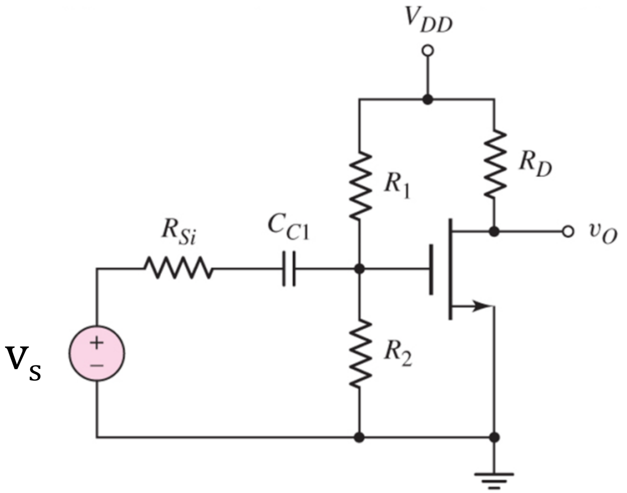
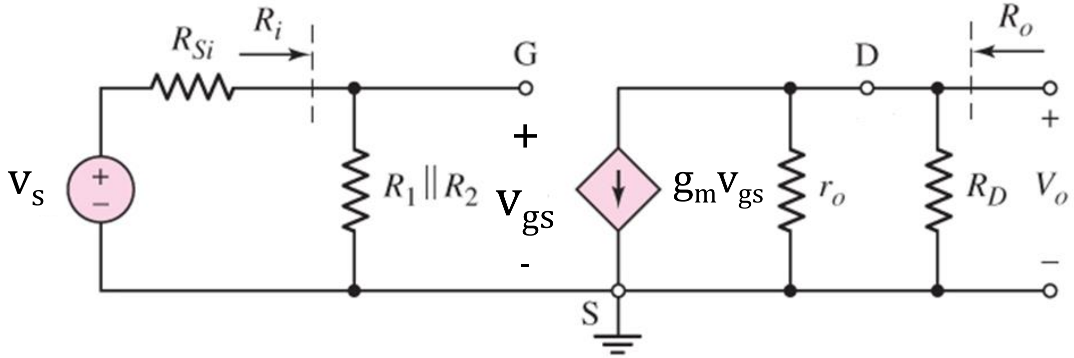
The MOSFET Amplifier - COMMON SOURCE

- The output is measured at the drain terminal
- The gain is negative value
- Three types of common source
  - source grounded
  - with source resistor, R_S
  - with bypass capacitor, C_S

Common Source - Source Grounded

- A Basic Common-Source Configuration:

