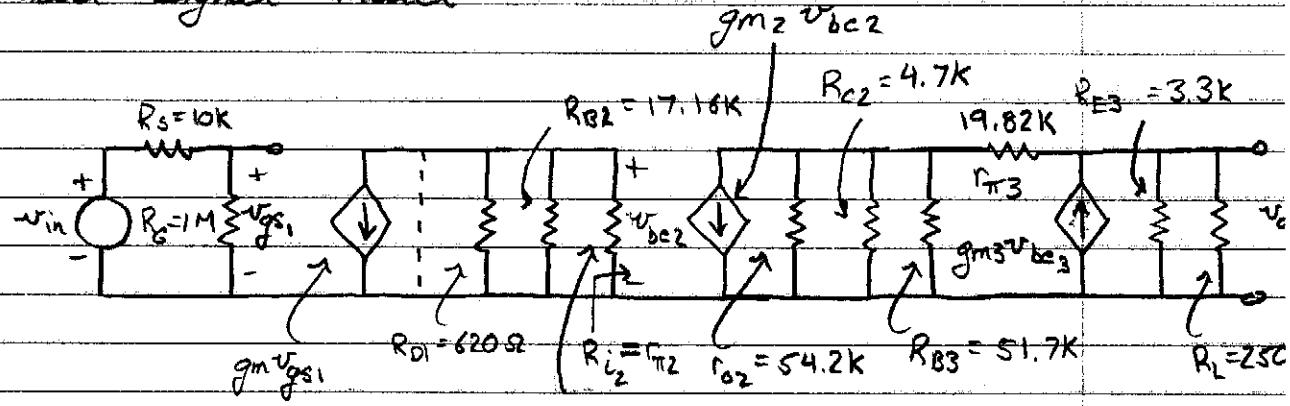
LECTURE - 22

ECE 3050

10/9/02

Voltage Amplifier - continued...

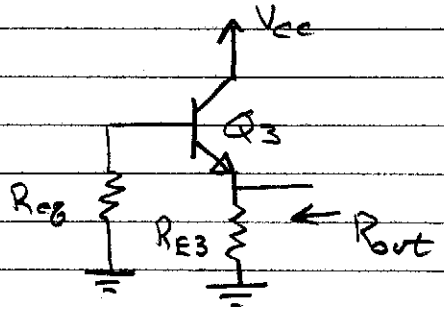
Small Signal Model -



$g_{m1} = 10mS$

$\beta_2 = 150$ $\quad g_{m2} = 62.8mS$

$\beta_3 = 80$ $\quad g_{m3} = 79.6mS$



$$R_{out} = 3.3K \,||\, \left[\frac{r_{\pi 3} + r_{o2} || R_{c2} || R_{B3}}{1+\beta_3} \right]$$

$$= 3.3K \,||\, \left[\frac{1K + (54.2K \,||\, 51.75K \,||\, 4.7K)}{81} \right]$$

$$= 3.3K \,||\, 61.6\,\Omega$$

$$= 60.4\,\Omega$$

$$\frac{v_{out}}{v_{in}} = \left(\frac{v_{out}}{v_{be3}}\right)\left(\frac{v_{be3}}{v_{be2}}\right)\left(\frac{v_{be2}}{v_{gs1}}\right)\left(\frac{v_{gs1}}{v_{in}}\right)$$

$$\frac{v_{out}}{v_{be3}} = +\left(g_{m3} + \frac{1}{r_{\pi 3}}\right)\left(R_{E3} \,||\, R_L\right) = \frac{1+\beta_3}{r_{\pi 3}}\left(R_{E3} \,||\, R_L\right)$$

$$= 81\left(\frac{232}{1000}\right)$$

$$= 18.82$$

$$\frac{v_{be3}}{v_{be2}} = -g_{m2}\left[\frac{r_{o2} \,||\, R_{c2} \,||\, R_{B2}}{R_{i3} + r_{o2} \,||\, R_{c2} \,||\, R_{B3}}\right] r_{\pi 3}$$

