

EE2005 Electronic Devices and Circuits

Tutorial 2 @ Week5

Q1: In an NMOS, what is the name given to the minimum gate voltage for the NMOS to turn on?

Q2: Once the gate voltage is above the minimum value described in Q1, how does increasing the gate voltage affect the drain current?

Q3: If V_{GS} is above the value described in Q1 and kept fixed, increasing V_{DS} will cause the I_D to increase at the same rate for all values of V_{DS} .

TRUE / FALSE

Q4: Explain the difference between V_{DS} and v_{ds} in a MOSFET amplifier.

Q5: In the small-signal equivalent circuit of a FET amplifier, DC voltage sources in the circuit should be replaced with what?

Q6: For the circuit in figure 6a, given $R_1 = R_2 = 100\text{k}\Omega$, $R_D = 2\text{k}\Omega$, $R_S = 400\Omega$, $V_{DD} = 10\text{V}$, $I_D = 2\text{mA}$, 10mS , and assume r_o is infinite.

a) Find V_{GS} and V_{DS} . (4.0V, 5.2V)

b) Find the input resistance in the passband, R_{in} . (50K Ω)

c) Draw the small-signal equivalent circuit using the small-signal model in figure 6b. Hence, determine the voltage gain A_v of the amplifier. ($A_v = -4$)

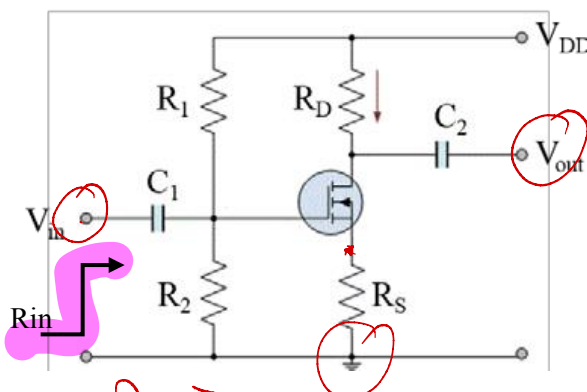


Figure 6a

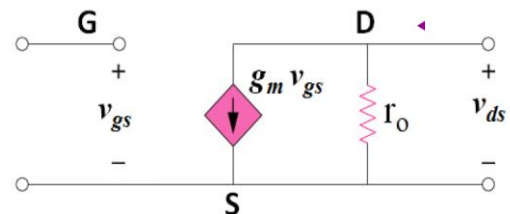
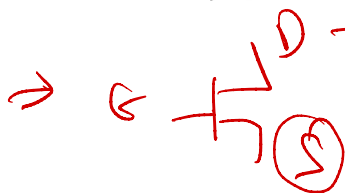
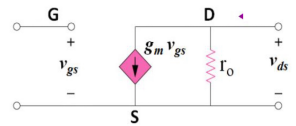
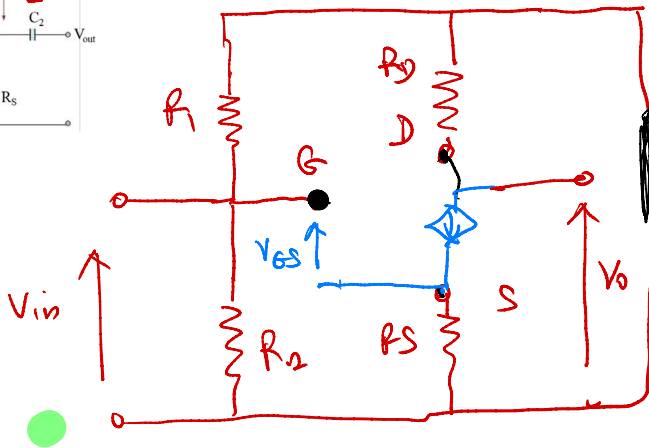
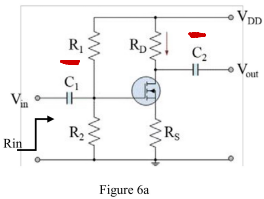


