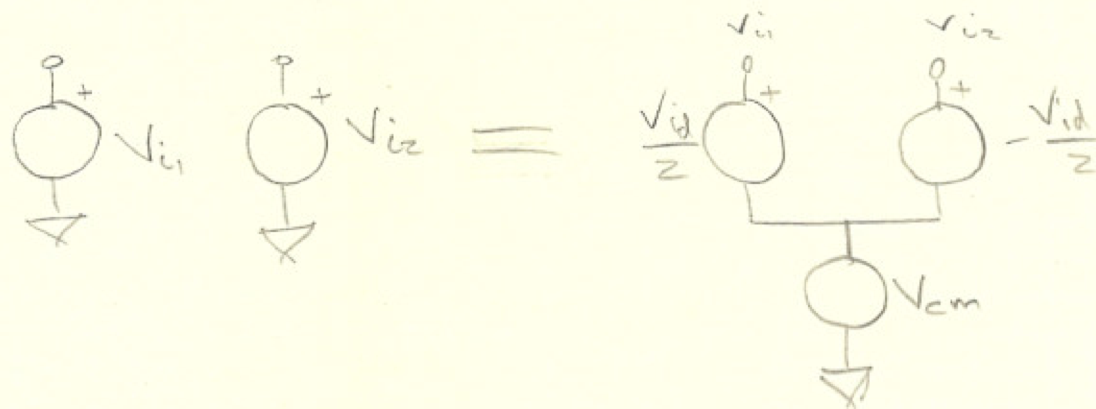
Assignment # 3: 8.91, 8.101, 8.104, 8.126

Differential and Common Modes

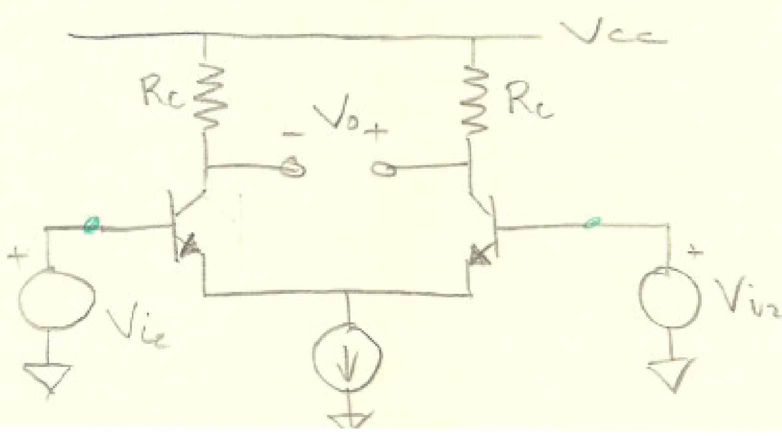


$$V_{i1} = \frac{V_{id}}{2} + V_{cm}$$
$$V_{i2} = -\frac{V_{id}}{2} + V_{cm}$$

$$V_{id} = V_{i1} - V_{i2}$$
$$V_{cm} = \frac{V_{i1} + V_{i2}}{2}$$

V_{id} = Differential-Mode Voltage
V_{cm} = Common-Mode Voltage.

Bipolar T. implementation of a differential Amp



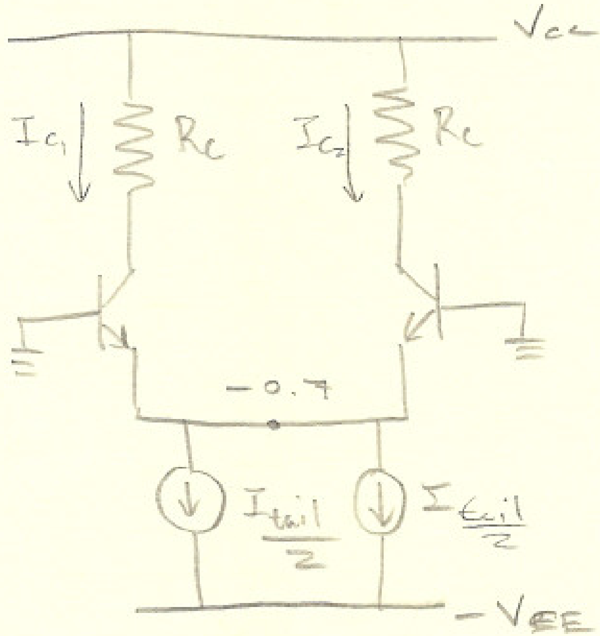
.. : input.

