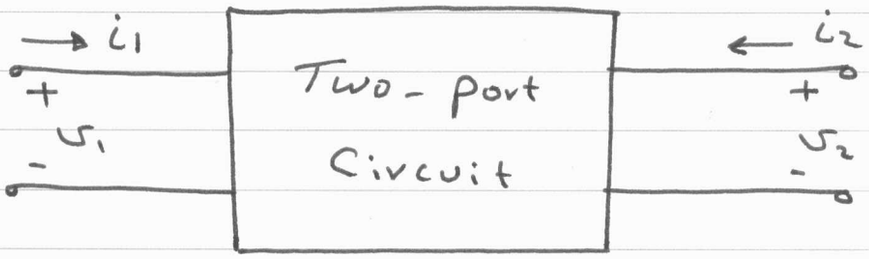
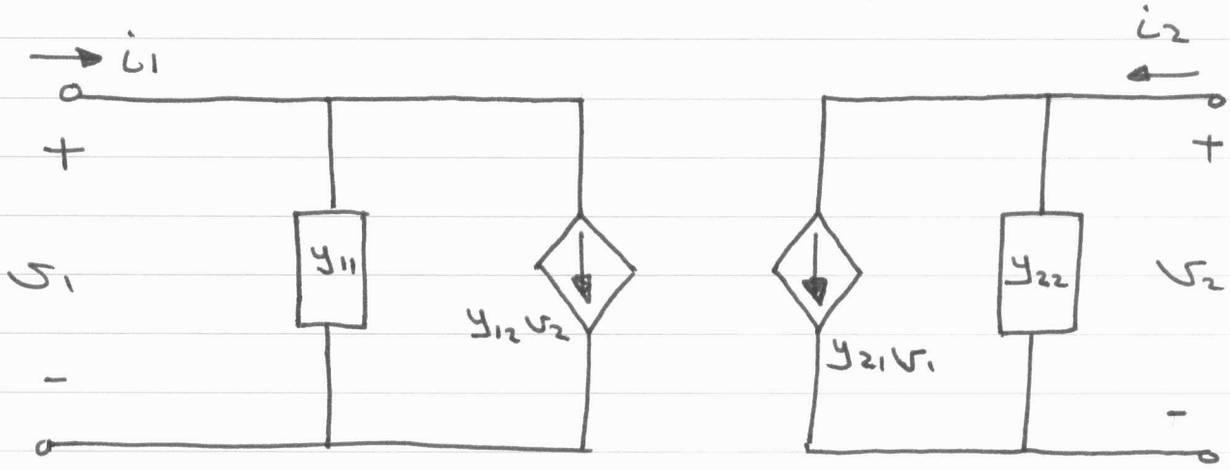
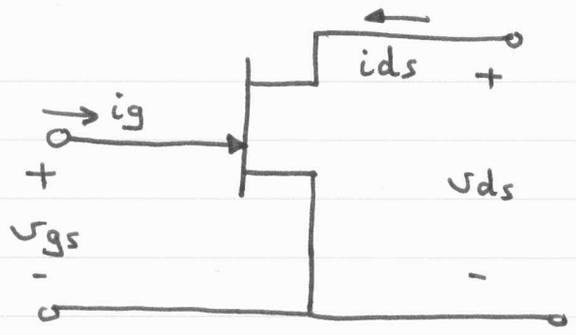
# Ac Small Signal Equivalent Circuit For FET




$$i_1 = y_{11} v_1 + y_{12} v_2$$

$$i_2 = y_{21} v_1 + y_{22} v_2$$






$$i_g = y_{11} v_{gs} + y_{12} v_{ds}$$

$$i_{ds} = y_{21} v_{gs} + y_{22} v_{ds}$$

$$y_{11} = \left.\frac{i_g}{v_{gs}}\right|_{v_{ds}=0} = \left.\frac{\Delta i_{G(t)}}{\Delta V_{GS(t)}}\right|_{V_{DS(t)} = V_{DSQ}}$$

$$i_{G(t)} = 0$$

$$\therefore \quad y_{11} = 0 \qquad \text{(open Circuit)}$$

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$$y_{12} = \left.\frac{i_g}{v_{ds}}\right|_{v_{gs}=0} = \left.\frac{\Delta i_{G(t)}}{\Delta V_{DS(t)}}\right|_{V_{GS(t)} = V_{GSQ}}$$

