EXAMINATION IN

TSEK03

RADIO FREQUENCY INTEGRATED CIRCUITS

Date:	2017-06-08
Time:	8-12
Location:	G36
Tools:	Calculator, Dictionary
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12 points are required to pass.
(12-15: 3, 16-19: 4, 20-24: 5)

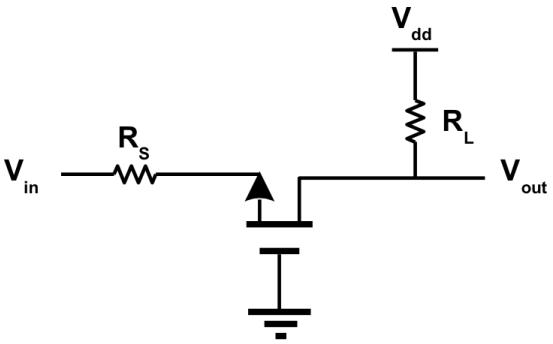
Please start each new problem at the top of a page!
Only use one side of each paper!

1.

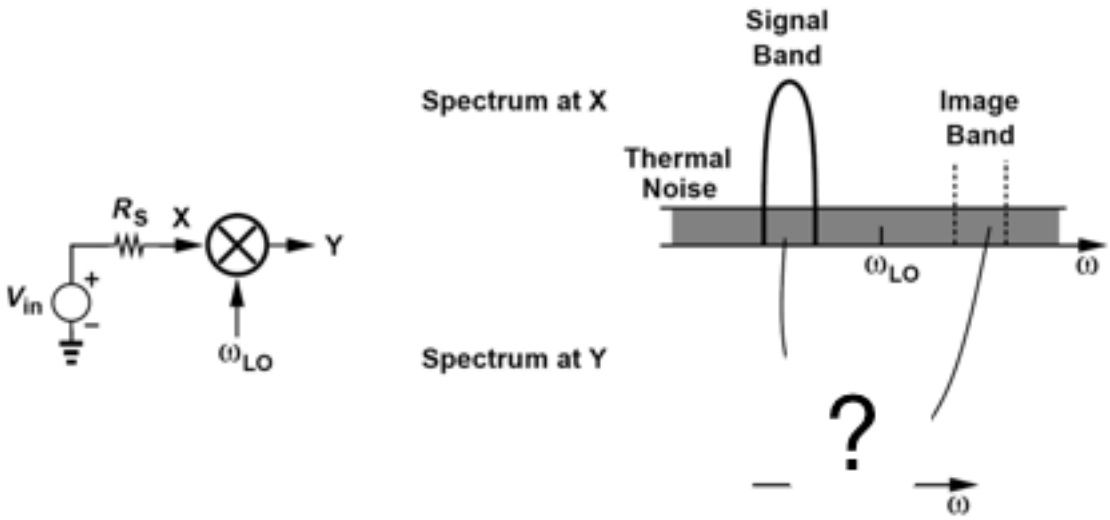
Consider the common-gate broadband amplifier below.

a. Derive an expression for the noise figure in the absence of gate noise. Select the transistor's g_m for use as an LNA. Neglect transistor capacitances, body effect, and channel-length modulation. (3 p)

b. Re-derive the noise figure, now taking gate noise into account. Hint: Model the gate noise using a voltage source of $4kTR_G/3$. (1 p)

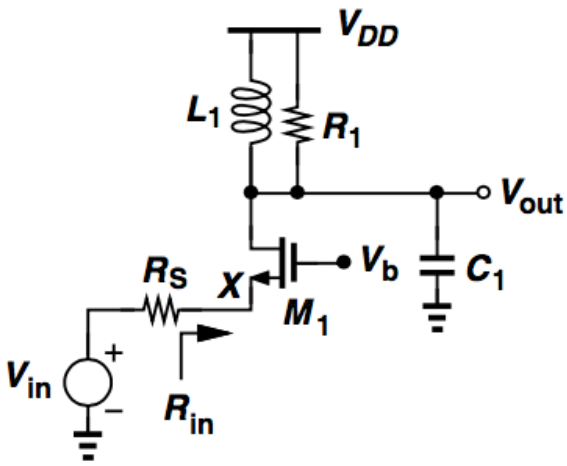


c. What is the noise figure of noiseless downconversion mixer and why? (1 p)



2.

