Written exam
IE1206 Embedded Electronics
IF1330 Electrical principles
Friday 23/8 2019 14.00-18.00

General Information
Examiner: Carl-Mikael Zetterling
Responsible teacher at exam: Per-Erik Hellström 08-790 43 25

All sheets that are handed in need your name and personal number written on them.
Mark every sheet with the problem it deals with.
You cannot have more than one problem per sheet.

Aids: Calculator
The exam consists of 8 problems (5 points each) distributed over the 4 modules in the course:
Module 1: problem 1 and 2
Module 2: problem 3 and 4
Module 3: problem 5 and 6
Module 4: problem 7 and 8

To pass the exam requires at least 2 points from each module and preliminary 20 points in total.
Grades are given as follows:

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<th>Points</th>
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<td>Grades</td>
<td>F</td>
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1.  \( R_1=2 \, \text{k}\Omega, \, R_2=3 \, \text{k}\Omega, \, R_3=2 \, \text{k}\Omega, \, R_4=3 \, \text{k}\Omega, \, R_5=0.5 \, \text{k}\Omega, \, I_A=1 \, \text{mA}, \, V_B=5 \, \text{V} \, , \, I_C=4 \, \text{mA} \)
   
   (A) Determine the voltage \( V_N \).
   
   (B) What is the power consumed in \( R_3 \)?

2.  Determine the Thévenin equivalent circuit seen at A-B.
   \( I_0=3 \, \text{mA}, \, V_1=4 \, \text{V}, \, R_0=2 \, \text{k}\Omega, \, R_1=8 \, \text{k}\Omega, \, R_2=4 \, \text{k}\Omega \).

3.  Determine the current \( I_2 \). The diode can be treated as an ideal diode with a threshold voltage \( V_T=0.7 \, \text{V} \). \( I_0=500 \, \mu\text{A}, \, R_1=R_2=5 \, \text{k}\Omega \).
4. Assume that the operational amplifier is ideal. \( R_1 = 10 \, k\Omega \), \( R_2 = 30 \, k\Omega \) and \( R_L = 32 \, k\Omega \).

(A) Determine the power dissipated in \( R_L \) when \( V_{in} = 2 \, V \).

(B) Determine \( V_L \) when \( V_{in} = 5 \, V \).

5. The switch has been open for a long time. At \( t=0 \) s the switch closes.

(A) Derive an expression for \( I_1(t) \) for \( t > 0 \) s in terms of \( I_0 \), \( R_0 \), \( R_1 \) and \( C_1 \).

(B) At what time \( t_1 \) is \( I_1(t_1) = 1 \, mA \) assuming \( I_0 = 12 \, mA \), \( R_0 = 1 \, k\Omega \), \( R_1 = 3 \, k\Omega \) and \( C_1 = 20 \, nF \).
6. The switch has been closed for a long time. At $t=0$ s the switch opens. $I_0=30$ mA, $R_0=1$ kΩ, $R_1=9$ kΩ, $R_2=10$ Ω. 
Determine $L$ so that $V_L(t=1 \text{ ms}) = 0.5V_L(t=0^+ \text{ s})$

![Diagram](image)

7. $V_A(t)$ is a steady-state cosine voltage source with amplitude 2 V, angular frequency $\omega=10^6$ rad/s and phase angle $\phi=0^\circ$. $L=1$ mH, $R_3=1$ kΩ and $C_1=1$ nF.
Determine $V_R(t)$.

![Diagram](image)

8. (A) Determine the Norton equivalent circuit seen at A-B when $V_A$ is a steady state cosine voltage source with amplitude=180 V and phase angle=90°. 
(B) Determine the components and their values and draw the Norton equivalent circuit when $\omega=1000$ rad/s.

![Diagram](image)
Answers to exam 20190823 in IE1206 and IF1330

1A: VN=5V
1B: PR3=50 mW
2: VTH=8 V, RTH=6.8 kOhm
3: I2=0.14 mA
4A: PRL=2 mW
4B: VL=15 V
5A: I1=Io*(R0/(R1+R0))*(1-exp(-t/tau)), tau=(R0//R1)*C1
5B: t1=6.1 µs
6: L=14.4 mH
7: VR(t)=2cos(wt-90) (or -pi/2)
8B: In the schematic R=12 Ohm and C=41.6 µF and Ino=3cos(wt+90) (or pi/2)