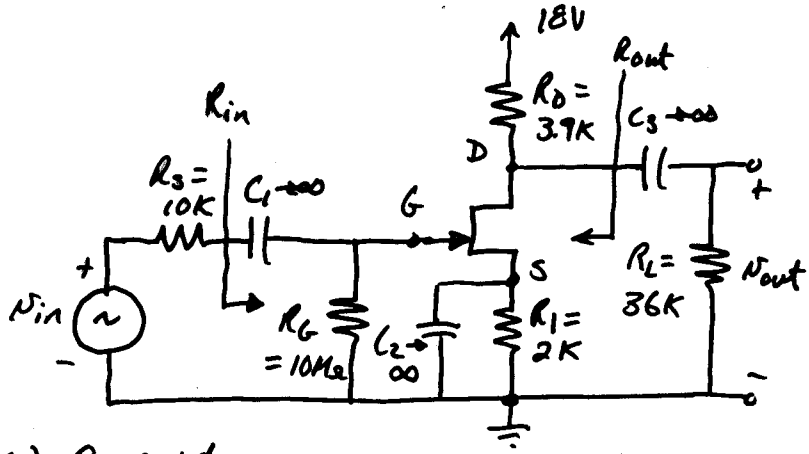
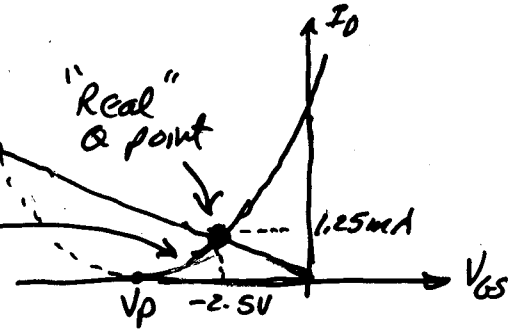
JFET Amplifier Example



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

a.) Q-point



1st eq. $V_{GS} + I_D R_1 = 0$

2nd eq. $I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_p}\right)^2$

$\therefore V_{GS} + R_1 I_{DSS}\left(1 - \frac{V_{GS}}{V_p}\right)^2 = 0$

which gives $V_{GS}^2 + 12.5 V_{GS} + 25 = 0 \rightarrow V_{GS} = -6.25 \pm 3.75$

$\therefore V_{GS} = -2.5V \quad I_D = 1.25mA \quad \& \quad V_{DS} = 10.6V$

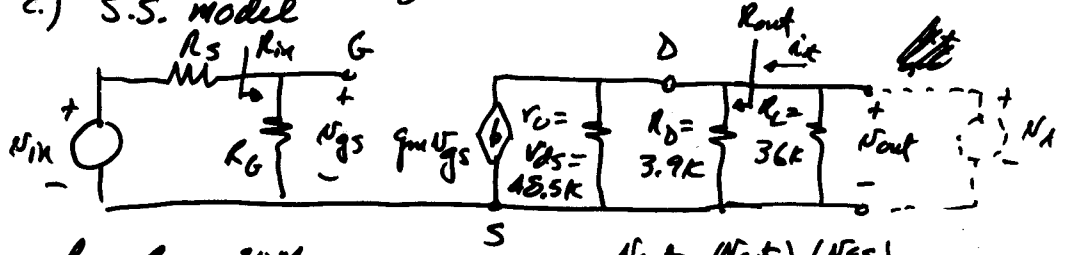
b.) SS model parameters

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

$$= 1.1mS$$

$$r_{ds} = r_o = \frac{\frac{1}{\lambda} + V_{DS}}{I_D} = \frac{50 + 10.6}{1.25mA} = 45.5k\Omega$$

c.) S.S. model



$R_{in} = R_G = 10M\Omega$

$R_{out} = \frac{v_t}{i_t} = r_{ds} \| R_D = 3.6k\Omega$

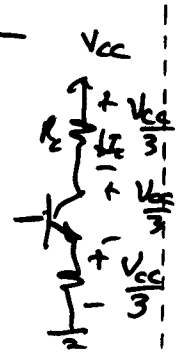
$$\frac{v_{out}}{v_{in}} = \left(\frac{v_{out}}{v_{gs}}\right)\left(\frac{v_{gs}}{v_{in}}\right)$$

$$= -(g_m r_{ds} \| R_D \| R_L)\left(\frac{R_G}{R_S + R_G}\right) = -3.6\frac{V}{V}$$