But $i_{G(t)} = 0$

$$\therefore \quad y_{12} = 0$$

$$\therefore \quad y_{12} v_{gs} = 0 \qquad \text{(open Circuit)}$$

$$y_{22} = \frac{i_{ds}}{v_{ds}}\Bigg|_{v_{gs}=0} = \frac{\Delta i_{DS}(t)}{\Delta v_{DS}(t)}\Bigg|_{v_{GS}(t)=V_{GSQ}}$$

$$\frac{1}{y_{22}} = r_{ds} = \frac{V_A}{I_{DSQ}}$$

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$$y_{21} = \frac{i_{ds}}{v_{gs}}\Bigg|_{v_{ds}=0} = \frac{\Delta i_{DS}(t)}{\Delta v_{GS}(t)}\Bigg|_{v_{DS}(t)=V_{DSQ}}$$

$$y_{21} = \frac{d\, i_{DS}(t)}{d\, v_{GS}(t)}\Bigg|_{Q}$$

$y_{21} = g_m$ ; Forward Transconductance

1) For JFET and DMOSFET

$$i_{DS}(t) = I_{DSS}\left(1 - \frac{v_{GS}(t)}{V_p}\right)^2$$

$$g_m = \frac{-2 I_{DSS}}{V_p}\left(1 - \frac{v_{GS}(t)}{V_p}\right)\Bigg|_{Q}$$

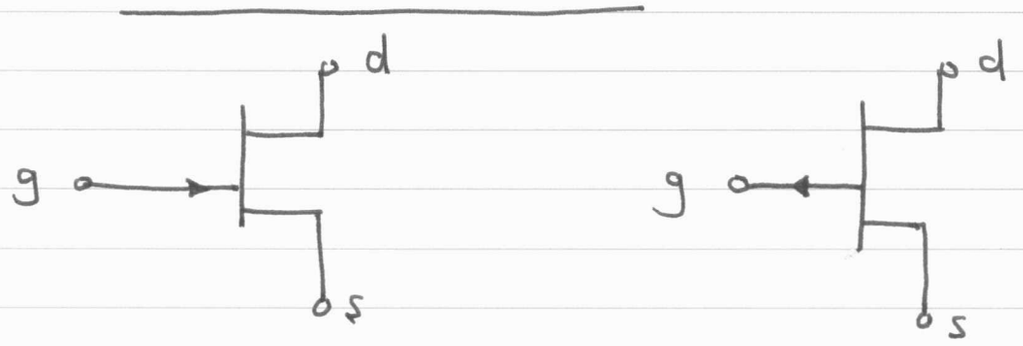
$$g_m = \frac{-2 I_{DSS}}{V_p}\left(1 - \frac{V_{GS}}{V_p}\right)$$

