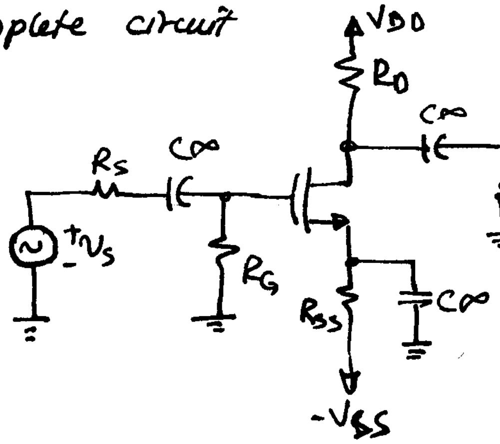
FET AMPLIFIERS (H.H. Erkaya)

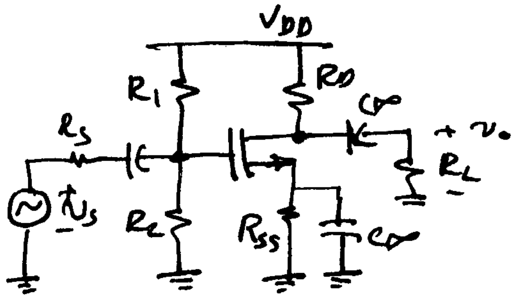
FETs are operated in constant current mode when they are used as amplifiers. (similar to the active mode) The configuration is named after the terminal that is common to input and output ports

Common Source Amplifier

Complete circuit



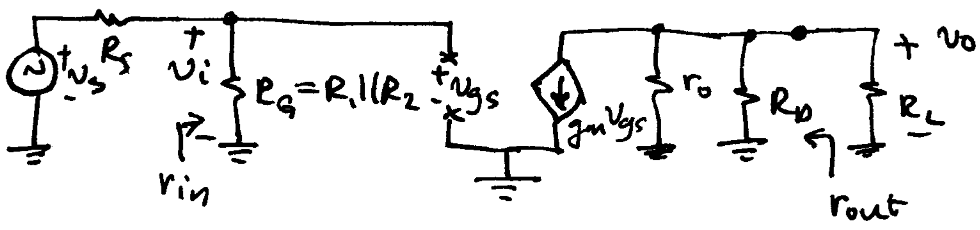
or



The small-signal equivalent circuit:

$g_m = 2\sqrt{K I_D}$

$r_o \cong \dfrac{V_A}{I_D}$



$r_{in} = R_G = R_1 \| R_2$

$r_{out} = r_o \| R_D$

$v_o = -g_m v_{gs} (r_o \| R_D \| R_L)$

$v_i = v_{gs}$

hence $\dfrac{v_o}{v_i} = -g_m (r_o \| R_D \| R_L)$

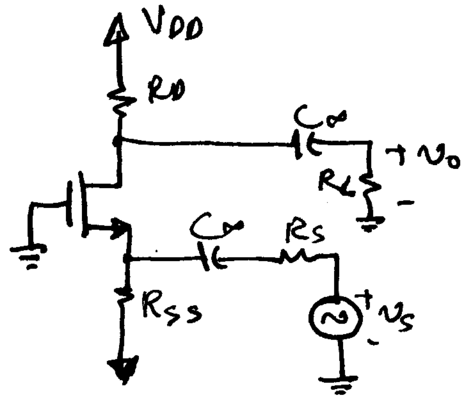
$\dfrac{v_i}{v_s} = \dfrac{r_{in}}{R_s + r_{in}}$

$\dfrac{v_o}{v_s} = -g_m v_{gs} (r_o \| R_D \| R_L) \dfrac{r_{in}}{R_s + r_{in}}$

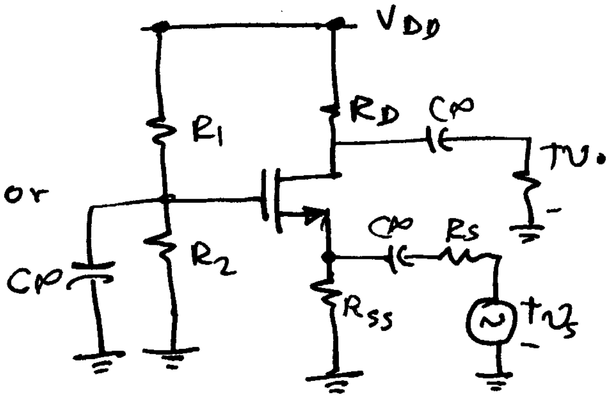
Note: r_o is often ignored due to its large value

Common Gate Amplifier

complete circuit:

