Lund University
Dept. of Electroscience

ETI 170

Written Exam
Integrated Radio Electronics

2002-03-05 kl. 14-19

The exam consists of 5 problems, which give a maximum of 6 points each. The total maximum is thus 30 points. To pass the course at least 15 points is needed on the exam, and the laborations must be approved.

Important:

- Always start **a new problem on a new page**
- Write **name and page number on all pages**
- Sort the pages before you hand them in
- All assumptions must be motivated
- Finish Your solution with an answer if possible
- The problems are not ordered according to difficulty
- The number of points a problem is worth does not always relate to its difficulty

Allowed to use:

- Textbook
- Table of mathematical and physical formulas and constants
- Data sheet for the CMOS process
- Pocket calculator

Good luck!

Problem 1.

You have an inductor library:

L (nH)	Q	f_s (GHz)
5	15	6
10	10	4
20	6	3.5
30	3	3
50	1.5	2

a. An LNA operating at 2GHz is to be designed and you need an inductor for the output circuit (load). Which of the inductors is to be chosen to achieve the lowest noise? Motivate! (2p)

b. A VCO at 2GHz is to be designed for a supply voltage of 2V. Which inductor gives the lowest possible phase noise? Motivate! (2p)

c. A parallel resonance circuit is designed from the 10nH,Q=10 inductor and a capacitor of 1pF, Q=30. What is the resonance frequency and Q of the resonance circuit? (2p)

Problem 2.

a. A power amplifier is to be connected to a 50Ω antenna using a capacitive tap. The power amplifier has a maximum output voltage swing of $6V_{pp}$ and the maximum output power to be delivered to the antenna is 24dBm. The operating frequency is 1900MHz and the desired bandwidth is 400MHz. Draw the schematic of the matching network, and calculate the component values. (4p)

b. If instead maximum bandwidth is desired, how large bandwidth can be achieved? Calculate the component values and draw the schematic. Can it be redrawn so it looks like another matching network topology, and in that case which? (2p)

Problem 3.

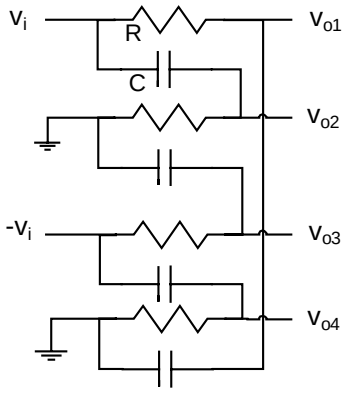

Fig. 1

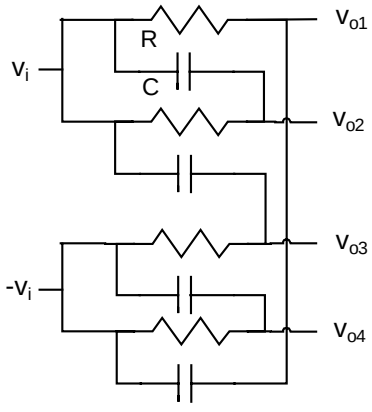

Fig. 2

a. A single stage polyphase filter is used to generate quadrature signals (fig.1). Calculate R and C so the circuit generates quadrature at 1GHz, and has an input impedance Z_i with a magnitude of 500Ω per input. How large are the output signals if the input signal v_i is $1V_{pp}$? (2p)

b. An alternative connection is (fig.2). Without changing R and C, what is the input impedance? How large are the output signals (v_i=$1V_{pp}$)? (2p)

c. Calculate the phase- and amplitude errors in the two circuits at f=1.1GHz. (2p)

Problem 4.

Derive an equation for the noise factor of a common-gate LNA. Neglect all capacitances, since they are assumed to be resonated away at the operating frequency. The amplifier is assumed to be matched to the generator impedance.

a. First just include the thermal noise from the channel as the only noise source except for the noise of the generator resistance. (2p)

b. Now also include the noise from the load. Assume a resistive load R_L. (2p)

c. Eventually include also the noise from the gate resistance, and the bias current source modelled as a resistance R_S between ground and the source-terminal of the transistor. (2p)

Problem 5.

A double balanced mixer (fig.3) is to be designed.

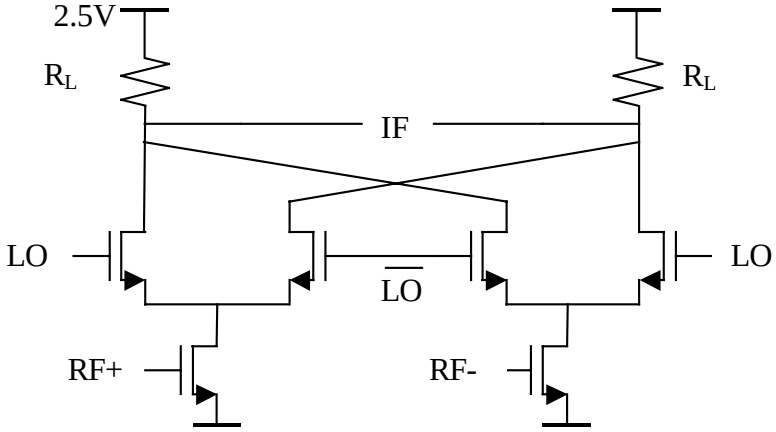

Fig. 3

f_{RF} = 1.8 - 1.9 GHz
f_{IF} = 80 MHz
$G_{c,v}$ = 10 dB
V_{dd} = 2.5V
I_{dc} < 2mA
$V_{in,\,max}$ = 400 mV_{pp}/side

Use the data sheet for the 0.35um CMOS process

a. If high-side injection is chosen, what is the required LO-frequency (band)? (1p)

b. If the switches are assumed to be ideal as long as their drain voltage exceed 1V, calculate R_L and the dimensions of the input transistors. (The signal at $f_{RF} + f_{IF}$ is assumed to be filtered off by the parasitic capacitances, therefore it can be disregarded.) To achieve a sufficiently low noise, the input devices must have a g_m>8mS. (3p)

c. If the threshold voltages (V_T) of the input devices differ by 5mV due to mismatch, how much LO→ IF leakage does it generate? A parasitic capacitance of 400fF to ground per side is assumed. (2p)