Summary of Chapt. 13 –

Table 13.6

	Common-emitter Amplifier	Common-Source Amplifier
Voltage Gain	$\frac{-\beta_o R_L}{r_\pi + R_{th}}\left(\frac{R_B}{R_B+R_S}\right)$ $\approx -g_m R_L$	$(-g_m R_L)\left(\frac{R_G}{R_S \| R_G}\right)$ $\approx -g_m R_L$
Rule of thumb voltage gains	$\approx -10 V_{cc}$	$\approx -V_{DD}$
R_{in}	$r_\pi \| R_B$	$\infty \| R_G$
R_{out}	$= R_c \| r_o \approx R_c$	$R_D \| r_{ds} \approx R_D$



Rules of Thumb –

BJT: $-g_m R_L = -\frac{I_C}{V_T} R_L = -\frac{(I_C R_L)}{V_T} \approx -\frac{V_{cc}}{3V_T}$

$= -\frac{40}{3} V_{cc} \approx -10 V_{cc}$

FET: $-g_m R_D = \frac{-I_D R_D}{\frac{V_{GS}-V_T}{2}} \approx -\frac{V_{DD}}{3}\frac{2}{V_{GS}-V_T} \approx -V_{DD}$

CHAPTER 14 – TRANSISTOR AMPLIFIERS IN GENERAL

Classes of Amplifiers

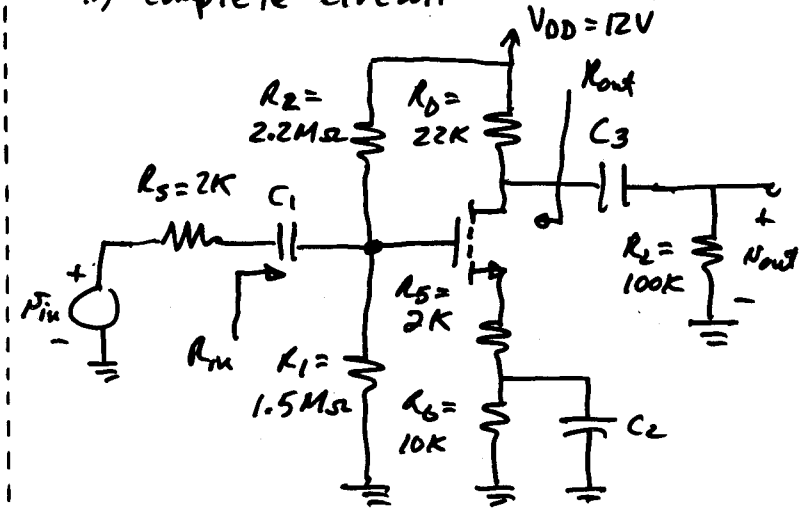
1. Common emitter / common source (CE/CS)
2. Common base / common gate (CB/CG)
3. Common collector / common drain (CC/CD)
4. Common nothing

Another classification of amplifiers is:

Inverting – CE, CS or common nothing
Noninverting – CC, CB, CD, CG

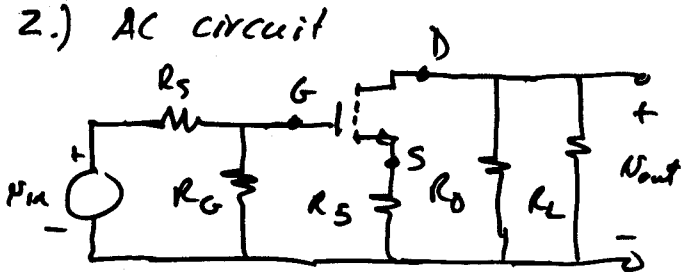
Common Nothing NMOS Amplifier (CS - Jaeger)

1.) Complete circuit



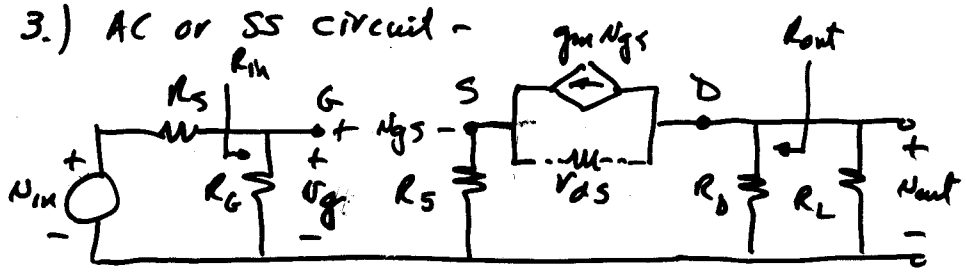
If $K_n = 0.5mA/V^2$, $V_{TN} = 1V$ and $\lambda = 0.02V^{-1}$ Do your thing.

2.) AC circuit



$R_G = R_1 \| R_2$

3.) AC or SS circuit –



4.) Find $\frac{v_{out}}{v_{in}}$, R_{in} & R_{out}

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

Assume that r_{ds} can be neglected.