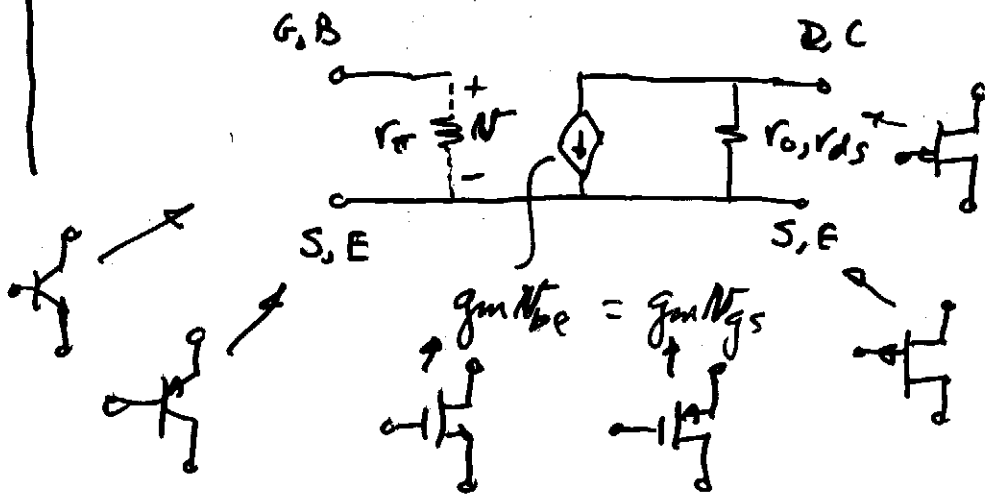
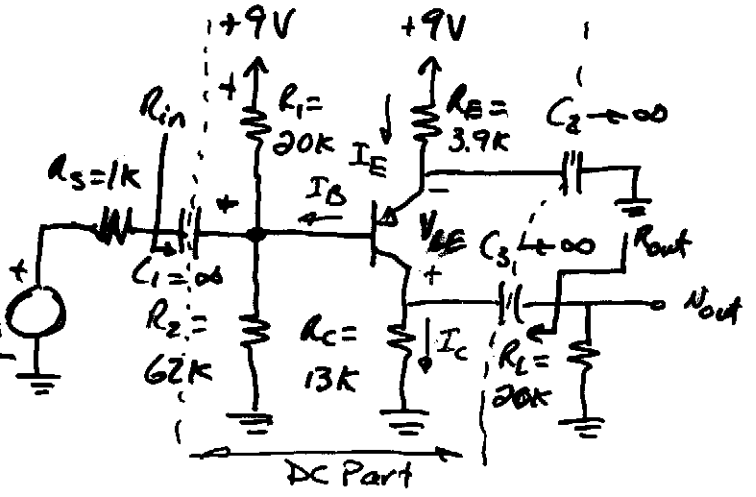
# BJT and FET Amplifiers

| | BJT | MOSFET | JFET |
|---|---|---|---|
| Large Signal Model | $i_C = I_S \exp\frac{v_{BE}}{V_t} \times \left(1 + \frac{v_{CE}}{V_A}\right)$ | $i_D = \frac{K'}{2}\frac{W}{L}(v_{GS} - V_T)^2 \times (1 + \lambda v_{DS})$ | $i_D = I_{DSS}\left(1 + \frac{v_{GS}}{V_p}\right)^2 \times (1 + \lambda v_{DS})$ |
| Small-signal model parameters | $g_m = \frac{I_C}{V_t}$<br>$r_o = \frac{V_A + v_{CE}}{I_C}$<br>$r_\pi = \frac{\beta}{g_m}$ | $g_m = \sqrt{2K'\frac{W}{L} I_D (1 + \lambda v_{DS})}$<br>$r_{ds} = \frac{v_{DS} + \frac{1}{\lambda}}{I_D}$ | $g_m = \frac{2}{\lvert V_p \rvert}\sqrt{I_{DSS} \cdot I_D (1 + \lambda v_{DS})}$<br>$r_{ds} = \frac{v_{DS} + 1/\lambda}{I_D}$ |
| Small-signal model |  | | |

## Example 3

If $\beta_F = 135$ and $V_A = 100V$, find $\frac{V_{out}}{V_{in}}$, $R_{in}$, & $R_{out}$.




a.) Find Q point

$V_{EB} \simeq 0.7\,V$

$V_{BB} = 9\frac{R_2}{R_1+R_2} = -9\frac{R_1}{R_1+R_2} = -\frac{9.20}{82} = -2.195\,V$, $R_{BB} = 20K \| 62K = 15.12K$

Treat as if NON-

$$V_{BB} = I_B R_{BB} + V_{BE} + (1+\beta_F) I_B R_E$$

$$2.195 = I_B\left[15.12K + \left(\frac{136}{1}\right) 3.9K\right] + 0.7$$

$$I_B = \frac{2.195 - 0.7}{15.12K + \frac{136}{1} \times 3.9K} = 2.75\mu A \Rightarrow I_C = 0.37mA$$

