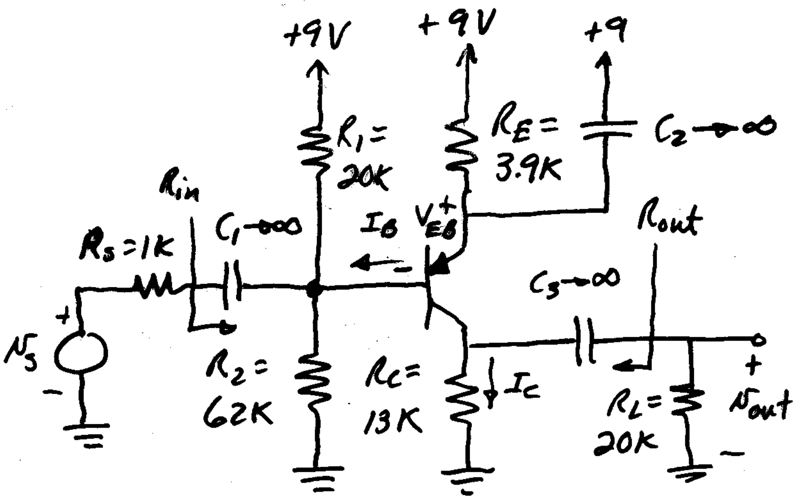
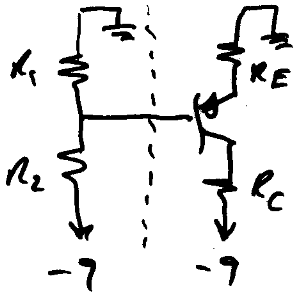
PNP Example

If $\beta_o = 135$ and $V_A = 100V$, find $\frac{v_{out}}{v_s}$, R_{in} and R_{out}.

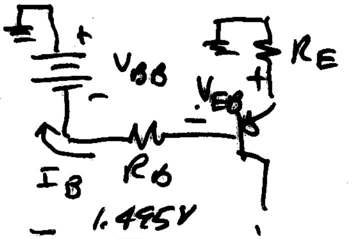


1.) Q point



$$V_{BB} = -9V\frac{R_1}{R_1+R_2} = \frac{-9(20K)}{82K} = -2.195V$$

$$R_B = R_1 \| R_2 = 15.12K$$



$$I_B = \frac{2.195 - \overset{V_{EB}}{\overset{\downarrow}{0.7}}}{R_B + (1+\beta_o)R_E} = \frac{1.495V}{15.12K + (136 \cdot 3.9k)} = 2.75\mu A$$