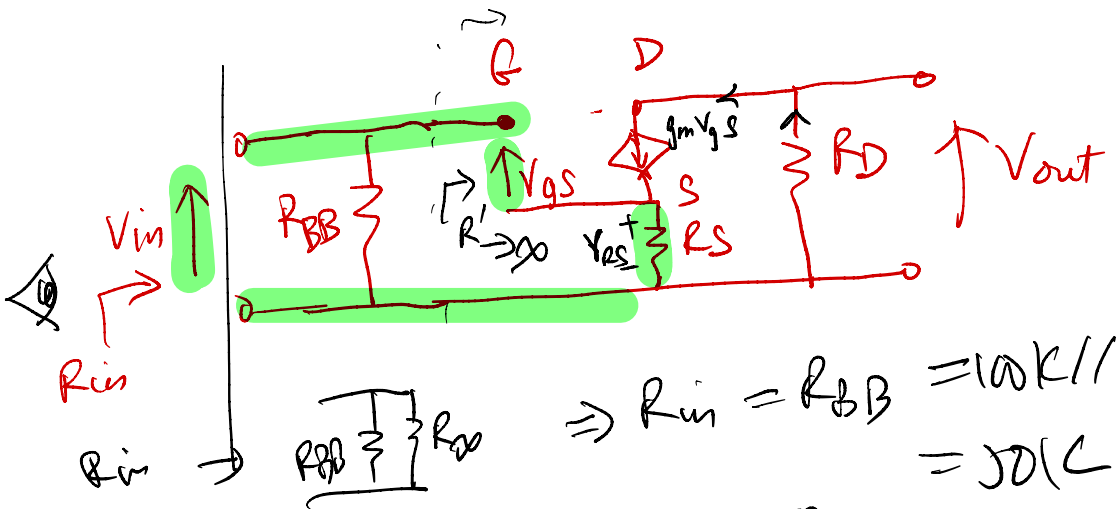
Figure 6b



common source amplifier



$$R_{BB} = R_1 \parallel R_2$$



$$A_v = \frac{V_{out}}{V_{in}} ; \quad V_{out} = -g_m V_{gs} R_D \quad \text{--- (1)}$$

$$V_{in} = V_{gs} + V_{RS} \quad \text{--- KVL}$$

$$V_{RS} = g_m V_{gs} R_S$$

$$V_{in} = V_{gs} + g_m R_S V_{gs} = V_{gs} (1 + g_m R_S) \quad \text{--- (2)}$$

$$A_v = \frac{-g_m V_{gs} R_D}{V_{gs} (1 + g_m R_S)} = \frac{-g_m R_D}{1 + g_m R_S}$$

if $R_S = 0$; $A_v = -g_m R_D$

Q7: The circuit in figure 7a is called a **source voltage follower**. Assume r_o is infinite:

- a) Draw the small-signal equivalent circuit using the hybrid-pi model in figure 7b. Then express the voltage gain $A_v = V_{out}/V_{in}$ in terms of the circuit and MOSFET parameters. You may simplify your answer by making some reasonable assumption. Can you get the reason why it is being called as a source voltage follower.

Ans: $A_v \sim 1$

- b) Express the input resistance in the passband, R_{in} , in terms of the circuit and MOSFET parameters.

Ans: $R_{in} = R_1 // R_2$

- c) Repeat (a) and (b) with the circuit in figure 7c.