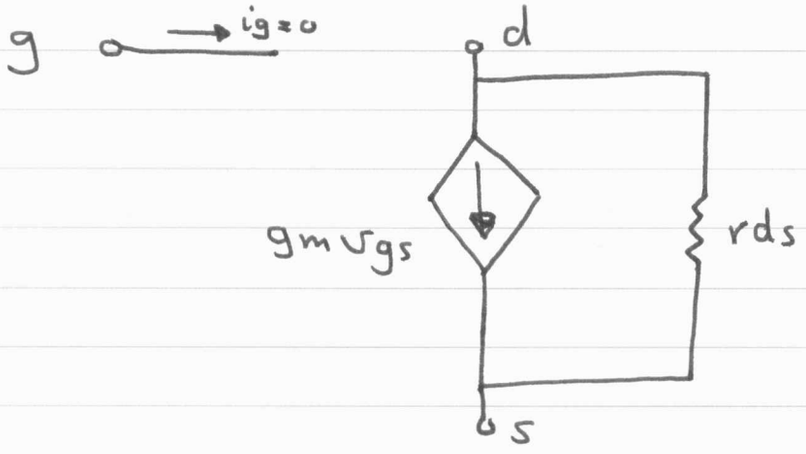
2) For EMOSFET

$$i_{DS}(t) = K_n \left( v_{GS}(t) - V_T \right)^2$$

$$g_m = 2 K_n \left( V_{GS} - V_T \right)$$

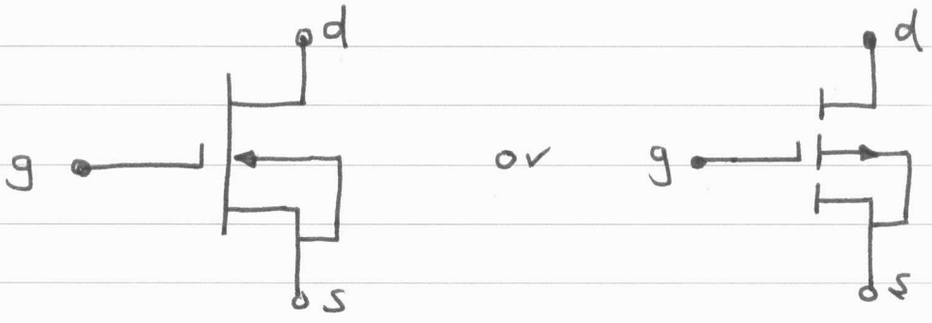
$$g_m = 2 \sqrt{K_n I_{DS}} \qquad \text{proof !!}$$

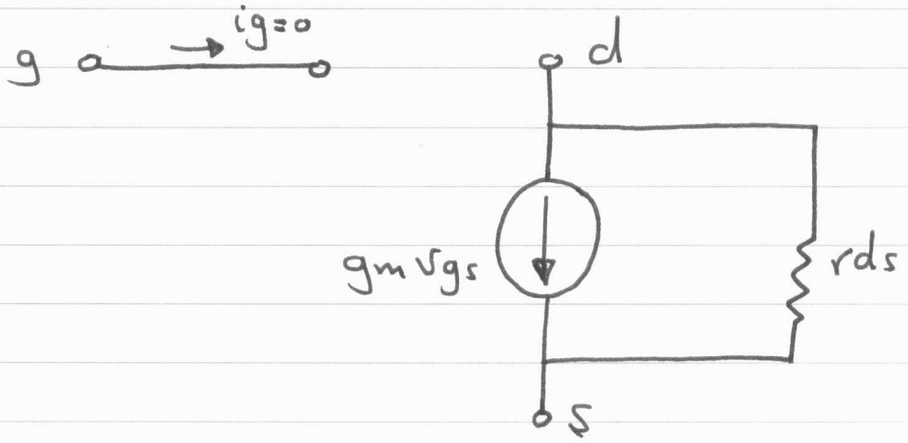



ac small signal equivalent circuit of JFET

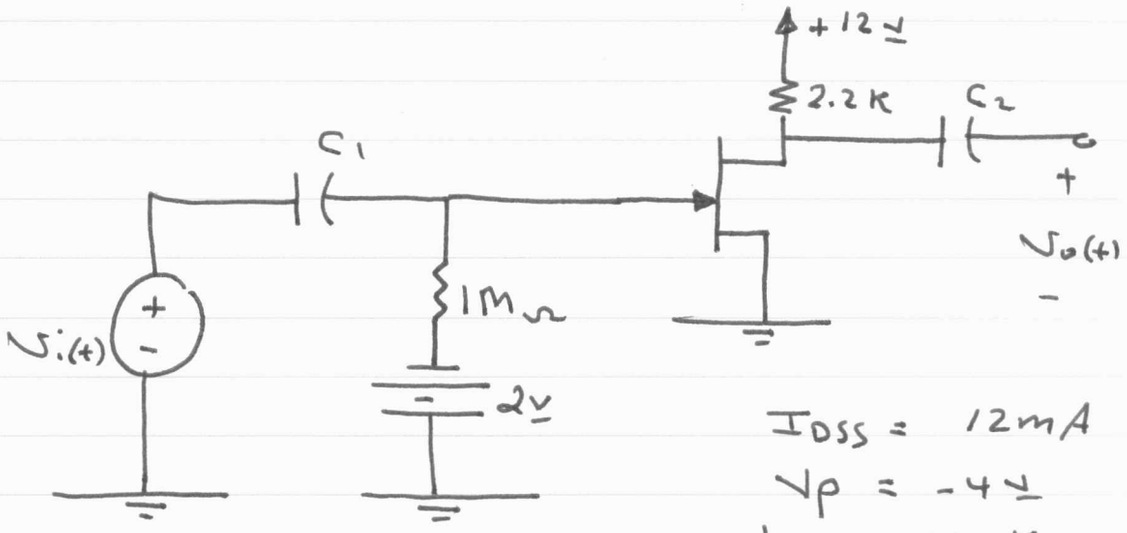
# Ac Small Signal Equivalent Circuit For MOSFET