$$I_C = 135 \cdot I_B = \underline{0.37mA} \rightarrow I_E = 0.373mA$$

$$V_{EC} = 9 - I_C R_C - I_E R_E = 9 - 4.81 - 1.454 = \underline{2.736V}$$

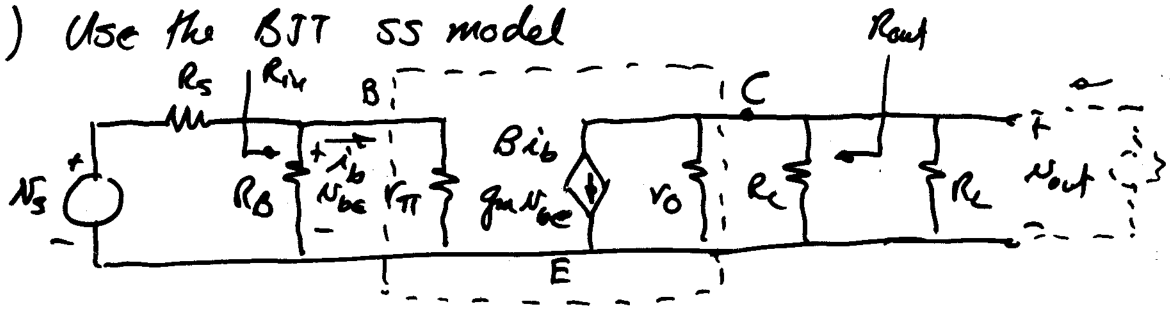
2.) Small-signal model parameters

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

$$r_o = \frac{V_A + V_{EE}}{I_C} = \frac{100 + 2.736}{0.37mA} = 278k\Omega$$

3.) Small-signal circuit –

4.) Use the BJT SS model



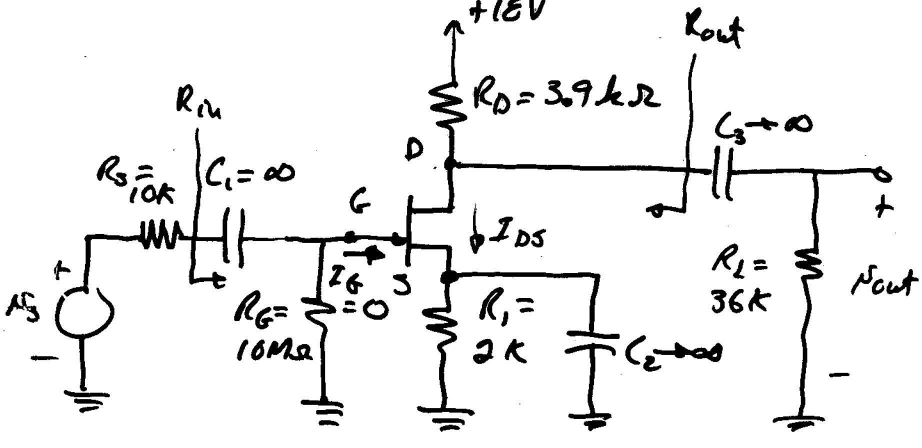
$R_{in} = R_B \| r_\pi = \underline{\underline{5.689k\Omega}}$ $R_{out} = r_o \| R_C = \underline{\underline{12.42k\Omega}}$

$R_{out} = \left.\frac{v_{test}}{i_{test}}\right|_{v_{in}=0}$

$$\frac{v_{out}}{v_s} = \left(\frac{v_{out}}{v_{be}}\right)\left(\frac{v_{be}}{v_s}\right) = \left[-g_m(r_o \| R_C \| R_L)\right]\left[\frac{R_B \| r_\pi}{R_s + R_B \| r_\pi}\right]$$

$$\left[-14.8 \times (278k \| 13k \| 20k)\right]\underbrace{\left[\frac{R_{in}}{R_s + R_{in}}\right]}_{\frac{5.689k}{6.689k}} = \underline{\underline{-96.44\ V/V}}$$

JFET Example

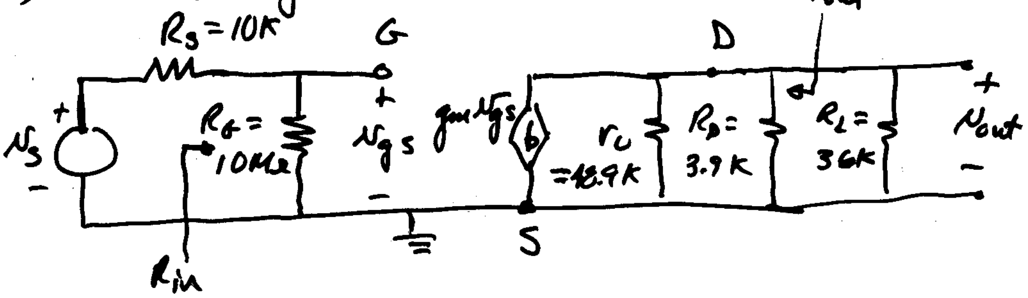


If $I_{DSS} = 5mA$, $V_p = -5V$ and $\frac{1}{\lambda} = 50V$ and $I_D = 1.25mA$ and $V_{DS} = 10.6V$ and if the JFET is in saturation region, then find R_{in}, R_{out} & $\frac{v_{out}}{v_{in}}$

1.) $$g_m = \frac{2}{|V_p|}\sqrt{I_{DSS} I_{DS}(1 + \lambda V_{DS})}$$
$$= \frac{2}{5}\sqrt{(5mA)(1.25mA)\left(1 + \frac{10.6}{50}\right)} = 1.1\,mS$$

$$r_o = \frac{\frac{1}{\lambda} + V_{DS}}{I_{DS}} = \frac{50 + 10.6}{1.25mA} = 48.48k\Omega$$

2.) Small-signal circuit.