$I_E = 0.373mA$

$V_{EC} = 9 - I_C R_C - I_E R_E$

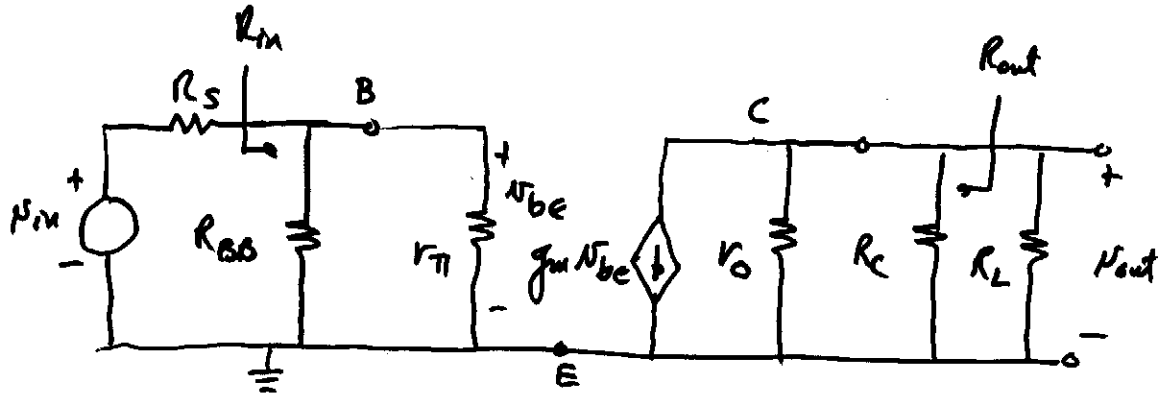
$V_{EC} = 9 - 4.81 - 1.454 = 2.736\,V$

b.) Calculate s.s. model parameters

$$g_m = \frac{I_C}{V_t} = \frac{0.37mA}{25mV} = \underline{14.8mS}, \quad r_\pi = \frac{135}{14.8mS} = \underline{9.12K}$$

$$r_o = \frac{100 + 2.736}{0.37mA} = \underline{278K}$$

c.)




$R_{in} = R_{BB} \| r_\pi = \underline{5.689\,k}$ $\qquad$ $R_{out}\Big|_{v_{in}=0} = r_o \| R_C = \underline{12.42\,k}$

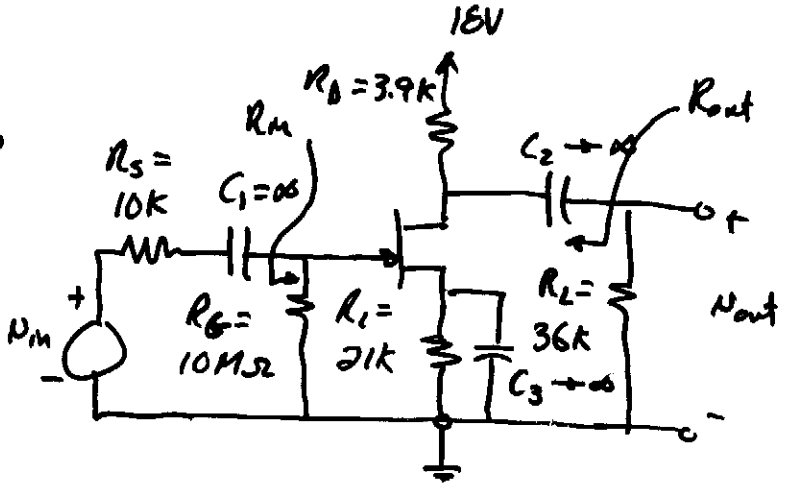
$$\frac{v_{out}}{v_{in}} = \left(\frac{v_{out}}{v_{be}}\right)\left(\frac{v_{be}}{v_{in}}\right)$$

$$= \left(-g_m \times r_o \| R_C \| R_L\right)\left(\frac{r_\pi \| R_{BB}}{R_S + r_\pi \| R_{BB}}\right) \quad (r_\pi \| R_{BB} = R_{in})$$

$$= \left(-0.0145 \times 7.662\,k\right)\left(\frac{5.689}{6.689}\right) = \underline{-96.44\ V/V}$$

Example 4

If $I_{DSS} = 5mA$, $V_p = -5V$, and $\lambda = \frac{1}{50}V$ find $R_{in}$, $R_{out}$, and $\frac{v_{out}}{v_{in}}$




$R_{in} = 10M\Omega$ $\qquad$ $R_{out} = 3.61k\Omega$ $\qquad$ $\frac{v_{out}}{v_{in}} = -3.605\ V/V$