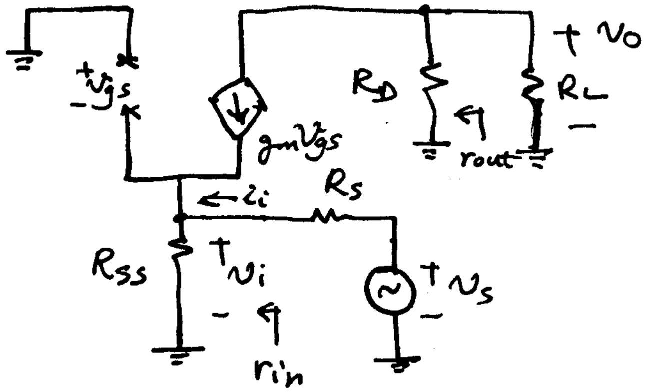


or



Small signal equivalent circuit

(ro is ignored) $g_m = 2\sqrt{K I_D}$



$r_{out} = R_D$

$r_{in} = R_{SS} \parallel \frac{1}{g_m}$

$v_o = -g_m v_{gs} (R_D \parallel R_L)$

$v_i + v_{gs} = 0$

$v_i = -v_{gs}$

$$\frac{v_o}{v_s} = g_m (R_D \parallel R_L) \frac{r_{in}}{R_s + r_{in}}$$

To find r_{in}:

By definition, $r_{in} = \frac{v_i}{i_i}$

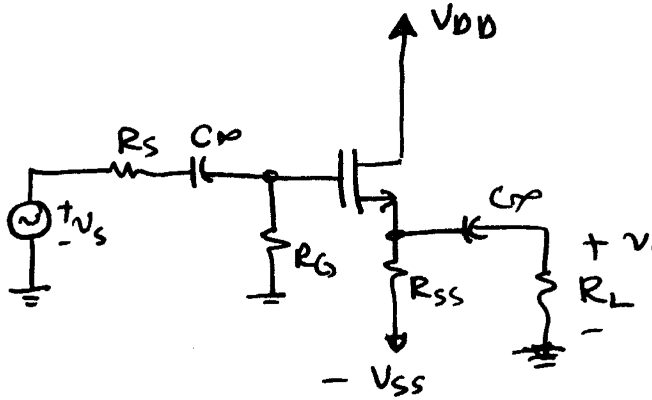
$$i_i = \frac{v_i}{R_{SS}} - g_m v_{gs} = \frac{v_i}{R_{SS}} + g_m v_i$$

$$r_{in} = \frac{v_i}{\frac{v_i}{R_{SS}} + \frac{v_i}{\frac{1}{g_m}}} = \frac{1}{\frac{1}{R_{SS}} + \frac{1}{\frac{1}{g_m}}} = R_{SS} \parallel \frac{1}{g_m}$$

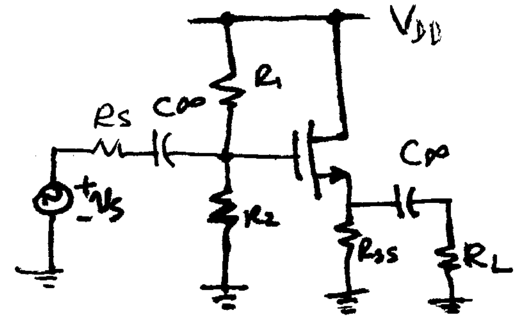
$$r_{out} = \left. \frac{v_{oc}}{i_{sc}} \right|_{R_L \to \infty} = \frac{-g_m v_{gs} R_D}{-g_m v_{gs}} = R_D$$

Common Drain Amplifier (source follower)

Complete circuit:



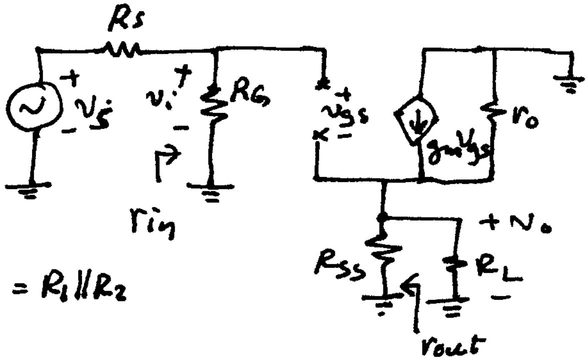
or



$$g_m = 2\sqrt{K I_D}$$

$$r_o \cong \frac{V_A}{I_D}$$

The small signal eq. ckt:



please note: r_o becomes parallel to R_{SS}

if $R_{SS} \ll r_o$, ignore r_o; else, $R_{SS} \leftarrow R_{SS} \| r_o$

$R_G = R_1 \| R_2$

$$r_{in} = R_G = R_1 \| R_2$$

$$r_{out} = R_{SS} \| r_o \| \frac{1}{g_m}$$

$$\left.\begin{aligned} v_o &= g_m v_{gs} \, (R_{SS} \| r_o \| R_L) \\ v_i &= v_o + v_{gs} \\ \frac{v_i}{v_s} &= \frac{R_{in}}{R_s + r_{in}} \end{aligned}\right\} \quad \frac{v_o}{v_s} = \frac{g_m (R_{SS} \| r_o \| R_L)}{1 + g_m (R_{SS} \| r_o \| R_L)} \, \frac{r_{in}}{R_s + r_{in}}$$