# FET Ac Small Signal Amplifiers

## 1) Common Source Amplifier




$I_{DSS} = 12mA$

$V_p = -4V$

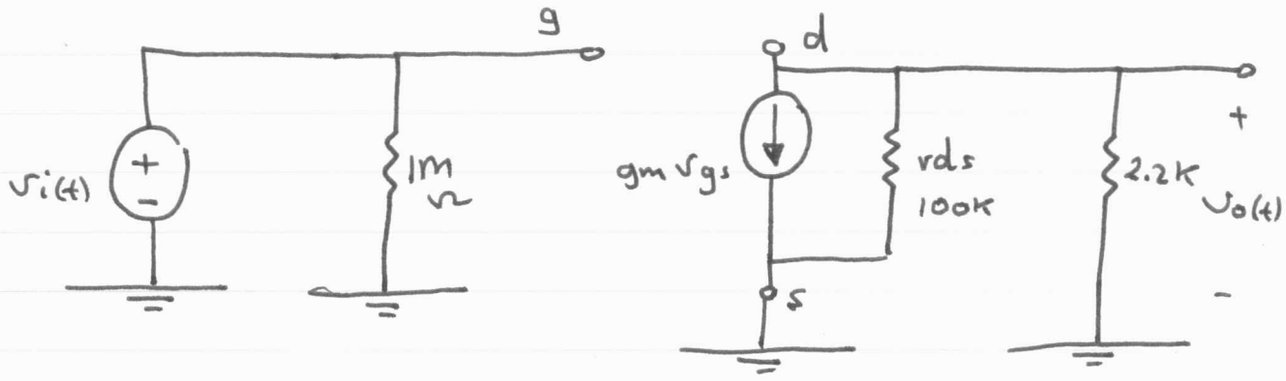
$r_{ds} = 100K$

$$g_m = \frac{-2I_{DSS}}{V_p}\left(1 - \frac{V_{GS}}{V_p}\right)$$

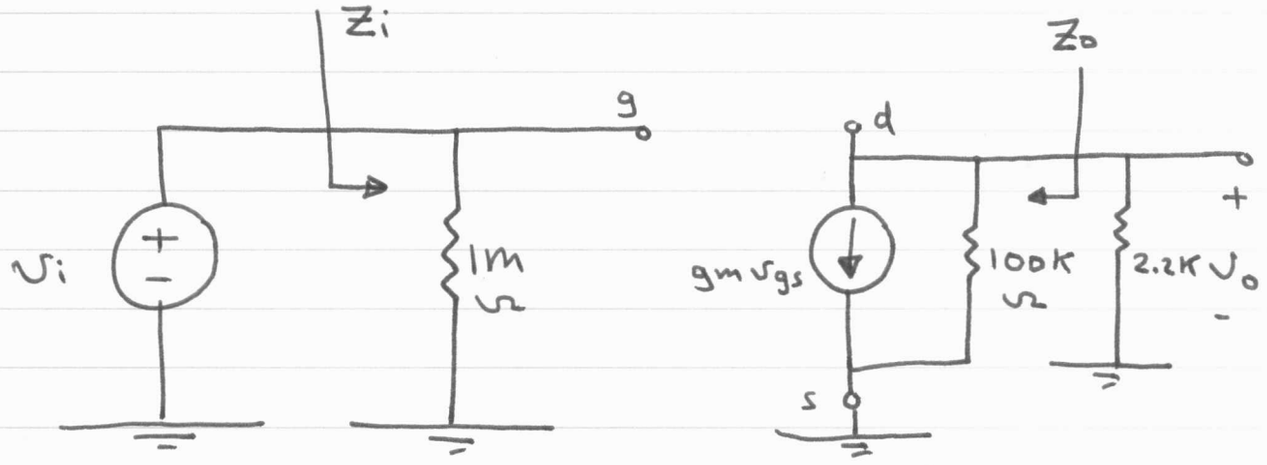
$V_{GS} = -2V$

$\therefore g_m = 3\,m\mho$

