Second SPICE Exercise

Fundamentals Of Electronics - a.a. 2018-2019 - University of Padua (Italy)

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Contents

Chapter 1

Analytic solution

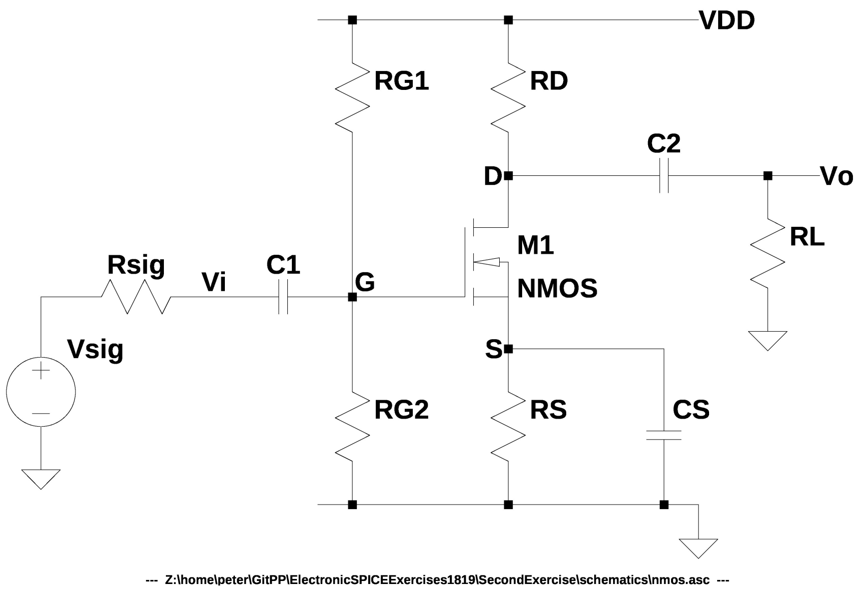

Figure 1.1: NMOS common source amplifier

Designing the common source amplifier of the figure 1.1 .
The MOSFET should have a $V_t = 1V$, a $K_n = 4mA/V$ and a $\lambda = 0$.
Other requested parameters are: $I_{DQ} = 0.5mA$, $V_S = 3.5V$, $V_D = 11V$, $V_{DD} = 15V$ and $R_{G2} = 1097752\Omega$.

1.1 Designing by a DC analysis

On a Direct Current analysis the capacitances can be considered as open circuits, the inductances can be considered as short circuits, the signal and the load are removed and the alternate inputs are not considered. The figure 1.2 represents the circuit for the DC analysis.

1.1.1 R_D

$$V_D = V_{DD} - R_D I_D \tag{1.1}$$

$$R_D = \frac{V_{DD} - V_D}{I_D} \tag{1.2}$$

$$R_D = \frac{15V - 11V}{0.5mA} = 8k\Omega \tag{1.3}$$

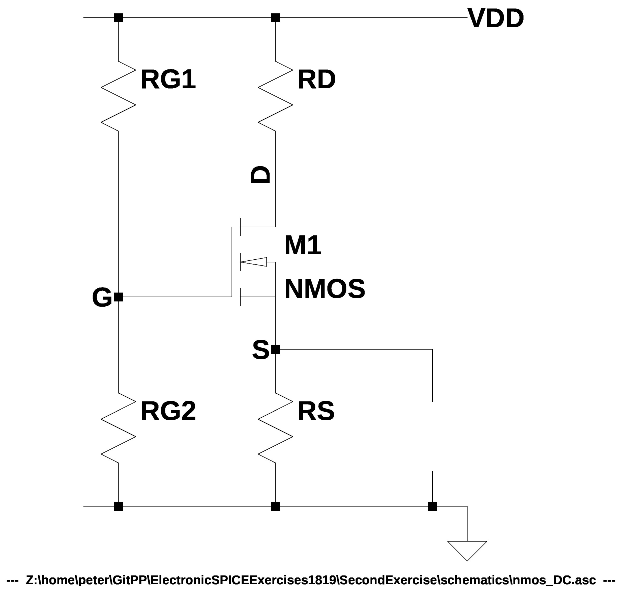

Figure 1.2: NMOS common source amplifier - DC analysis

1.1.2 R_S

$$V_S = R_S I_D \implies R_S = \frac{V_S}{I_D} \tag{1.4}$$

$$R_S = \frac{3.5V}{0.5mA} = 7k\Omega \tag{1.5}$$

1.1.3 V_{GS}

$$I_D = \frac{1}{2} K_n V_{ov}^2 \implies V_{ov} = \pm\sqrt{\frac{2I_D}{K_n}} \tag{1.6}$$

$$V_{ov} = \pm\sqrt{\frac{2 \cdot 0.5mA}{4mA/V^2}} \tag{1.7}$$

$$V_{ov} = \begin{cases} +0.5V & \text{Real value of } V_{ov}. \\ -0.5V & \text{No physical sense.} \end{cases} \tag{1.8}$$

$$\tag{1.9}$$

$$V_{ov} = V_{GS} - V_t \implies V_{GS} = V_{ov} + V_t \tag{1.10}$$

$$V_{GS} = 0.5V + 1V = 1.5V \tag{1.11}$$

$$\tag{1.12}$$

1.1.4 R_{G1}

$$V_{GS} = V_G - V_S \implies V_G = V_{GS} + V_S \tag{1.13}$$

$$V_G = 1.5V + 3.5V = 5V \tag{1.14}$$

$$\tag{1.15}$$

$$I_G R_{G2} - V_{GS} - I_D R_S = 0 \implies I_G = \frac{V_{GS} + I_D R_S}{R_{G2}} \tag{1.16}$$

$$I_G = \frac{1.5V + 0.5mA \cdot 7k\Omega}{1097.752k\Omega} = 4.5547628\mu A \simeq 4.55\mu A \tag{1.17}$$

$$\tag{1.18}$$

$$R_{G1} = \frac{V_{DD} - V_G}{I_G} \tag{1.19}$$
$$= \frac{15V - 5V}{4.5547628\mu A} \tag{1.20}$$
$$= 2.19550M\Omega \simeq 2.20M\Omega \tag{1.21}$$

1.1.5 g_m

$$g_m = K_n V_{ov} = 4mA/V^2 \cdot 0.5V = 2mA/V \tag{1.22}$$

1.1.6 r_0

$$r_0 = \frac{1}{\lambda I_D} \xRightarrow{\lambda=0} r_0 = \infty \quad r_0 \text{ is considered an open circuit.} \tag{1.23}$$
$$\tag{1.24}$$

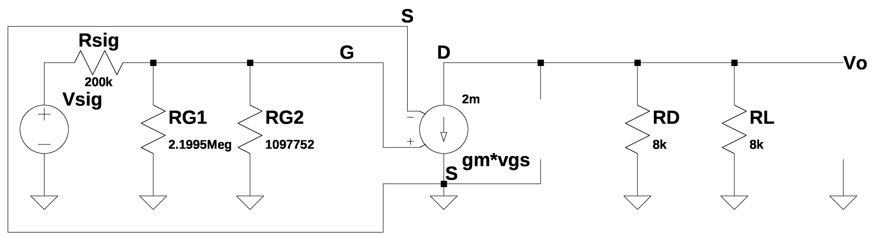

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Figure 1.3: NMOS common source amplifier - AC analysis

Chapter 2

SPICE simulations