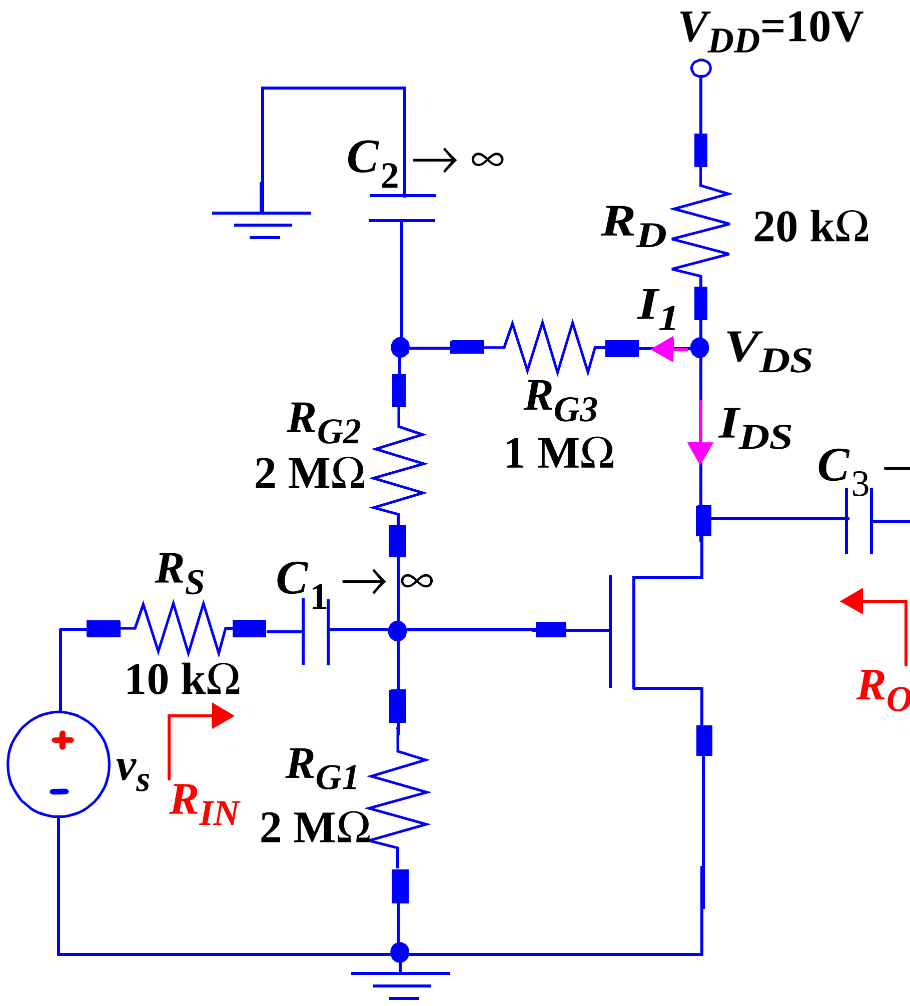
Example of CS Amplifier

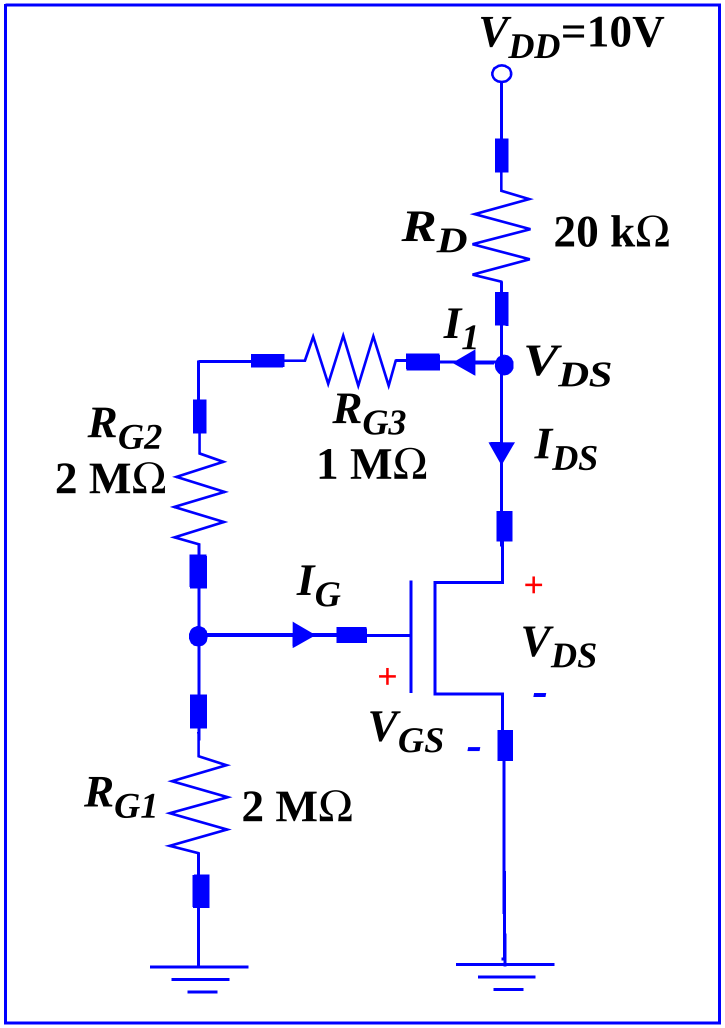


$V_{TN} = 1V$

$K_n = 500\mu A/V^2$

$\lambda = 0.0167V^{-1}$

DC Analysis (p. 631)