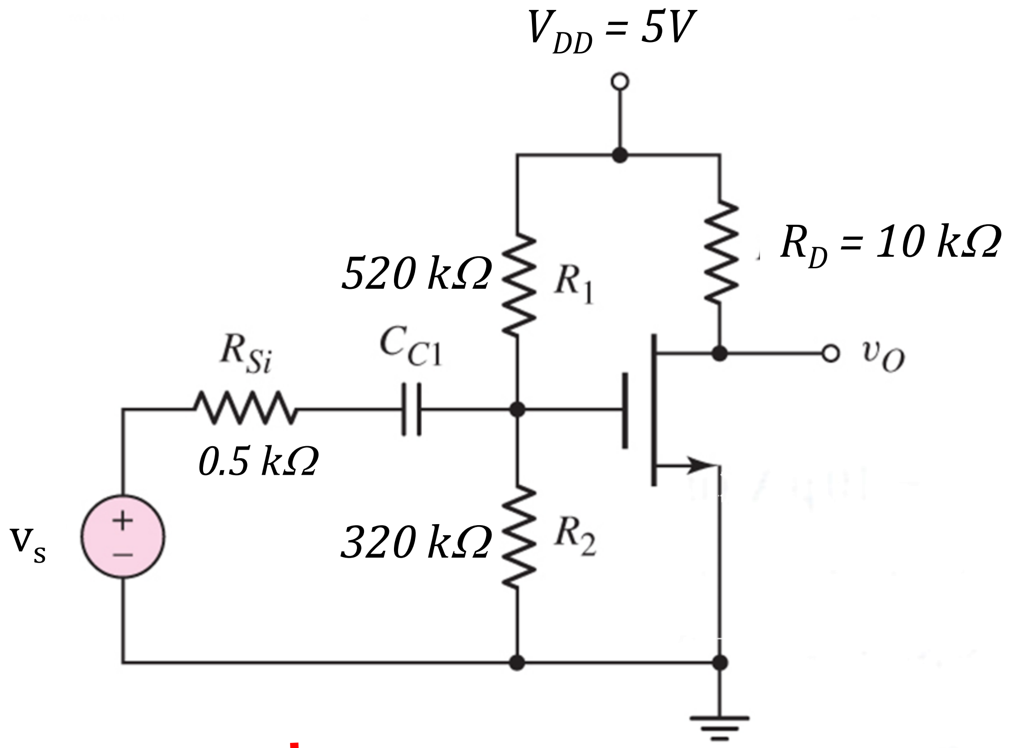




Assume that the transistor is biased in the saturation region by resistors R_1 and R_2, and the signal frequency is sufficiently large for the coupling capacitor to act essentially as a short circuit.

EXAMPLE

The transistor parameters are:
$V_{TN} = 0.8V$, $K_n = 0.2mA/V^2$ and $\lambda = 0$.

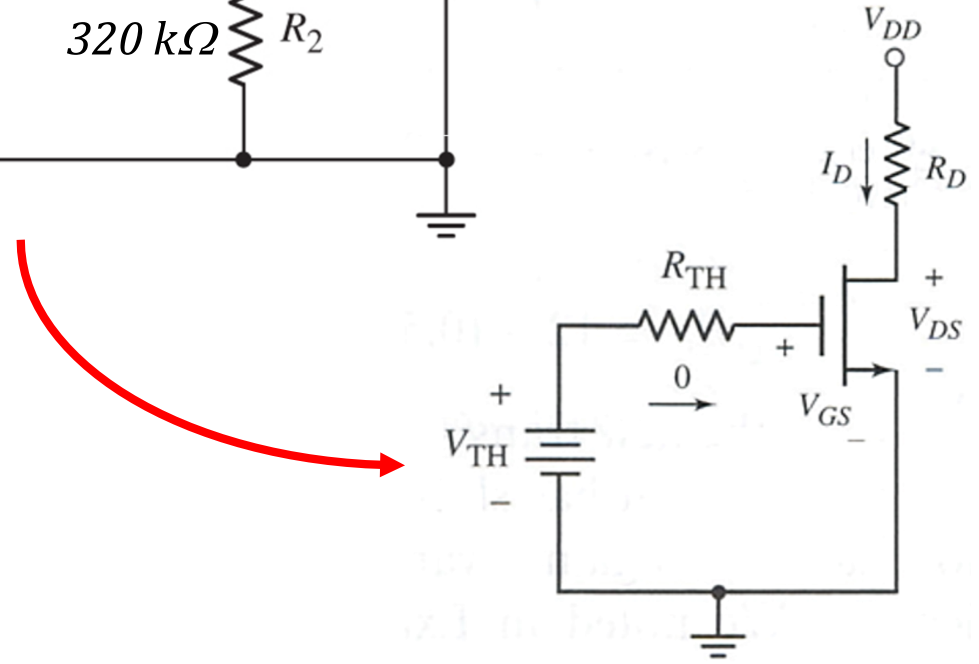


Voltage Divider biasing:

Change to Thevenin Equivalent

$R_{TH} = 198\ k\Omega$

$V_{TH} = 1.905\ V$



DC ANALYSIS

1. Calculate the value of V_{GS}

$V_{GS} - V_{TH} = 0$

$V_{GS} = 1.905\ V$

2. Assume the transistor is biased in the saturation region, the drain current:

$$I_D = K_n(V_{GS} - V_{TN})^2$$

$$I_D = 0.2(1.905 - 0.8)^2 = 0.244mA$$

3. Use KVL at DS loop

$I_D R_D + V_{DS} - V_{DD} = 0$

$V_{DS} = V_{DD} - I_D R_D = 2.56\ V$

4. Calculate $V_{DSsat} = V_{GS} - V_{TN} = 1.905 - 0.8 = 1.105\ V$

5. Confirm your assumption: $\mathbf{V_{DS} > V_{DSsat}}$, our assumption that the transistor is in saturation region is correct

