Fondamenti di Elettronica - Ingegneria Elettronica – a.a. 2014/15
Unscheduled Examination – May 7th, 2015

State clearly the question you are answering. E.g. 1a).
Solve first questions in bold. This is a 3-hour in-class closed-book exam.

Exercise 1

Let's consider again the circuit shown in Fig. 1a.

a) **Draw in a time diagram, providing values for all the relevant points, the curve of the current $I_{out}(t)$, when the input voltage is the one shown in Fig. 1b *(periodic)*, if $T = 48\ ms$. Provide justification for your answer.**

b) Draw in a time diagram, providing values for all the relevant points, the curve of the voltage $I_{out}(t)$, when the input voltage is the one shown in Fig. 1b *(periodic)*, if $T = 2.4\ ms$. Provide justification for your answer.

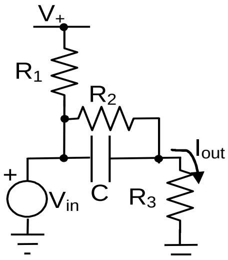


Fig. 1a

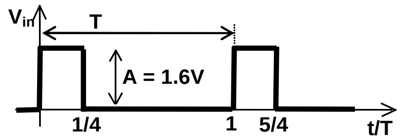


Fig. 1b

$R_1=1k\Omega$

$R_2=3k\Omega$ $\quad R_3=4k\Omega$

$C=200nF$ $\quad V_+=+3V$

Exercise 2

Let's refer to the MOSFET circuit shown in Fig. 2. i_{in} is a small signal current generator.

a) **Find the value of resistor R_s that provides *1 mA* static current in the transistor. Find, then, the circuit bias point (i.e. the DC voltages at all the nodes and the DC current in all the branches).**

b) **Find the small-signal transfer function v_{out}/i_{in} at high frequency (C e C_2 short-circuited).**

c) Draw the magnitude Bode diagram of the transfer function v_{out}/i_{in}.

d) Find the maximum current amplitude, in the case of a sinusoidal signal at *5 Hz* frequency, that ensures a linearity error below or equal to 4%.

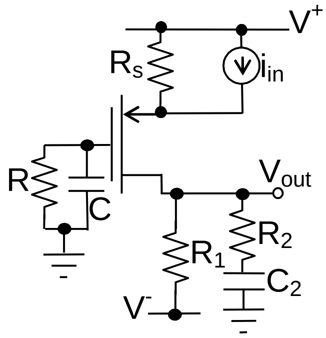


Fig. 2

$V+ = -V^- = 4\ V$

$|k_p| = ½\mu_p C_{ox}(W/L)_p = 1\ mA/V^2$

$V_{Tp} = -1\ V$

$R = 2.5\ M\Omega$

$R_1 = 4\ k\Omega$

$C = 220nF$

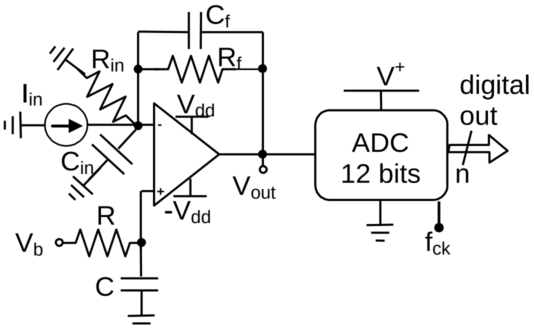
$C_2 = 47nF$

$R_2 = 4\ k\Omega$

$r_0 = \infty$.

Exercise 3

Let's consider the acquisition chain shown in Fig. 3. Let us assume that the operational amplifier saturates at the power supply voltages. The ADC is based on a successive approximation logic.



$V^+ = 2.5\ V$

$V_{dd} = 5\ V$

$R_{in} = 100\ k\Omega$

$R_f = 10\ M\Omega$

$R = 10\ k\Omega$

$C = 1\ \mu F$

$C_f = 2\ pF$

$C_{in} = 5\ pF$

$f_{ck} = 5\ MHz$

a) **Draw the magnitude Bode diagram of the transfer function V_{out}/I_{in} assuming an ideal operational amplifier and $V_b = 0\ V$.**

b) **Find the achievable input resolution when converting a zero-average sinusoidal current with *100 nA* amplitude and *100 Hz* frequency and the required value for the voltage V_b.**

c) Find the maximum frequency of a sinusoidal current signal with maximum amplitude compatible with the ADC dynamic range (assume the proper value of V_b is given) that can be properly digitized with an error below or equal to *1 LSB*.

d) Draw the magnitude Bode diagram of the transfer function V_{out}/I_{in} if the operational amplifier feature a gain-bandwidth product $GBWP = 5\ MHz$, assuming $V_b = 0\ V$.