$$V_{DS} = 10 - 2 \times 10^{4}(I_{DS} + I_1)$$

$$I_{DS} = \frac{K_n}{2}(V_{GS} - V_{TN})^2 \text{ for } V_{DS} \geq (V_{GS} - V_{TN}) \text{ and } \lambda \approx 0.$$

Since $I_G = 0$, then, $I_1 = \frac{V_{DS}}{R_{G3} + R_{G2} + R_{G1}} = \frac{V_{DS}}{5 \times 10^6}$

$$V_{GS} = \frac{R_{G1}}{R_{G3} + R_{G2} + R_{G1}} V_{DS} = \frac{2 \times 10^6}{5 \times 10^6} V_{DS} = 0.4 V_{DS}$$

$$V_{DS} = 10 - 2 \times 10^4 \left(\left\{ \frac{5 \times 10^{-4}}{2} (0.4 V_{DS} - V_{TN})^2 \right\} + \frac{V_{DS}}{5 \times 10^6} \right)$$

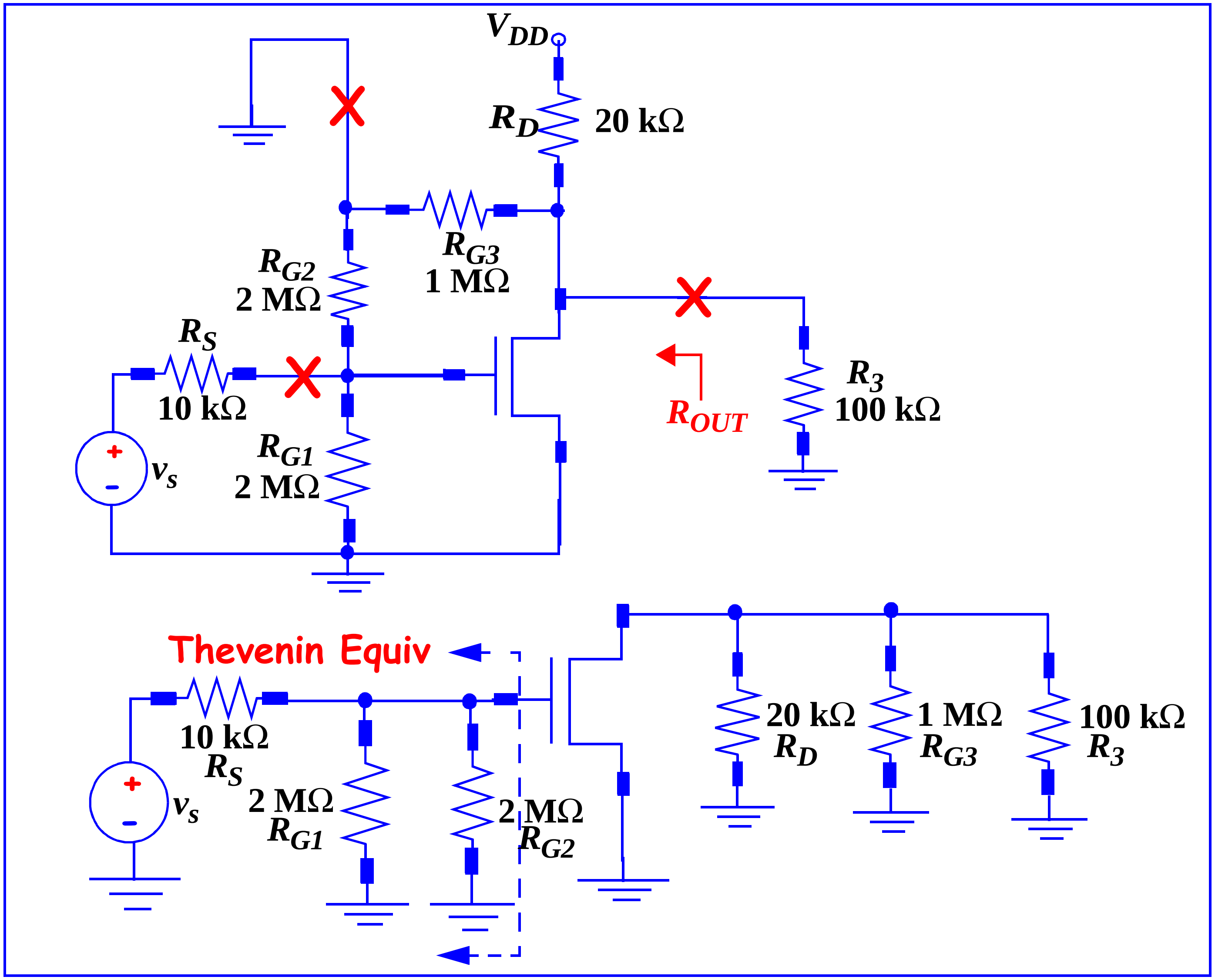
$0.8 V_{DS}^2 - 3 V_{DS} - 5 = 0$. Solving, $V_{DS} = 5V$ or $V_{DS} = -1.25V$.