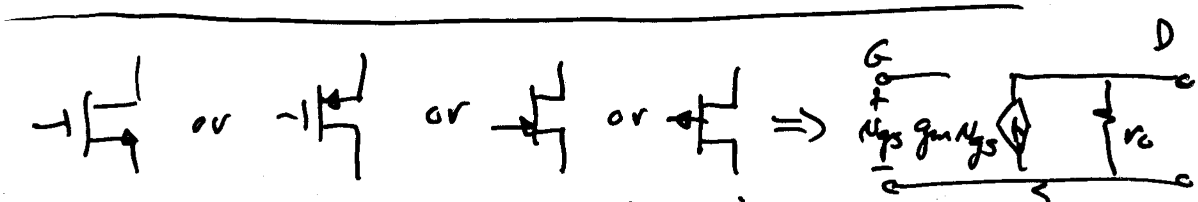
$R_{in} = \underline{\underline{10M\Omega}}$, $R_{out} = r_o \| R_D = \underline{\underline{3.61K\Omega}}$

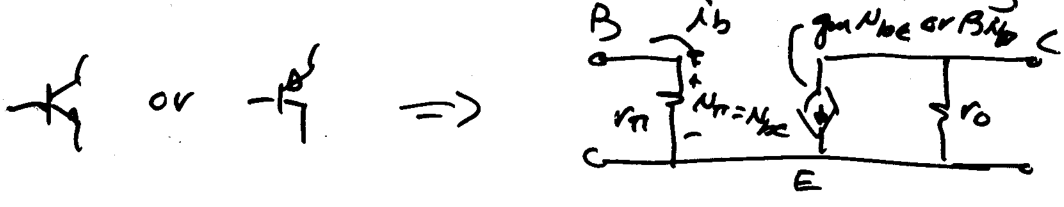
$$\frac{v_{out}}{v_s} = \left(\frac{v_{out}}{v_{gs}}\right)\left(\frac{v_{gs}}{v_s}\right) = \left(-g_m \times r_o \| R_D \| R_L\right)\left(\frac{R_G}{R_S + R_G}\right)$$

$$= -1.1(3.221)\left(\frac{10}{10.01}\right) = -\underline{\underline{3.605}}\ \frac{V}{V}$$

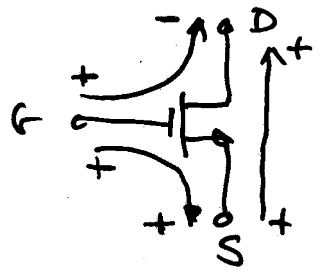
Study Table 13.5 in text.

	CE	CS
$\frac{v_{out}}{v_s}$	—	—
R_{in}	—	—
R_{out}	—	—

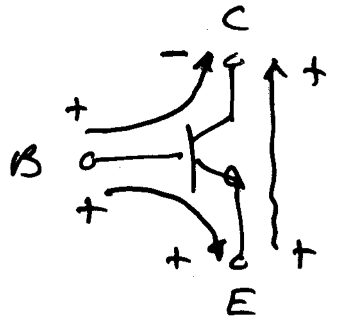




Signal Flow in transistors

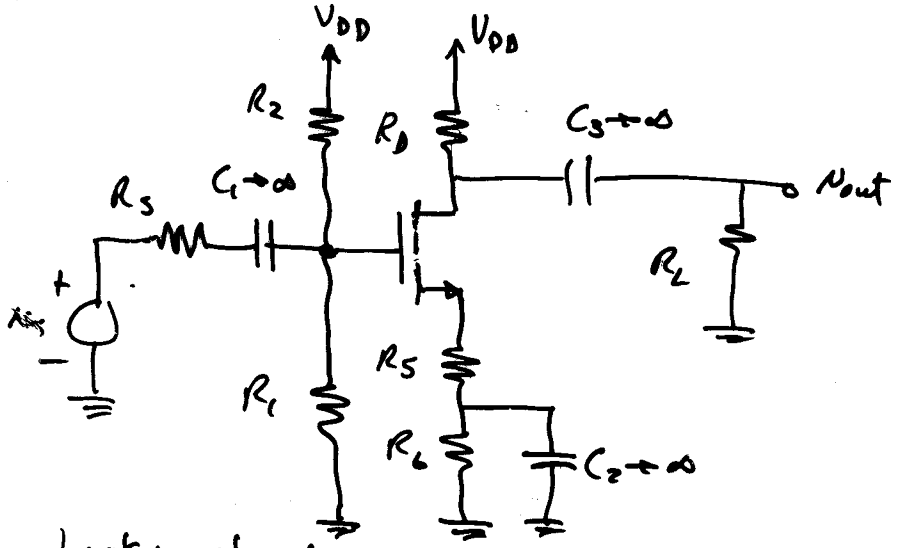


The gate is NEVER an output.
The drain is NEVER an input.



The base is NEVER an output.
The collector is NEVER an input.

Common Nothing



Looking ahead –