$$g_m = 2\sqrt{K_n I_{DQ}} \Rightarrow g_m = 0.442\ mA/V$$

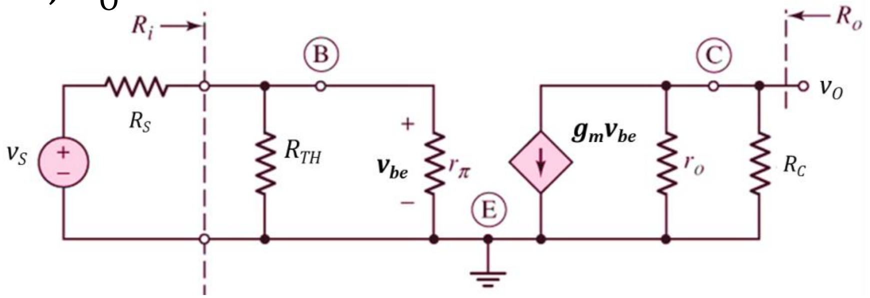
COMMON EMITTER GROUNDED

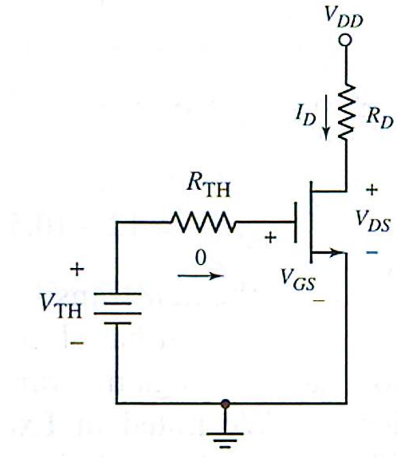
OUTPUT SIDE

1. Get the equivalent resistance at the output side, R_O
2. Get the v_o equation where $v_o = -g_m v_{be} R_O$

INPUT SIDE

3. Calculate R_i
4. Get v_{be} in terms of v_i





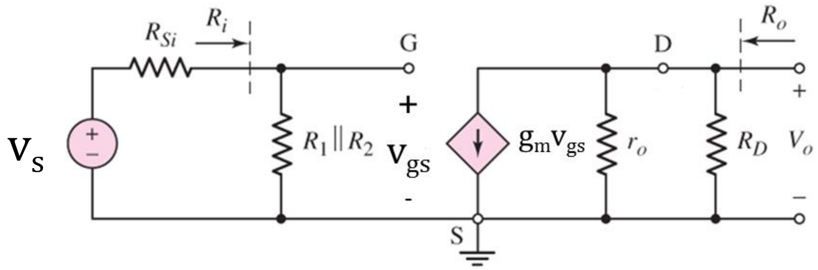
COMMON SOURCE GROUNDED

OUTPUT SIDE

1. Equivalent resistance at the output side, R_O
2. Get the v_o equation where $v_o = -g_m v_{gs} R_O$

INPUT SIDE

3. Get v_{gs} in terms of v_i



OUTPUT SIDE

1. Equivalent resistance at the output side, $R_O = r_o || R_D$
2. Get the v_o equation where $v_o = -g_m v_{gs} R_O = -g_m v_{gs} (r_o || R_D)$

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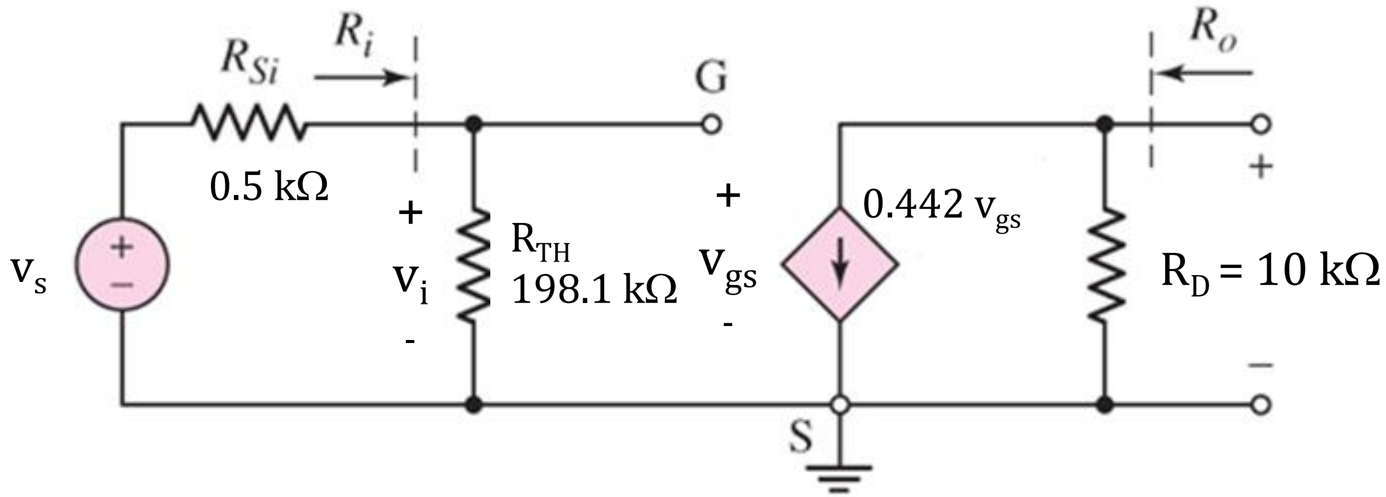
INPUT SIDE