$$= \left(\frac{v_{be3}}{v_{b3}}\right)\left(\frac{v_{i3}}{v_{be2}}\right) = \left(\frac{r_{\pi 3}}{R_{i3}}\right)\left(-g_{m2} R_{eq}\right)$$

$$R_{eq} = r_{o2} \,||\, R_{c2} \,||\, R_{b3} \,||\, R_{i3}$$

$$\frac{v_{be3}}{v_{be2}} = \left(\frac{v_{be3}}{v_{b3}}\right)\left(\frac{v_{b3}}{v_{be2}}\right) = \left(\frac{1}{19.82}\right)\left(-62.8 \times 3.322\right)$$

$$= -\frac{208.6}{19.2} \; V/V$$

$$\frac{v_{be2}}{v_{gs1}} = -g_{m1}\left(R_{D1} \,||\, R_{B2} \,||\, r_{\pi 2}\right)$$

$$= (-10)(0.478)$$

$$= -4.786 \; V/V$$

$$\frac{v_{gs1}}{v_{in}} = \frac{R_G}{R_S + R_G} = \frac{1}{1.01}$$

All together:

$$\frac{v_{out}}{v_{in}} = \left[(18.82)\left(\frac{1}{19.82}\right)\right](-208.6)(-4.786)\left(\frac{1}{1.01}\right) = 938.6 \; V/V$$

$$\frac{i_{out}}{i_{in}} = \frac{v_{out}/R_L}{\frac{v_{in}}{R_s + R_G}} = \frac{v_{out}}{v_{in}} \times \frac{R_s + R_G}{R_L} = 3.79 \times 10^6 \ A/A$$

Max input for small-signal operation:

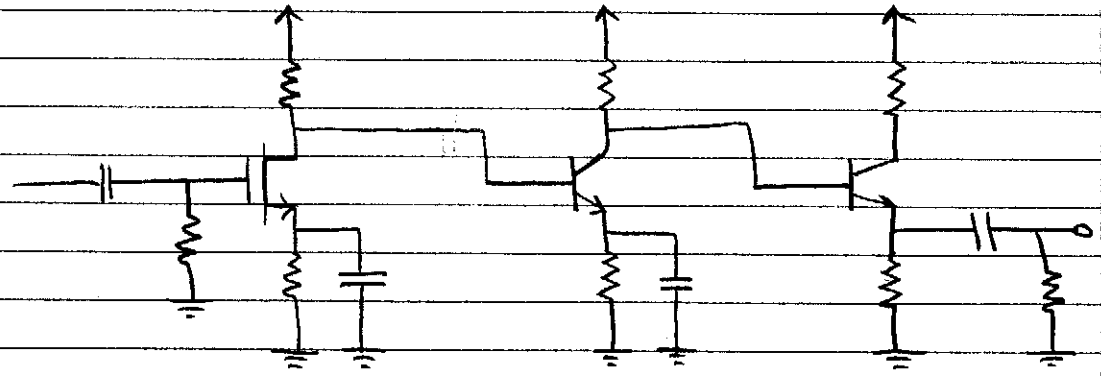
$$v_{be} < 5mV$$

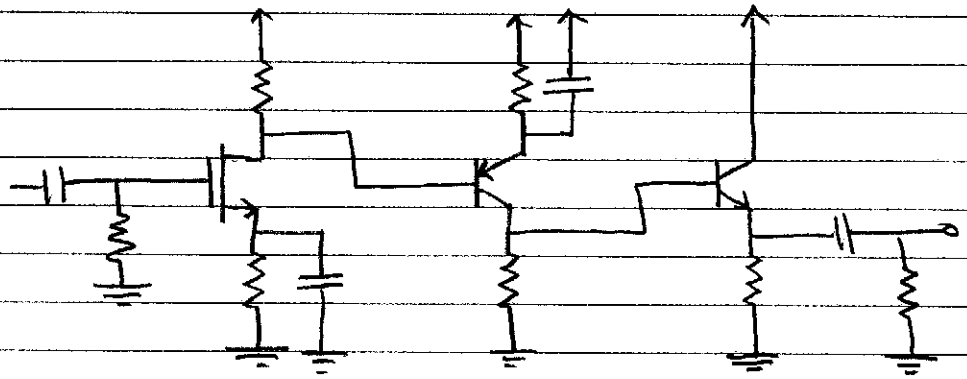
$$v_{gs} \leq \frac{V_{gs} - V_{TN}}{5}$$