$Q_1 = Q_2$

* Bias Calculation

Assume:

$V_{cm} = 0$
$V_{id} = 0$



$I_{C1} = I_{C2}$

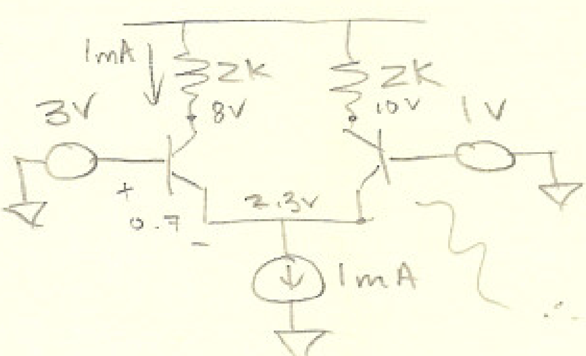
$V_{C1} = V_{CC} - \alpha \frac{I_{tail}}{2} R_{C1}$

$= V_{CC} - I_C R_{C1}$

$V_{CE1} = V_{C1} - V_{E1} = V_{C1} + 0.7V$

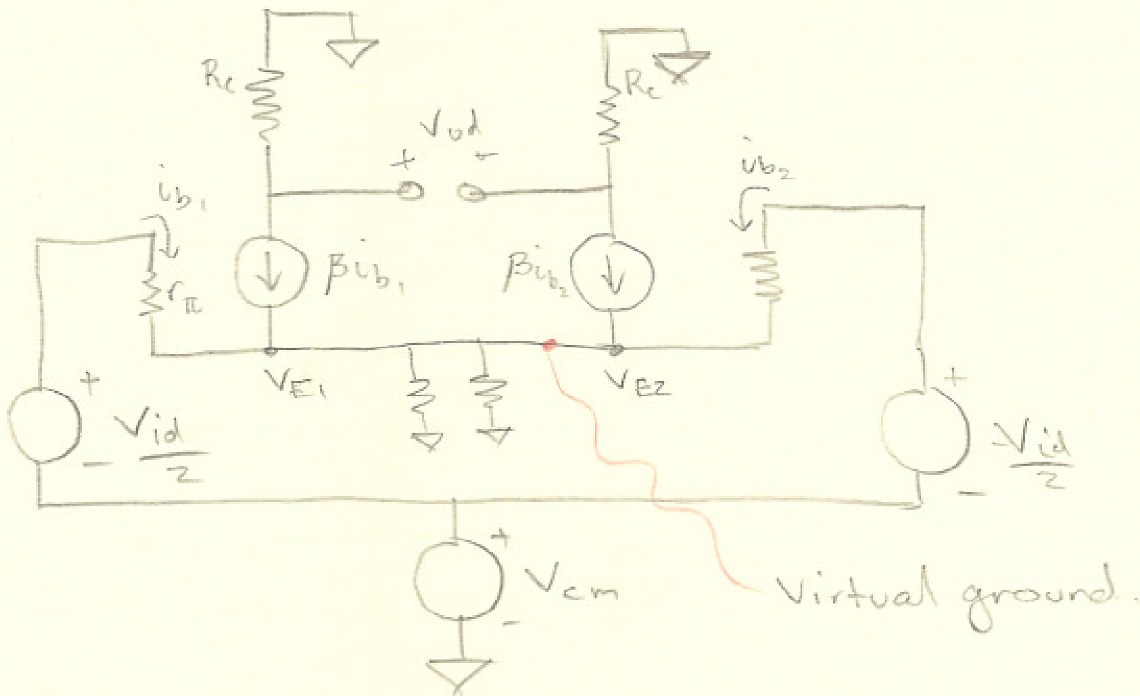
$V_{CE1} \geq V_{CESAT}$ for FA region

EX



∴ this transistor is in cut off

* Small signal analysis.