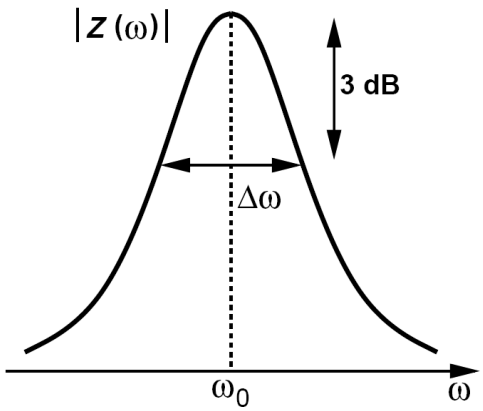
A common-gate LNA is shown below. Derive the noise factor at the output resonance frequency if $g_m \neq R_S$. (4 p)



3.

A WLAN 802.11ac LNA must achieve a -3-dB bandwidth from 4900 to 5900 MHz in order to fulfill a -1-dB bandwidth for different ISM bands (different parts of the world) in this frequency range.

a. If the LNA incorporates a second-order LC tank as its load, what is the maximum allowable tank Q? (2 p)
b. This tank Q is given by the combination of the Q for the L:s and for the C:s. Which component of the L and C typically have the lowest Q (highest losses) when realized on-chip in a typical CMOS process, thus limiting the Q of the tank? (1 p)
c. What are the main sources of the losses in this component (give at least one)? (1 p)

