EXAMINATION IN

TSEK03

RADIO FREQUENCY INTEGRATED CIRCUITS

Date:	2019-01-07
Time:	14-18
Location:	TER2
Tools:	Calculator, Dictionary
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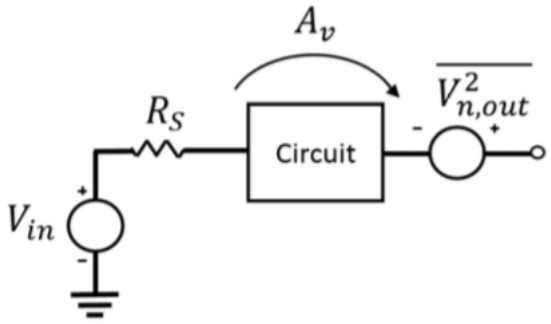
12 points are required to pass.
(12-15: 3, 16-19: 4, 20-24: 5)

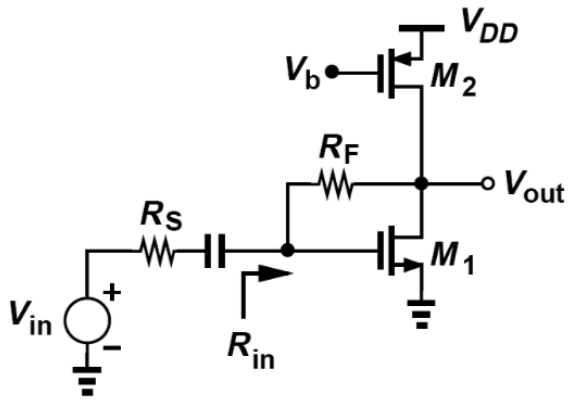
Please start each new problem at the top of a page!
Only use one side of each paper!

1. A circuit exhibits a noise figure of 3 dB.
a) What percentage of the output noise power is due to the source resistance, R_S ? (3 p)
b) Repeat the problem for NF = 1 dB. (1 p)

Use the simplified circuit model shown below.

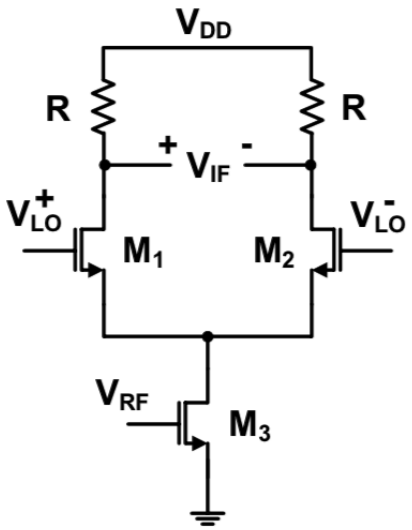


2. A common-source low noise amplifier (LNA) with feedback is shown below. R_S is the input source resistance. Assume that the transistors are long-channel devices.

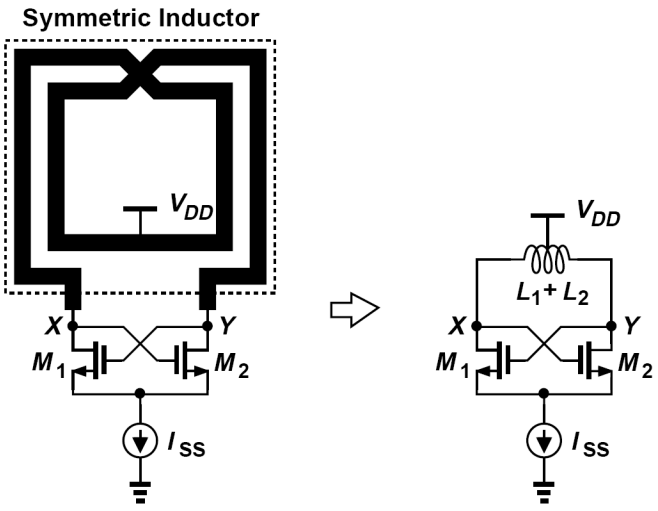


a) Determine the input impedance (R_{in}) of the LNA. (1 p)
b) Calculate the voltage gain of the LNA (i.e., V_{out}/V_{in}) after matching if $R_F = 25\ R_S$. (2 p)
c) Derive an expression for the output noise of the LNA contributed by R_S after matching if $R_F = 25\ R_S$. (2 p)