### ac Small Signal Equivalent Circuit



# Ac Small Signal Equivalent Circuit




$$V_o = -g_m V_{gs} \left( 100K \parallel 2.2K \right)$$

$$V_{gs} = V_g - V_s$$

$$V_g = V_i \quad ; \quad V_s = 0$$

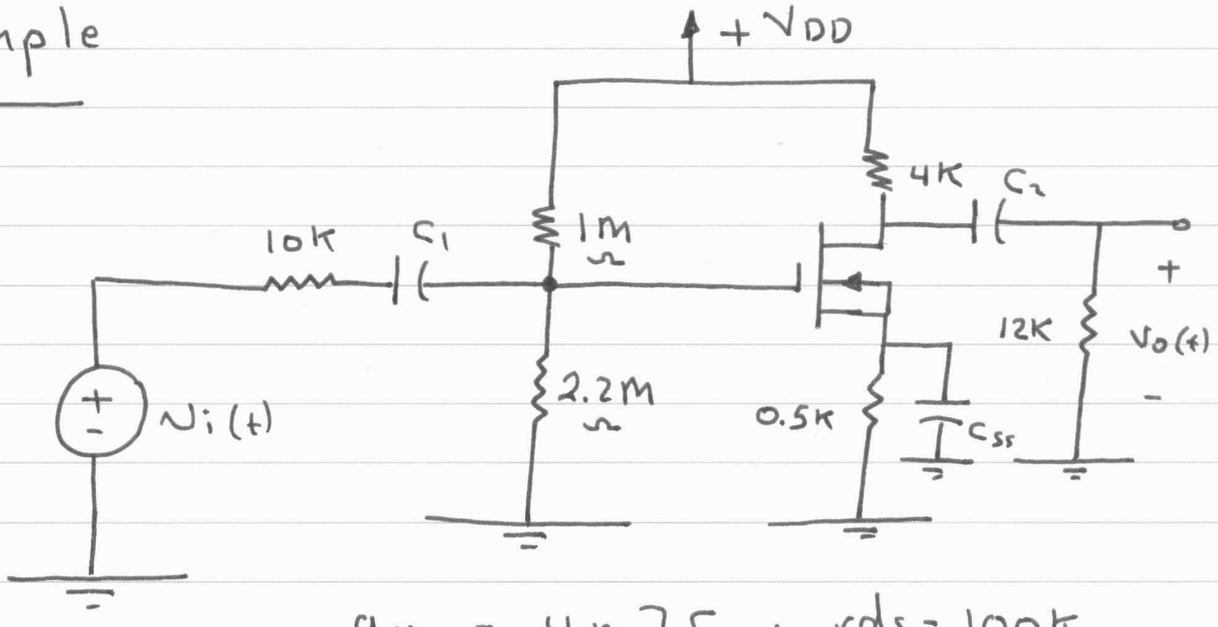
$$\therefore A_V = \frac{V_o}{V_i} = -g_m \left( 2.2K \parallel 100K \right)$$