Therefore, max input for S.S. operation is

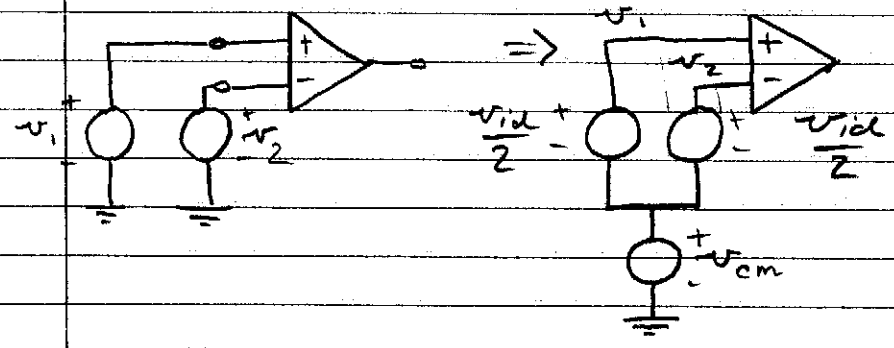
100 μV or 0.1 mV

DC Coupled Amplifier





Differential Amplifier



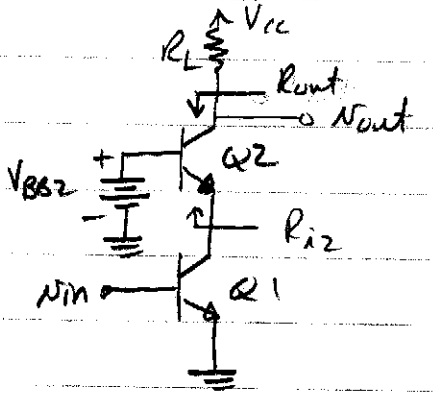
$$v_{id} = v_1 - v_2$$

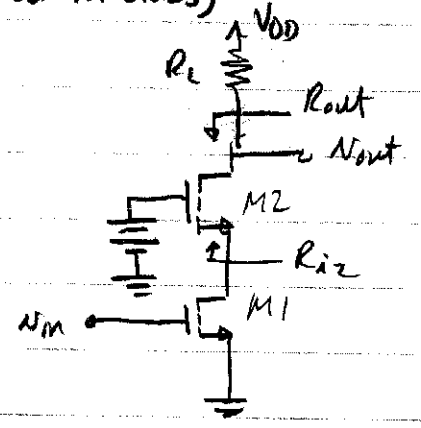
$$v_{cm} = \frac{v_1 + v_2}{2}$$

$$v_1 = \frac{v_{id}}{2} + v_{cm}$$

$$v_2 = -\frac{v_{id}}{2} + v_{cm}$$

Cascode Amplifier (Not covered in class)





$$\frac{V_{out}}{V_{in}} \approx -g_{m1} R_L$$

$$R_{in} = r_{\pi 1}$$

$$R_{out} \cong \beta_{02} r_{02}$$

$$R_{i2} \approx \frac{1}{g_{m2}} \text{ (depends on } R_L\text{)}$$

$$\frac{V_{out}}{V_{in}} \approx -g_{m1} R_L$$

$$R_{in} = \infty$$

$$R_{out} \approx g_{m2} r_{02} r_{01}$$

$$R_{i2} \approx \frac{1}{g_{m2}} \text{ (depends on } R_L\text{)}$$