For $V_{DS} = 5V$, $V_{GS} = 2V$ and $I_{DS} = 250\mu A$.

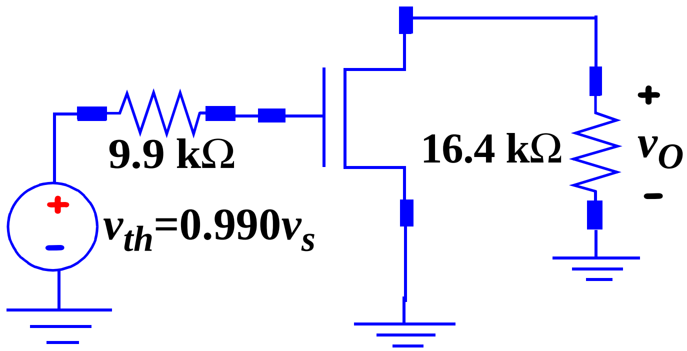
Since $V_{DS} \geq V_{GS} - V_{TN}$, then our assumption is correct.

Quiescent Point is $(I_{DS}, V_{DS}) = (250\mu A, 5V)$.

AC Analysis



V_{DD}
R_D
20 kΩ
R_{G3}
1 MΩ
R_{G2}
2 MΩ
R_S
10 kΩ
v_s
R_{G1}
2 MΩ
R_{OUT}
R_3
100 kΩ
Thevenin Equiv
10 kΩ
R_S
v_s
2 MΩ
R_{G1}
2 MΩ
R_{G2}
20 kΩ
R_D
1 MΩ
R_{G3}
100 kΩ
R_3



$V_{TN} = 1V$

$K_n = 500\mu A/V^2$

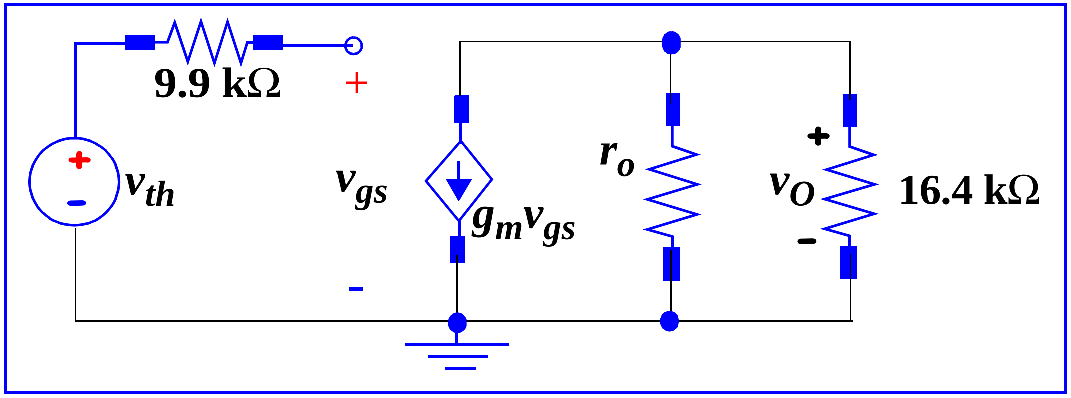
$\lambda = 0.0167V^{-1}$

Transconductance - $g_m = \sqrt{2K_nI_{DS}(1+\lambda V_{DS})} = 5.20 \times 10^{-4}S$

Output Resistance of MOSFET - $r_o = \dfrac{(1/\lambda) + V_{DS}}{I_{DS}} = 260k\Omega$

Output Voltage $v_o = (-g_m v_{gd})(r_o \parallel 16.4k) = -8.02v_{gs}$ and $v_{gs} = 0.990v_s$,

so $A_V = \dfrac{v_o}{v_s} = -8.02 \times 0.990 = -7.94$



What is the amplification factor μ_f of the MOSFET above and how does it compare with A_V? $\mu_f = g_m r_o = 135$ **and** $A_V \ll \mu_f$

What is the largest value of v_s of the circuit that corresponds to a small-signal for the amplifier for the circuit at the top of page 22-1? What is the largest value of v_o that corresponds to a small-signal for this amplifier?

$$v_s = \frac{v_{gs}}{0.990} = \frac{0.2(V_{GS} - V_{TN})}{0.990} = 202mV \quad \text{and} \quad v_o = A_V v_s = 1.60V$$

Input Resistance

Is limited by gate bias resistors since input gate impedance is ∞.

$$R_{IN} = R_{G1} \| R_{G2} = 1M\Omega$$

Output Resistance

$$R_{OUT} = R_D \| R_{G3} \| r_o = 18.2k\Omega$$