$$A_V = -6.6$$

$$Z_i = 1M\Omega$$

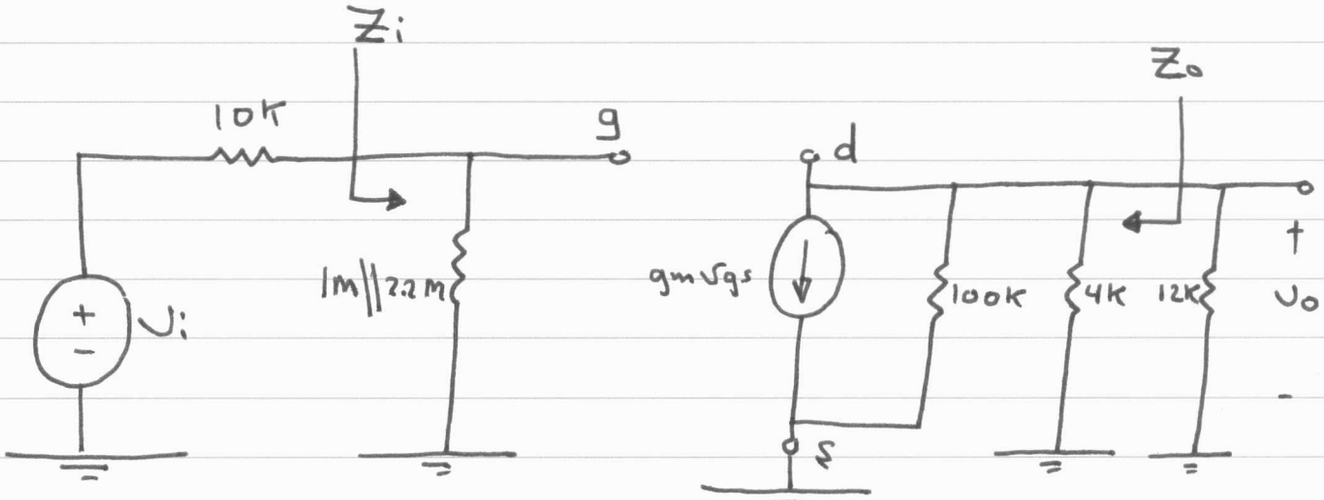
$$Z_o = r_{ds} = 100K$$

Example




$g_m = 4m25$ ; $r_{ds} = 100K$

ac small Signal equivalent ckt :




