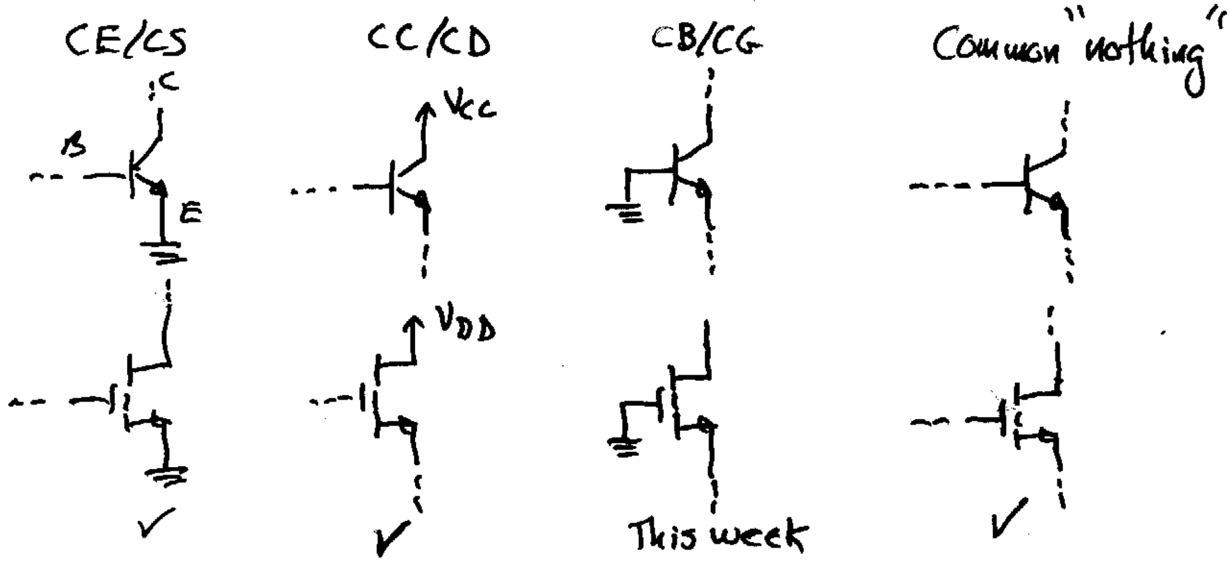
# Configurations of the transistor




## Small-signal analysis –

1.) Rin } Must be defined
2.) Rout }
3.) Voltage gain
4.) Current gain

$$r_o = \frac{\frac{1}{V_A} + V_{CE}}{I_C}$$

## Memorize –

1.) Formulas for $g_m$

$$g_m(FET) = \sqrt{2 K_n I_{DS}} \qquad K_n \to \frac{I_{DSS}}{V_P^2}$$

$$g_m(BJT) = \frac{I_C}{V_t}$$

2.) $r_o(FET) \simeq \frac{1}{\lambda I_{DS}}$

$r_o(BJT) \simeq \frac{V_A}{I_C}$

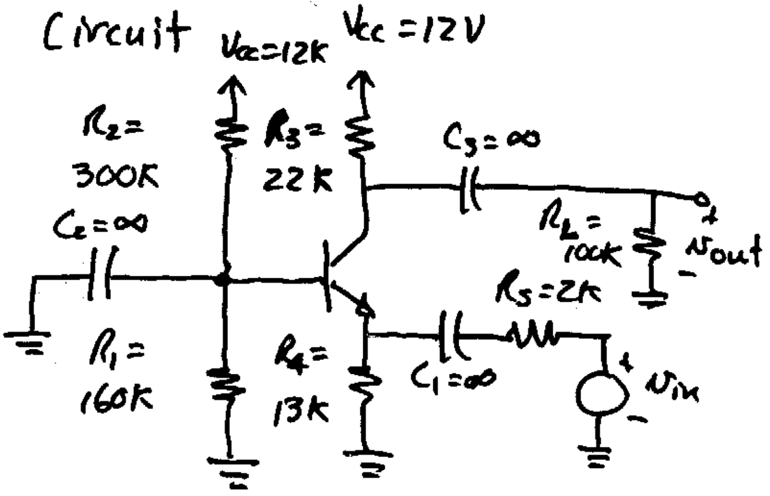
$$r_\pi = \frac{\beta_o}{g_m}$$

3.)

| Configuration | Rin | Rout | Voltage Gain |
| --- | --- | --- | --- |
| CE/CS | $> r_\pi$ | Large | Neg. & large |
| CC/CD | Very large | Small $\simeq \frac{1}{g_m}$ | $< +1$ |
| CB/CG | Medium-small | Large | Positive & large |
| Common Nothing | Large | Large | Neg. & moderate |

## CB Amplifier

1.) Circuit




$\beta_F = 100$

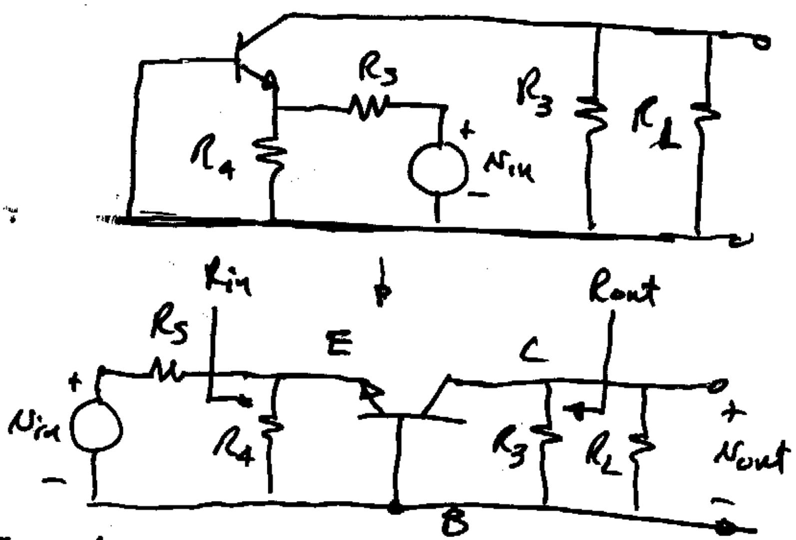
$V_A = 50$

DC Analysis:

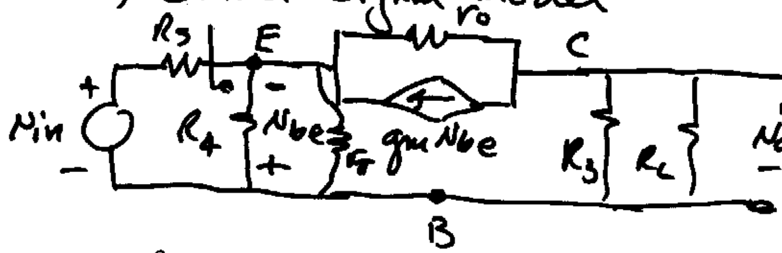
$I_C = 245\mu A$

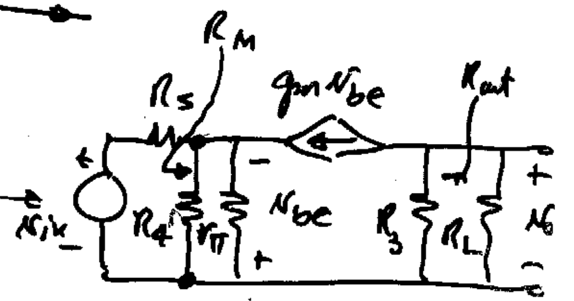
$V_{CE} \approx 3.4V$

2.) AC Circuit

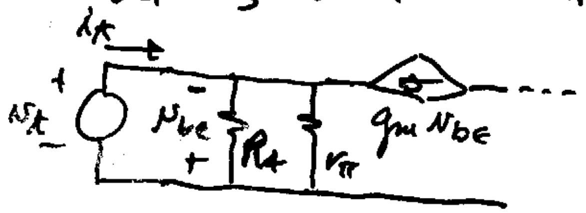



3.) Small-signal model




$R_{out} = R_3 = 22K$   $R_{in} = ?$

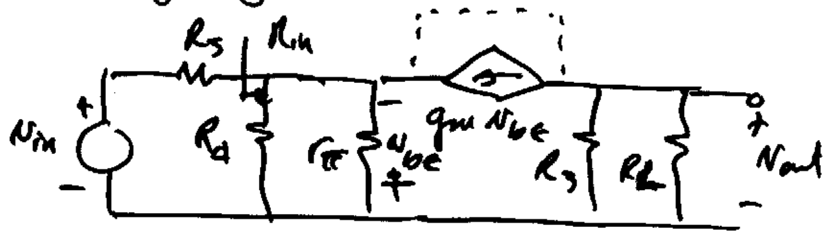



$i_x = \frac{N_x}{R_4} + \frac{N_x}{r_\pi} - g_m N_{be}$

$i_x = N_x \left[ \frac{1}{R_4} + \frac{1}{r_\pi} + g_m \right]$

$R_{in} = \frac{N_x}{i_x} = \frac{1}{\frac{1}{R_4} + \frac{1}{r_\pi} + g_m} = \frac{1}{g_m} \| r_\pi \| R_4 \approx$

Voltage gain




$$\frac{v_{out}}{v_{in}} = \left(\frac{v_{out}}{v_{be}}\right)\left(\frac{v_{be}}{v_{in}}\right) = \left(-g_m R_3 \| R_L\right)\left(\frac{-R_{in}}{R_{in}+R_S}\right)$$

$$= \frac{+g_m (R_3 \| R_L) R_{in}}{R_{in}+R_S}$$

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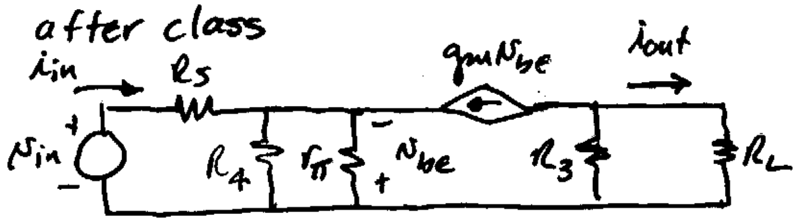
Done after lecture

Numerical evaluation of the above example

$g_m = 9.8\,mS$, $r_\pi = 10.2K$, and $r_o = 204K$

$R_{out} = 22K$ $\quad R_{in} \cong \frac{1}{g_m} = 102\,\Omega \quad A_v = +8.48\,V/V$

Question by Dee Dee – What is the current gain?
after class




$$\frac{i_{out}}{i_{in}} = \left(\frac{i_{out}}{v_{be}}\right)\left(\frac{v_{be}}{i_{in}}\right) = \left(-\frac{g_m R_3}{R_3+R_L}\right)\left(-R_{in}\right) = \frac{g_m R_3 R_{in}}{R_3+R_L}$$

$$\frac{i_{out}}{i_{in}} = \frac{(9.8)(22)\,0.102}{122} = 0.18\ A/A$$

(losing most of the current in $R_3$ as opposed to $i_{out}$ which is thru $R_L$.)