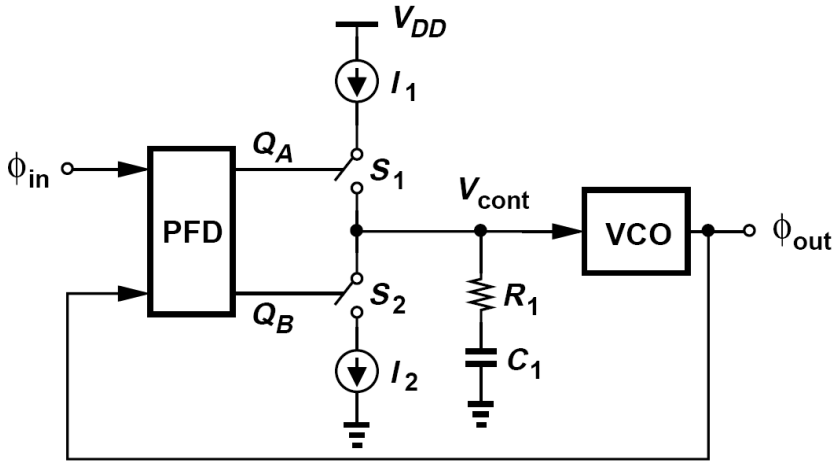
3. A single-balanced mixer is shown below.
If the LO signal is a square wave toggling between 0 and 1 with 50 % duty cycle and LO switching is abrupt, derive an expression for the conversion gain of this mixer. Ignore channel length modulation. (3 p)



4. The symmetric inductor in the figure below has a value of 2 nH (from port X to port Y) and a Q of 5 at 2.45 GHz. $M_1 = M_2$. What is the minimum required transconductance (g_m) of M_1 and M_2 to guarantee startup? (2 p)



5. Derive an expression for the closed-loop phase transfer function, $H(s) = \Phi_{out}(s)/\Phi_{in}(s)$, of the CP-PLL shown below. The transfer function of the VCO is K_{VCO}/s and the transfer function of the PFD/CP is $I_0/(2\pi)$ (I_o is the charge pump current). (4 p)



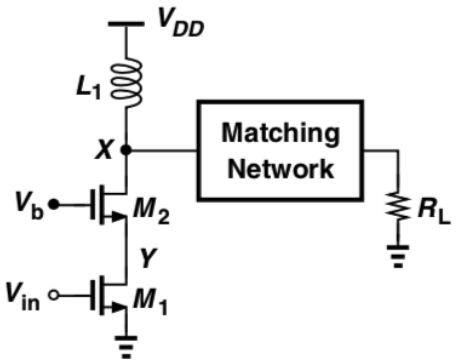
6. A cascode power amplifier is shown below.

24 dBm average output power is to be delivered to the load for an LTE up-link signal (terminal to basestation) with a Peak-to-Average-Power Ratio (PAPR) of 5 dB (peak power is 5 dB higher than the average power). The matching network has an additional loss of 1.5 dB.

a. What is the required peak power in Watts to be delivered by the power amplifier? (1 p)

b. What should be the load at X (looking into the Matching network) to have the PA deliver this peak power into the 50 Ω load using V_{DD} = 1.8 V. (2 p)

c. But wait... why are we using a cascode PA, why not just single transistor (M1) in the amplifier? (1 p)



7. Please provide short answers (no or very short motivations are needed) to the following questions:

a) For RF-circuits, a design aspect is associated with the names Stern or Rollett. What design aspect? (0.5 p)

b) If changing the circuit topology from a single-balanced to a double-balanced mixer, what happens with the conversion gain? (0.5 p)

c) Can the fringe (grid) capacitor used in advanced CMOS processing be used as a varactor? (0.5 p)

d) Circuit types/names like Clapp, Colpitt, and Hartley are associated with a certain type of radio building blocks. What type? (0.5 p)