frac{20M}{3K} = 6667$ (Beta too large)

∴ Choose the CD configuration

2.)



Voltage gain –

$$\frac{v_{out}}{v_{in}} = \left(\frac{v_{out}}{v_{gs}}\right)\left(\frac{v_{gs}}{v_{in}}\right), \quad \frac{v_{out}}{v_{gs}} = g_m(R_s \| 3k)$$

$$v_{gs} = v_g - v_s = v_{in} - v_{out} = v_{in} - g_m(R_s \| 3k)\, v_{gs}$$

$$v_{gs}\left[1 + g_m(R_s \| 3k)\right] = v_{in}$$

$$\frac{v_{out}}{v_{in}} = \frac{g_m(R_s \| 3k)}{1 + g_m(R_s \| 3k)} \geq 0.85 \rightarrow g_m(R_s \| 3k) \geq 5.67$$

Choosing $R_s = 3k\Omega \rightarrow g_m \geq 3.78mS$

3.) Examine the MOSFET

Range of I_{DS} –

$$g_m = \sqrt{2K_n I_{DS}}$$

Data sheet gives, K_n is from 0.1 to 20 $\frac{mA}{V^2}$

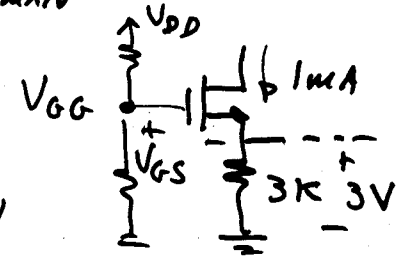
Choosing $K_n = 10mS$ & knowing that $V_{TN} = 1V$

then, $I_{DS} = \frac{K_n}{2}(V_{GS} - V_{TN})^2 \rightarrow V_{GS} = \sqrt{\frac{2I_{DS}}{K_n}} + V_{TN}$

Also if $K_n = 10mS$ and $g_m \geq 3.78mS$

$$\therefore I_{DS} = \frac{g_m^2}{2K_N} = 0.714mA \rightarrow 1mA$$

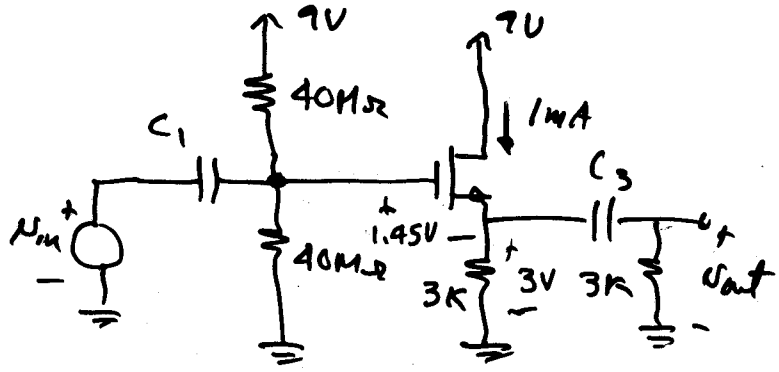
$$\therefore V_{GS} = \sqrt{\frac{2 \cdot 1mA}{10mA/V^2}} + 1 = 1.45V$$



$V_{GG} = 1.45 + 3 = 4.45V$

Choosing $R_1 \| R_2 = 20M\Omega \Rightarrow R_1 = R_2 = 40M\Omega$

$V_{DD} = 2 \times 4.45V = 8.9V \rightarrow 9V$



$$\frac{v_{out}}{v_{in}} = \frac{g_m(1.5k)}{1+g_m(1.5k)} = \frac{15}{1+15} = \frac{15}{16} \geq 0.85$$ ✓

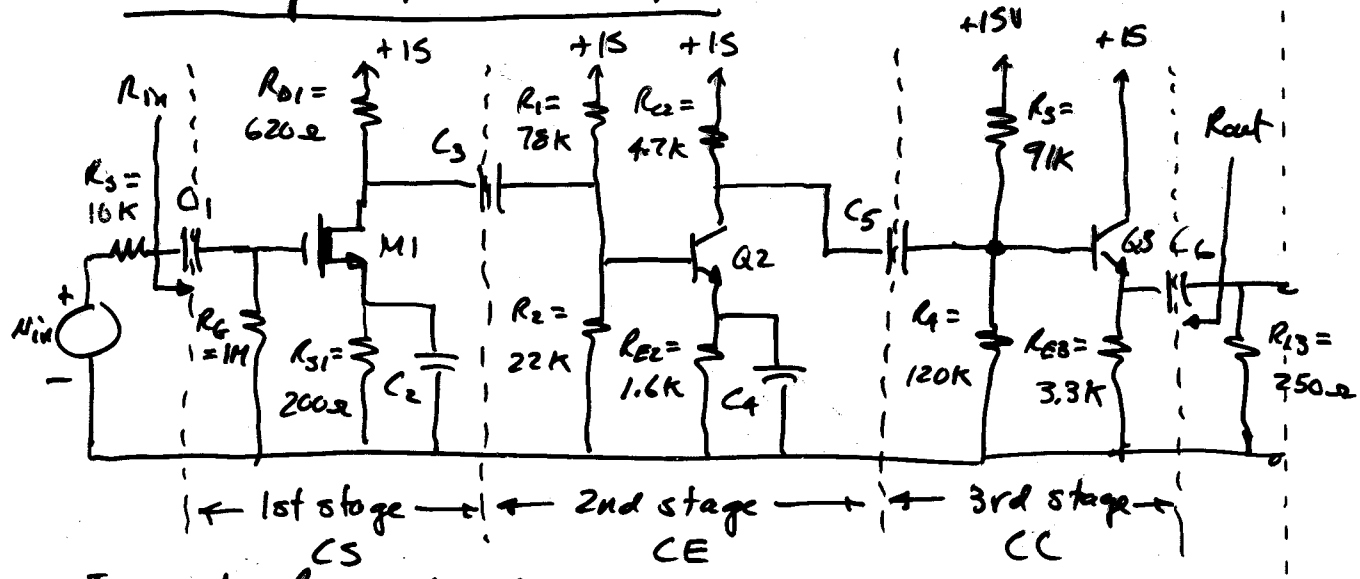
CHAPTER 15 – MULTISTAGE AMPLIFIERS

Multistage Example

Darlington

Diff. amps.

Multistage Amplifier Example



Transistor Parameters:

M1: $K_n = 10mA/V^2$, $V_{TN} = -2V$, $\lambda = 0.02V^{-1}$

Q2: $\beta_o = \beta_F = 150$, $V_A = 50V$, $V_{BE} = 0.6V$

Q3: $\beta_F = 50$, $V_A = 60V$, $V_{BE} = 0.6V$

Q-point & SS model parameters

M1: $I_{DS1} = 5mA$, $V_{DG1} = 10.9V$ → $g_{m1} = 10mS$ & $r_{o1} = 12.2 k\Omega$

Q2: $I_{C2} = 1.57mA$, $V_{CE2} = 5.09V$ → $g_{m2} = 62.8mS$, $r_{\pi 2} = 2.39 k\Omega$

$r_{o2} \cong 54.2 k$

Q3: $I_{C3} = 1.99mA$, $V_{CE3} = 8.36V$ → $g_{m3} = 79.6mS$

$r_{\pi 3} = 1k$

$r_{o3} = 34.1 k$