National Taiwan Normal University

CSU0007 - Basic Electronics Homework 5

100 points total. Due on 9AM, Monday, 6/8/2020.

Submit your answer via Moodle. Clearly state your analysis to earn full score.

Please tweak your image files to help save some ink! For example, grey-out the background color. Thanks!

請影像處理您的作業照片以節省列印墨水 (例如把背景顏色調淡)~ 謝謝!

We assume all MOSFETs have V_T=1 V, K=1 mA/V^2, and we use the SCS model.

1 Explain the following concepts in your own words. You may use figures to illustrate your points.

1.1 (10 points) Suppose that the MOSFET is in the cutoff region. If we fix voltage V_{DS} (and suppose that $V_{DS} > 0$) and gradually increase voltage V_{GS}, the MOSFET will move to the other two regions in the following order: $\rightarrow$ saturation $\rightarrow$ triode.

1.2 (10 points) Suppose that the MOSFET is in the triode region. If we fix voltage V_{GS} and gradually increase voltage V_{DS}, the MOSFET will move to the saturation in the end.

2 Consider the MOSFET circuit in Figure 1 and answer the following questions.

2.1 (10 points) Suppose V_{in}=3 V. Then i_{DS} = ?

2.2 (10 points) Suppose V_{in}=3 V, V_{out}=5 V, and R_L=10 kΩ. Then V_S = ?

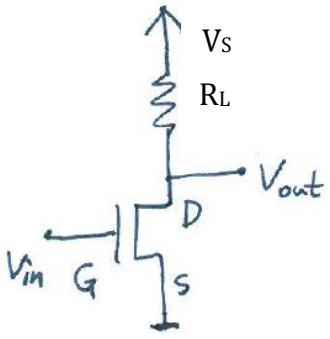


Figure 1

3 Consider the MOSFET circuit in Figure 2.

3.1 (5 points) Suppose V_2=4 V. What would be the range of V_1 for the MOSFET to operate in the saturation region?

3.2 (5 points) Suppose that the MOSFET is operating in the triode region. Could we make the MOSFET to move into the saturation region by just increasing V_2? If your answer is yes, give the range of V_2.

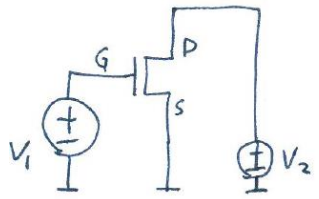


Figure 2

4 (10 points) Consider the MOSFET amplifier in Figure 3. Assume the MOSFET is operating in the saturation region. Suppose V_S=15 V, R_L=5 kΩ, and V_{in}=3V. Compute the gain for this configuration.

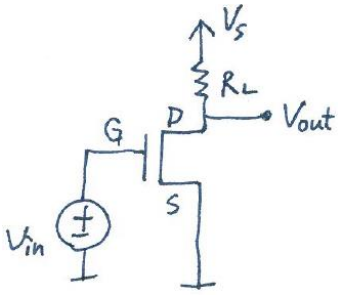


Figure 3

5 Consider the MOSFET amplifier in Figure 4. Suppose that the MOSFET is in the saturation region, and V_S=15 V, R_1=5 kΩ, R_2=10 kΩ, and R_3=2 kΩ. (Note: If you've downloaded the earlier version of the lecture note, make sure you've made the following correction: the last equation on page 77 should have a square over the parenthesis.)

5.1 (5 points) If V_{in}=8 V. Find V_{out}.

5.2 (5 points) Find the minimum value of V_{in} for the MOSFET to stay in the saturation region.

5.3 (5 points) If we can change R_3, what is the maximum value of R_3 for the MOSFET to stay in the saturation region?

5.4 (5 points) What is the maximum V_{in} that will make the gain larger than or equal to 1?

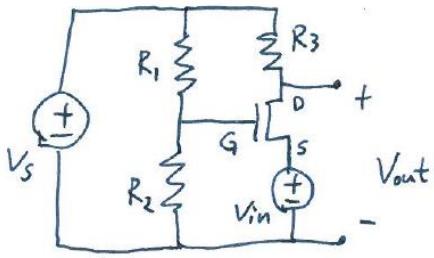


Figure 4

6 Consider the MOSFET amplifier in Figure 5.

6.1 (5 points) Apply the graphical analysis to explain the following phenomenon: if we decrease R_L, then the same V_{in} will produce a larger V_{out}.

6.2 (5 points) Apply the graphical analysis to illustrate an example that if we increase V_T, the valid range of V_{in} for the MOSFET to stay in the saturation region will decrease.

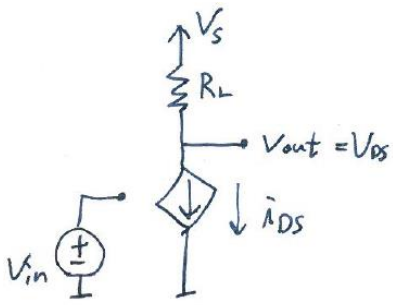
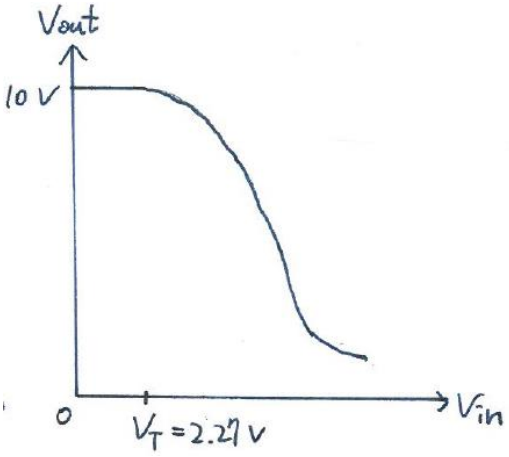


Figure 5

7 Apply the graphical analysis for the following two questions. Consider the MOSFET amplifier in Figure 5.

7.1 (5 points) Suppose the following plot of V_{out}-V_{in} relation is accurate. To estimate the maximum V_{in} for the MOSFET to stay in the saturation region, which one of the following three estimation is better than the other two, and why? (A) 4.2 V; (B) 6.8; (C) 8.1.



7.2 (5 points) Following Question 7.1, suppose V_{GSmax} in the following plot is our estimation of the maximum V_{in}. Determine the value of V_Z.