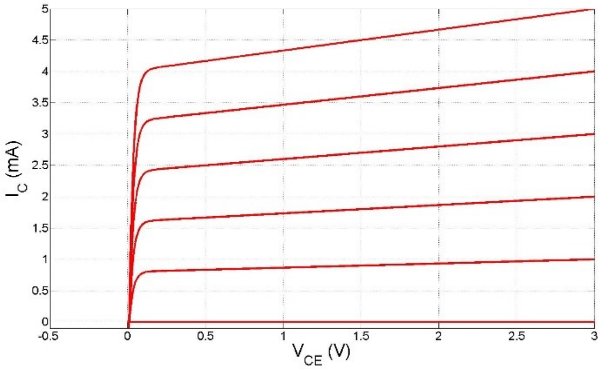
Exam – modern electronics (ETIN70) 2016-10-25 14.00-19.00

GOOD LUCK!
Total number of points = 20
Johannes Svensson, 0768-539891

---

1. BJTs (2p)

In an ideal BJT, I_C should be constant with increasing V_{CE} in the forward active mode. However, in reality the characteristics in the figure below can be obtained.



a) What is the name and origin of the effect causing I_C to not saturate? You are welcome to draw images to explain. (1 p)

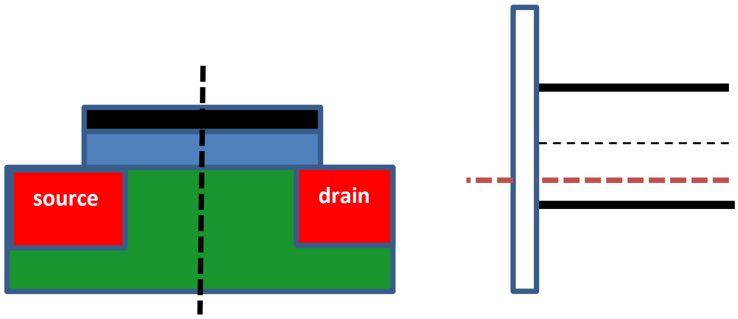
b) Describe <u>two</u> different modifications you can do in the device design to reduce this effect. Motivate your answers. What detrimental effects (if any) would your suggested modifications have on the transistor performance? (1 p)

2. MOSFETs I (4p)

a) Three different Si n-MOSFETs have been measured and the results can be seen in the table below. The source is grounded (V_S=0 V). Fill out the missing information in each row. Note that device 1 has been measured at two different bias conditions. You should present your full calculations for the values and motivate your answers for the operating modes. The three possible operating modes are cut-off, saturation and linear. $k'*(W/L) = 44$ mA/V^2 for all the devices. (2 p)