3. Get v_{gs} in terms of $v_i \rightarrow v_{gs} = v_i$

4. $A_v v_i = v_o = -g_m v_{gs} (r_o || R_D)$ ← open circuit voltage

$A_v v_i = -g_m v_i (r_o || R_D)$

$A_v = -g_m (r_o || R_D)$ ← open circuit voltage gain



1. The output resistance, $R_o = R_D$
2. The output voltage:

$$v_o = -g_m v_{gs} (R_o) = -g_m v_{gs} (10) = -4.42\ v_{gs}$$

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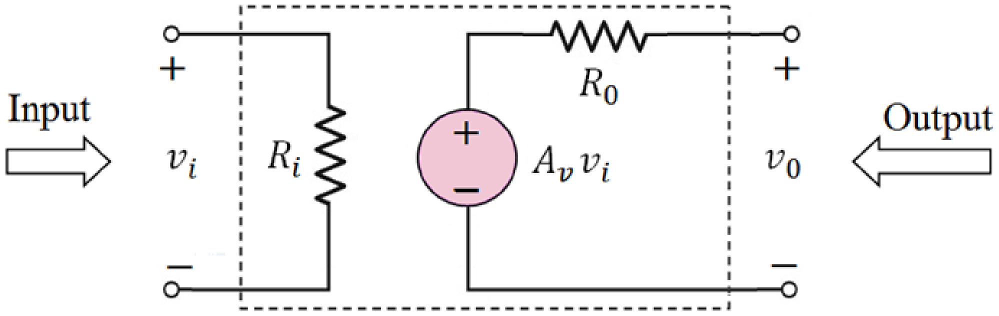
3. Get v_i in terms of v_{gs}

$$v_{gs} = v_i$$



Equivalent circuit of a voltage amplifier

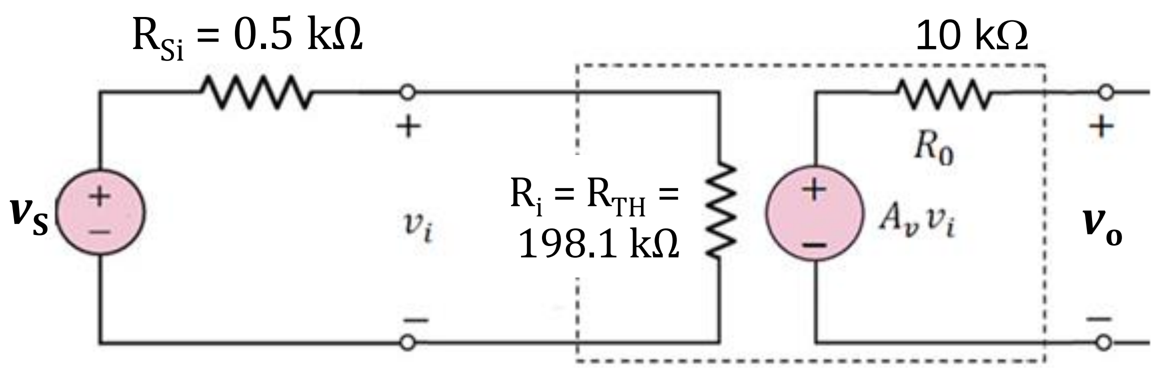
Equation of v_o : $v_o = -\,g_m v_{gs} (R_o) = -\,g_m v_{gs} (10) = -4.42\ v_{gs}$

$v_i = v_{gs}$

$A_v v_i = v_o$ ← open circuit voltage

$A_v \cancel{v_i} = -4.42\ v_{gs} = -4.42 \cancel{v_i}$

$A_v = -4.42$ ← open circuit voltage gain



Equivalent circuit of a voltage amplifier

To find new voltage gain, v_o/v_s with input signal voltage source, v_s

v_i in terms of v_s → use voltage divider:

$v_i = [\, R_i / (\, R_i + R_s\,)] * v_s = 0.9975\ v_s$

$v_o = A_v v_i$ ← because there is no load resistor

$v_o = -4.42\ (0.9975\ v_s)$

$v_o/v_s = -4.41$