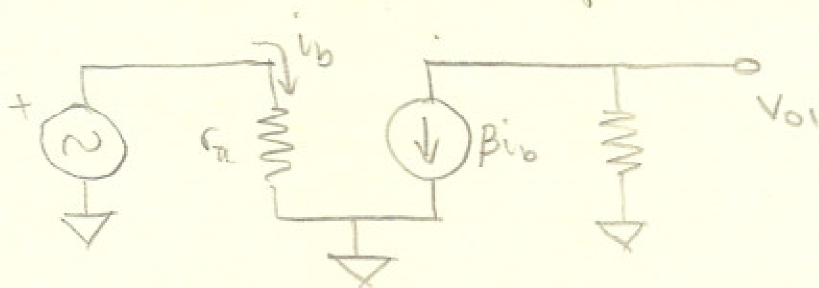


This is a linear circuit, hence superposition applies; We can analysis differential and common mode seperately.

Assuming $V_{cm}=0$; $V_{id}>0$

$$\left.\begin{aligned} V_{E1} &= -V_{E2} \\ V_{o1} &= -V_{o2} \\ i_{b1} &= -i_{b2} \end{aligned}\right\} \text{b/c of sym}$$

∴ we can solve half the circuit.



$$V_{od} = V_{o1} - V_{o2} = 2V_{o1}$$

a_{dm} : differential mode gain

$$a_{dm} = \frac{V_{od}}{V_{id}}$$

$$a_{dm} = \frac{2V_{o1}}{V_{id}}$$

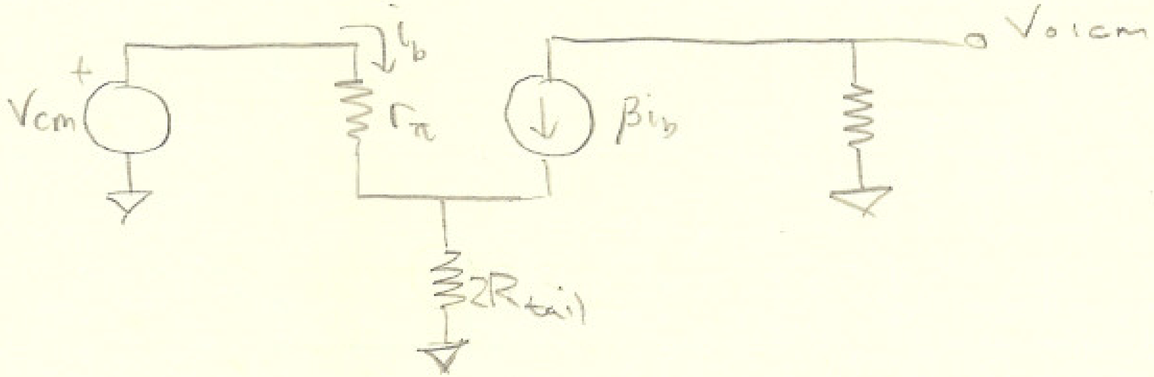
$$\frac{V_{o1}}{V_{id}} = \frac{-g_m R_c}{2}$$

$$\therefore \quad a_{dm} = -g_m R_c$$

Now Assuming $V_{cm} > 0$; $V_{id} = 0$

$$\left.\begin{aligned} V_{o1} &= V_{o2} \\ i_{b1} &= i_{b2} \\ V_{e1} &= V_{e2} \end{aligned}\right\} \text{ b/c of sym.}$$

Analyse One half circuit.



a_{cm} : common mode gain

$$a_{cm} = \frac{V_{ocm}}{V_{cm}} = \frac{-g_m r_\pi R_c}{r_\pi + (1+\beta)2R_{tail}} = \frac{-\beta R_c}{r_\pi + (1+\beta)2R_{tail}}$$