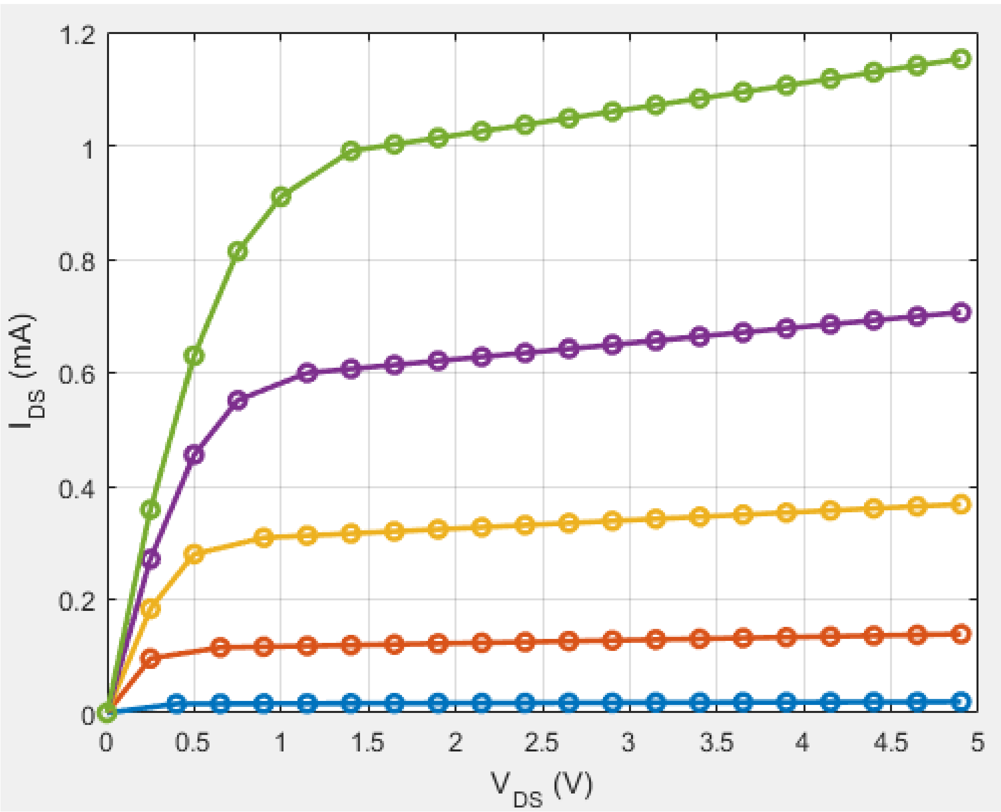
Device	V_t [V]	λ [V^{-1}]	V_{GS} [V]	V_{DS} [V]	I_D [mA]	Operating mode
1	**???**	**???**	2.5	2.5	198	**???**
1	**???**	**???**	2.5	3.5	206.8	**???**
2	-0.5	0.02	1	**???**	55	**???**
3	1	0.005	0.8	3	**???**	**???**

b) Consider device 2 and 3 (at the corresponding bias conditions) in problem 2a. Sketch the band structure perpendicular to the transport direction (similar to the right image) for the position indicated by the dashed line in the figure to left. Make sure you draw the Fermi level position with respect to the bands correctly and indicate any differences for the two cases. (2p)



3. MOSFETs II (2p)

A n-MOSFET with W=12 μm, L=1.5 μm, V_t=0.6 V and μ_n=350 cm^2/Vs has the following output characteristics for V_{GS}= 0.75, 1, 1.25, 1.5, 1.75 V.

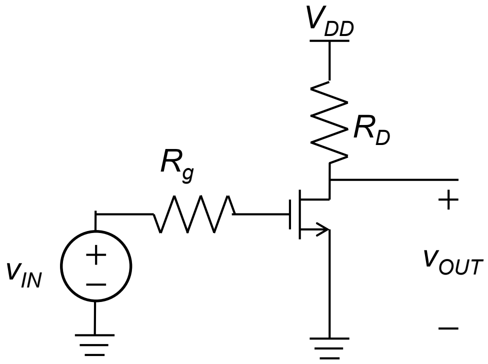


(a) Plot the transconductance as function of V_{GS} at V_{DS}= 3 V. (1 p)

(b) Calculate the thickness of the SiO_2 gate dielectric. (1 p)

4. Amplifiers I (5p)

A basic common-source amplifier is shown below.



(a) Draw the schematic small-signal equivalent circuit. (1p)

(b) Calculate the Miller capacitance. (1p)

(c) What is the physical origin of the Miller capacitance? (1)

(d) Derive the frequency-dependent transfer function $H(s)=v_o/v_{in}$ (2p)

5. Amplifier II (3p)

Calculate the -3-dB frequency of the small-signal voltage gain of the MOS common-source stage shown above in task Amplifier I. Use the following NMOS transistor data:

R_g=10 kΩ, R_L=5 kΩ, C_{gd}=20 pF, C_{gs}=30 pF, I_d=10 mA, W=100 µm, L=2 µm, k'= 60µA/V^2 (3p)

6. Amplifiers III (4p)

During the course a number of single transistor amplifiers as well as more advanced transistor coupled amplifiers have been discussed. Draw the basic configuration of four different amplifiers and discuss the advantages and characteristic features for the four different amplifiers! (4p)