$$V_o = -g_m V_{gs} \left( 100K \parallel 4K \parallel 12K \right)$$

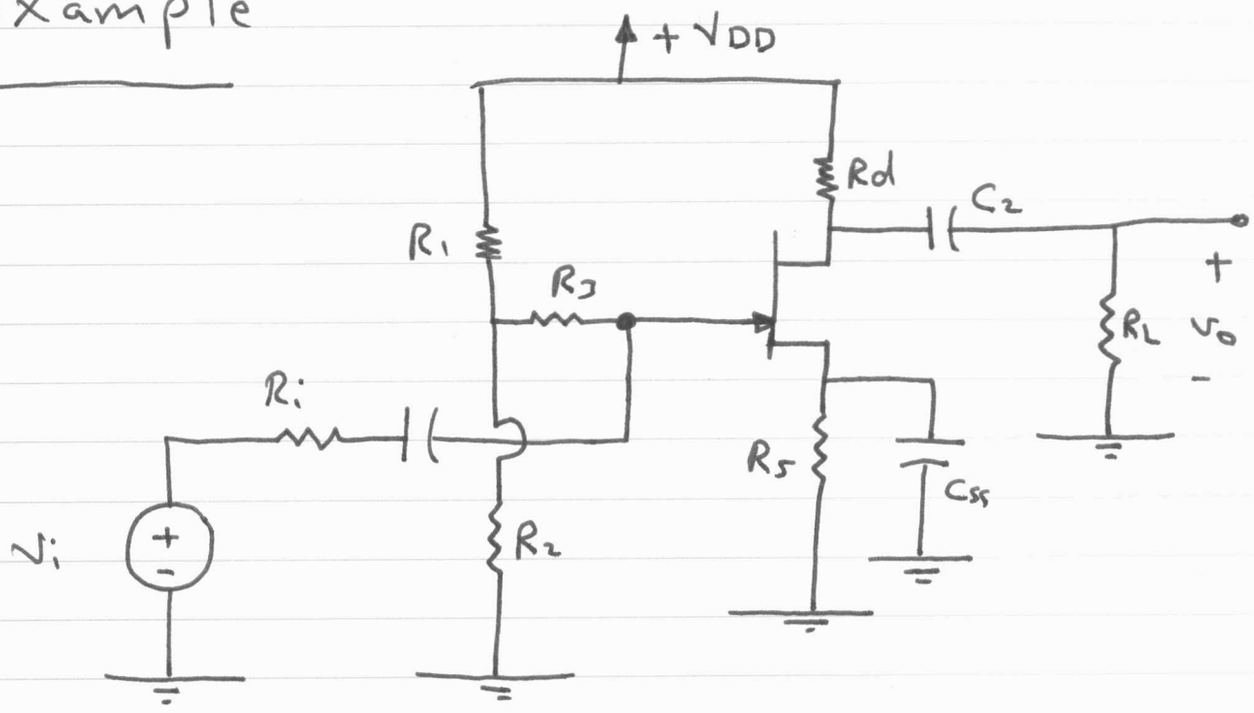
$$V_{gs} = V_g - V_s$$

$$V_g = \frac{1M \parallel 2.2M}{1M \parallel 2.2M + 10K} V_i \quad ; \quad V_s = 0$$

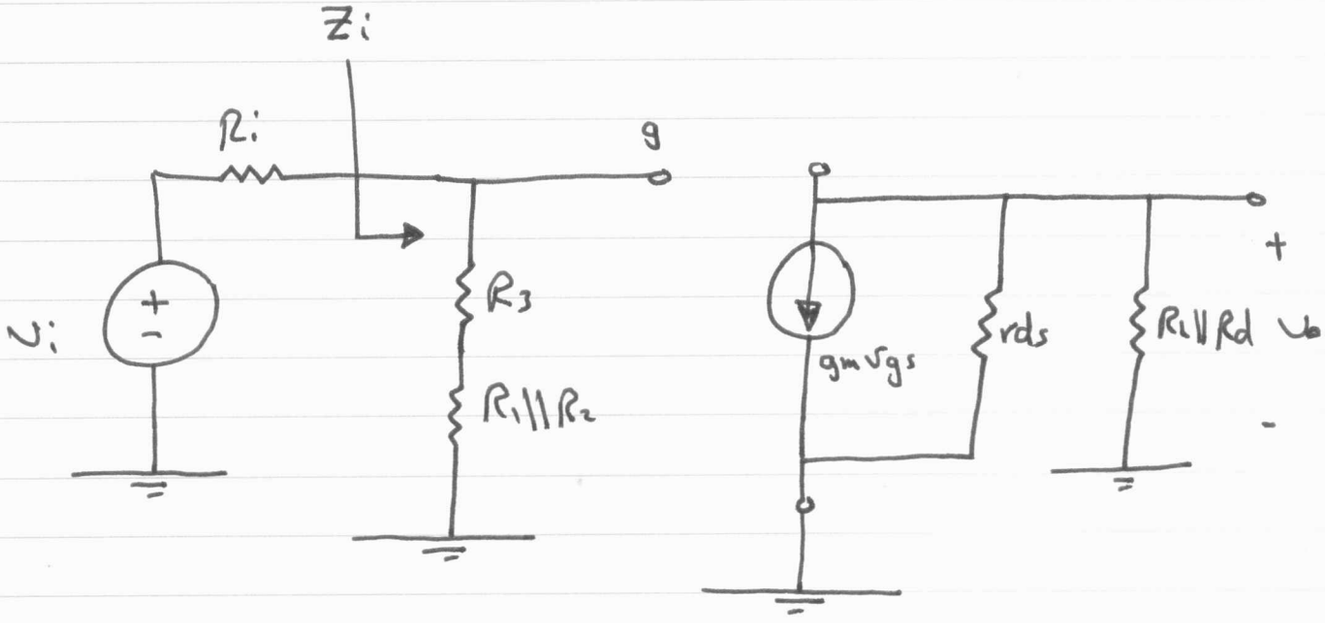
$$\therefore A_v = \frac{V_o}{V_i} = -11.48$$

$$Z_i = 1M \parallel 2.2M \quad ; \quad Z_o = 100K \parallel 4K$$

Example




ac small Signal equivalent CKT :




$$Z_i = R_3 + R_1 \| R_2$$