Literature:

MOSFET: p 292-318

Transistor amplifier: P 350-431

Frequency response: p 649 – 675

Assignments:

8.1:

A MOSFET circuit is shown in Fig. 1. It is assumed that: $V_{DD} = 10$ V, $R_G = 33\ K\Omega$, $R_D = 5.6\ K\Omega$ and the channel length modulation coefficient $\lambda = 0$. Furthermore, we assume that $V_{TH} = 2\ V$ and $k_n = 0.9 * 10^{-3}\ A/V^2$.

(a) To achieve $I_D = 1\ mA$, $V_{GS} = ?$
(b) To have V_{GS} obtained in (a), V_{BB} =? Explain why.
(c) To ensure the MOSFET operating in saturation, how large is the output signal swing?
(d) Setup a small signal circuit and calculate the component values and voltage gain A_v.
(e) To achieve a maximum output signal swing for $I_D = 1\ mA$, R_D =?
(f) If the channel length modulation coefficient $\lambda = 0.5$ and $R_D = 5.6\ K\Omega$ are considered, the output resistance r_o =? The voltage gain A_v =?

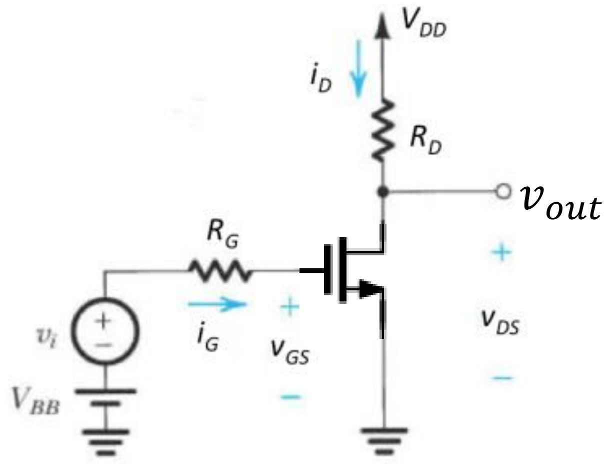


Fig. 1 A MOSFET circuit

Solution:

(a) $I_D = \frac{1}{2} k_n (V_{GS} - V_{TH})^2 \rightarrow V_{GS} = \sqrt{\frac{2I_D}{k_n}} + V_{TH} \approx 3.5\ V$

(b) Since $I_G = 0 \rightarrow V_{R_G} = 0 \rightarrow V_{BB} = V_{GS} = 3.5\ V$

(c) $V_{DS} = V_{DD} - R_D I_D = 10 - 5.6K\Omega * 1mA$ = 4.4 V

To ensure the MOSFET working in saturation, $V_{DS} \geq V_{GS} - V_{TH} = 1.5\ V$, i.e., $V_{DS,min} = 1.5\ V$. In addition, $V_{DS} \leq V_{DD} = 10\ V$. Thus, the swing of the output signal = $\min\{4.4 - 1.5, 10 - 4.4\} = 2.9\ V$.

(d) $g_m = \frac{2I_D}{V_{GS} - V_{TH}} = 1.3\ mS \rightarrow A_v = -g_m R_D \approx -7.5$

(e) To achieve a maximum output signal swing, we need to ensure the $V_{DS,Q}$ is located in the middle of the available range:

$V_{range} = V_{DD} - V_{DS,min} = 10 - 1.5 = 8.5\ V \rightarrow V_{DS,Q} = \frac{V_{range}}{2} + V_{DS,min} = 5.75\ V \rightarrow V_{R_D} = V_{DD} - V_{DS,Q} = 4.25$

$\rightarrow R_D = \frac{V_{R_D}}{I_D} = \frac{4.25V}{1\ mA} = 4.25\ K\Omega$

(f) $r_o = \frac{1}{I_D \lambda} = \frac{1}{1mA * 0.5} = 2\ K\Omega$

$A_v = -g_m * (R_D || r_o) = -1.3\ mS * (5.6K\Omega || 2K\Omega) = 1.9$

8.2:

A common gate amplifier is given in Fig.2.

(a) Draw the internal capacitors of the circuit.
(b) Simplify the circuit by merging the capacitors.
(c) Is there any floating capacitor in the circuit?
(d) If yes, how to decompose the floating capacitor into two capacitors connected to AC ground by using Millers theorem?

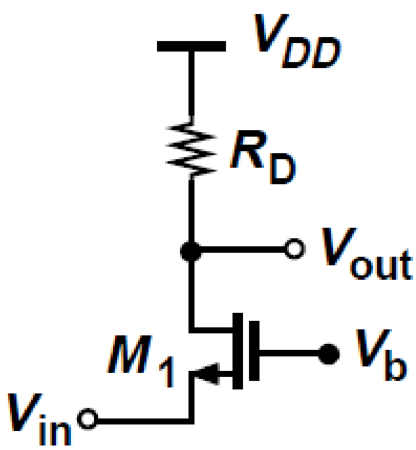
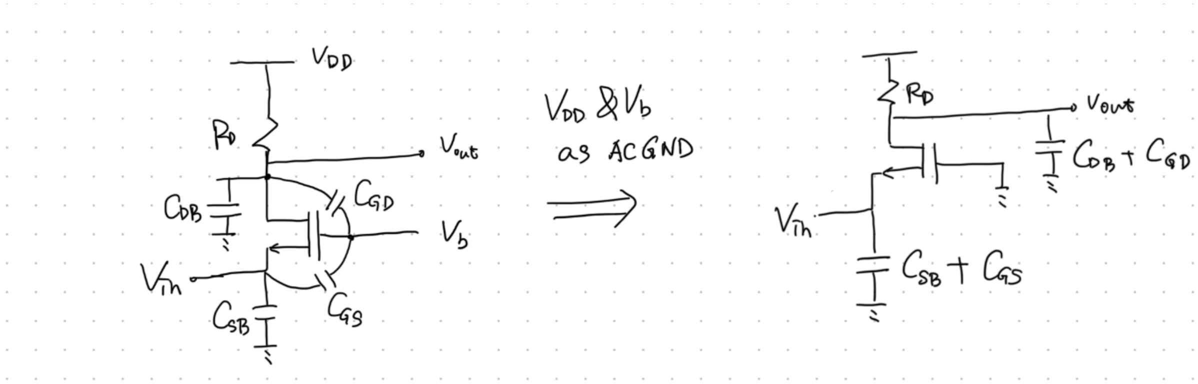


Fig. 2 A common gate amplifier

Solution:



No floating capacitor in the circuit.