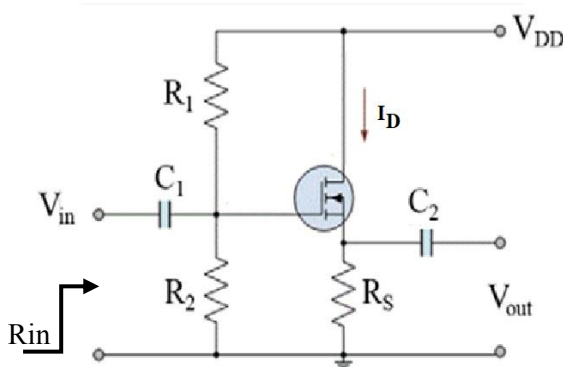


Figure 7a

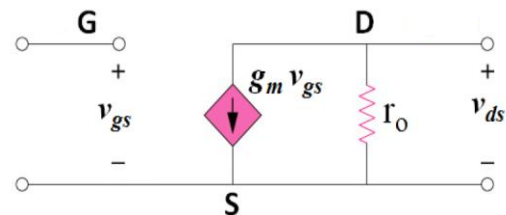


Figure 7b

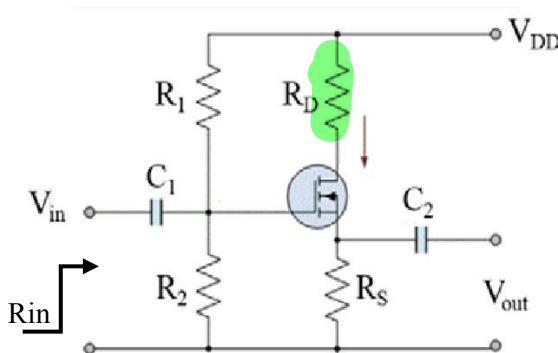
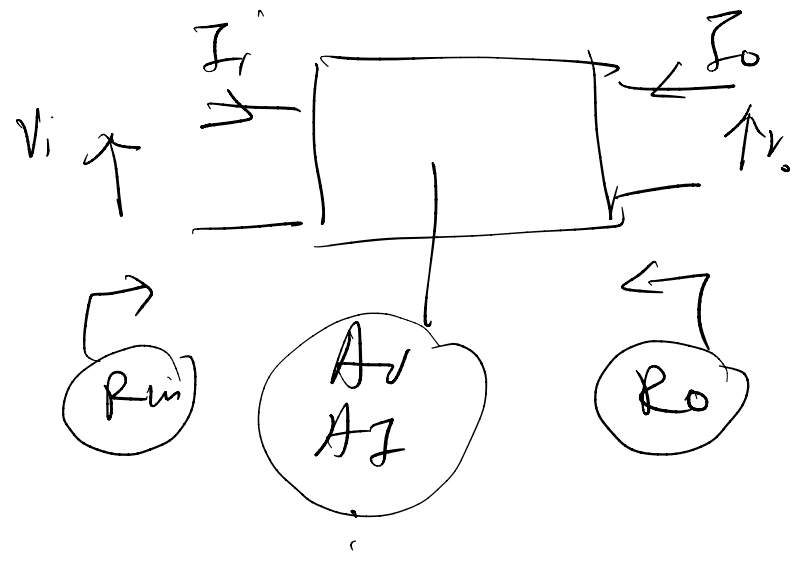
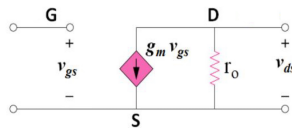
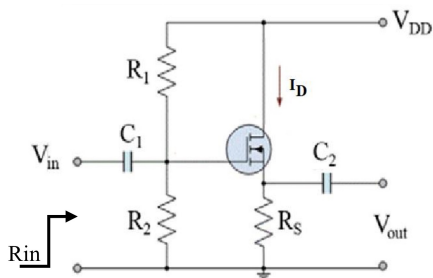


Figure 7c





$$A_v = \frac{V_{out}}{V_{in}}$$

$$V_{out} = g_m V_{gs} R_S \quad (1)$$

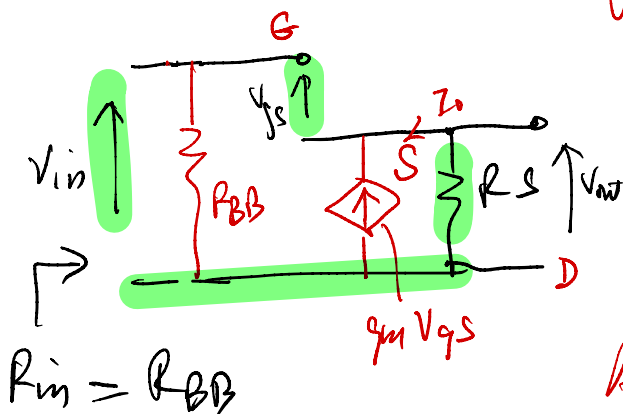
$$V_{in} = V_{gs} + V_{RS}$$

$$\uparrow$$

$$g_m V_{gs} R_S$$

$$V_{in} = V_{gs} + g_m V_{gs} R_S$$

$$= V_{gs} (1 + g_m R_S) \quad (2)$$



$$R_{in} = R_{BB}$$

$$A_v = \frac{V_{out}}{V_{in}} = \frac{g_m V_{gs} R_S}{V_{gs} (1 + g_m R_S)}$$

$$A_v = \frac{g_m R_S}{1 + g_m R_S}$$

$$g_m R_S \gg 1$$

$$A_v \approx 1$$