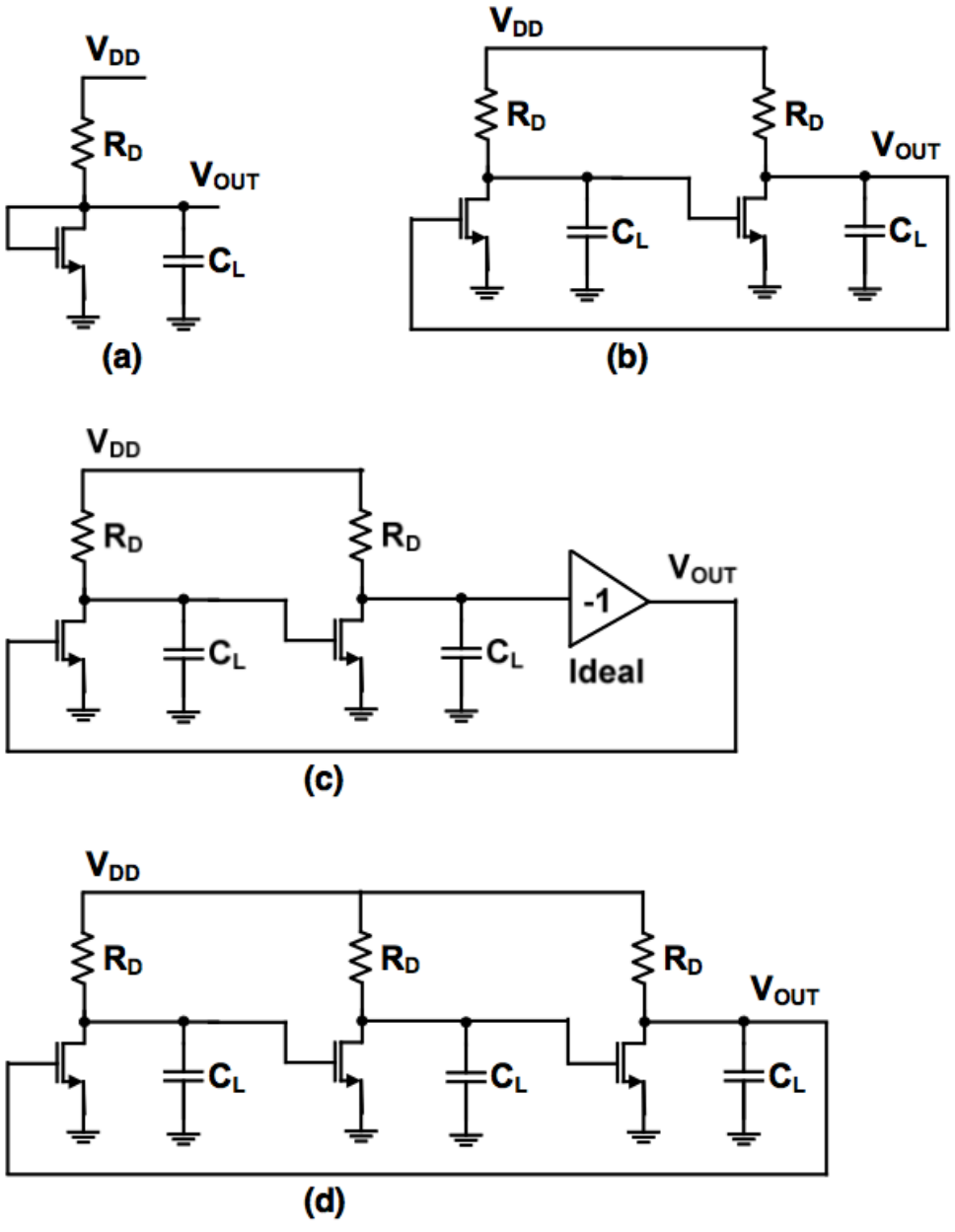


4.

Which of the following circuits oscillate? (4p)

For each circuit, state the reason in terms (some or all) of:

- DC shift,
- frequency dependent phase shift,
- open loop circuit poles,
- total phase shift,
- conclusion: no or possible oscillation.



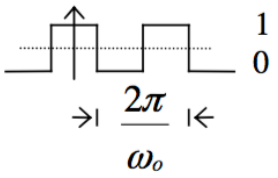
5.

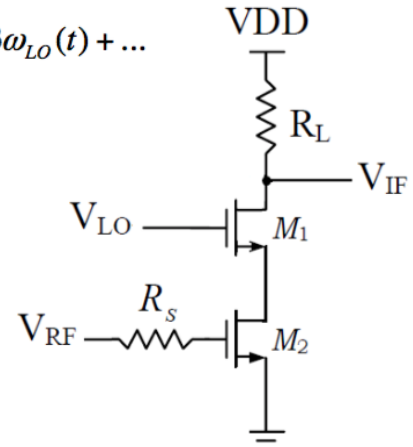
An unbalanced mixer is shown in the figure below. Assume that the switching transistor M_1 is an ideal switch with zero on-resistance. Also assume that the transistors are long-channel devices with $\lambda = 0$.

a. Derive an expression for the conversion gain of this mixer. (2 p)

b. Derive an expression for the noise factor of this mixer. Assume that the switching transistor does not generate any noise. Consider only the thermal noise sources and ignore the gate noise of the transistors. (2 p)

$$i_{LO}(t) = \frac{1}{2} + \frac{2}{\pi}\cos\omega_{LO}(t) - \frac{2}{3\pi}\cos 3\omega_{LO}(t) + \ldots$$





6.

Please answer the following power amplifier questions and with (short) motivations for your answers.

a. Best class for linearity? A or B? (0.5 p)
b. Best class for linearity? A or D (inverter-based class-D)? (0.5 p)
c. Best class for efficiency? A or AB? (0.5 p)
d. Best class for lowest voltage peaks? A or E? (0.5 p)

e. What is the difference between Drain Efficiency (DE or η_D) and Power-Added Efficiency (PAE)? Which one is always higher? (1 p)