EXAMINATION IN

TSEK03

RADIO FREQUENCY INTEGRATED CIRCUITS

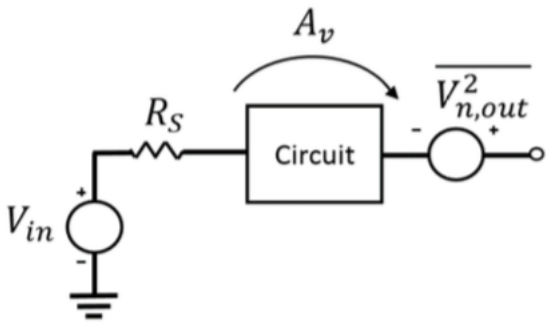
Date:	2018-10-22
Time:	8-12
Location:	G35
Tools:	Calculator, Dictionary
Teachers:	Ted Johansson (070-6270237) Oscar Morales (070-4023671)

12 points are required to pass.
(12-15: 3, 16-19: 4, 20-24: 5)

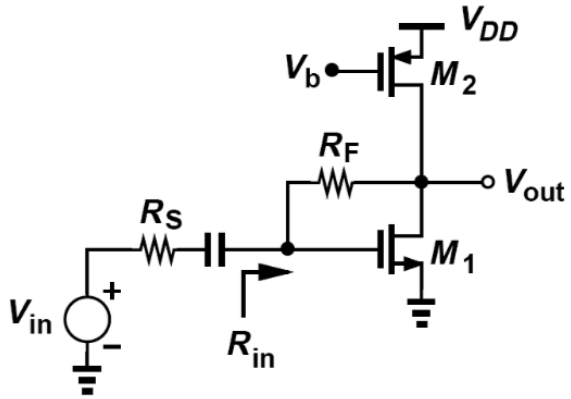
Please start each new problem at the top of a page!
Only use one side of each paper!

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.



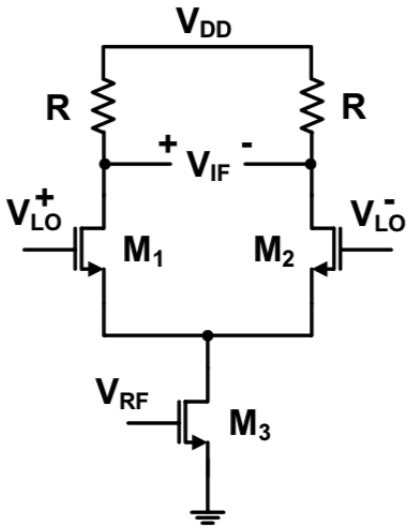
2.
A common-source low noise amplifier (LNA) with feedback is shown below. R_S is the input source resistance. Assume that the transistors are long-channel devices.



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

a) For a well-designed transistor, is the gate noise is higher or lower than the channel noise? (0.5 p)

b) What is the noise figure of noiseless mixer (”single-sideband noise)? (0.5 p)

c) When the colleagues discuss ”fractional spurs” in the coffee room, what kind of circuit and variant are most likely discussed? (0.5 p)

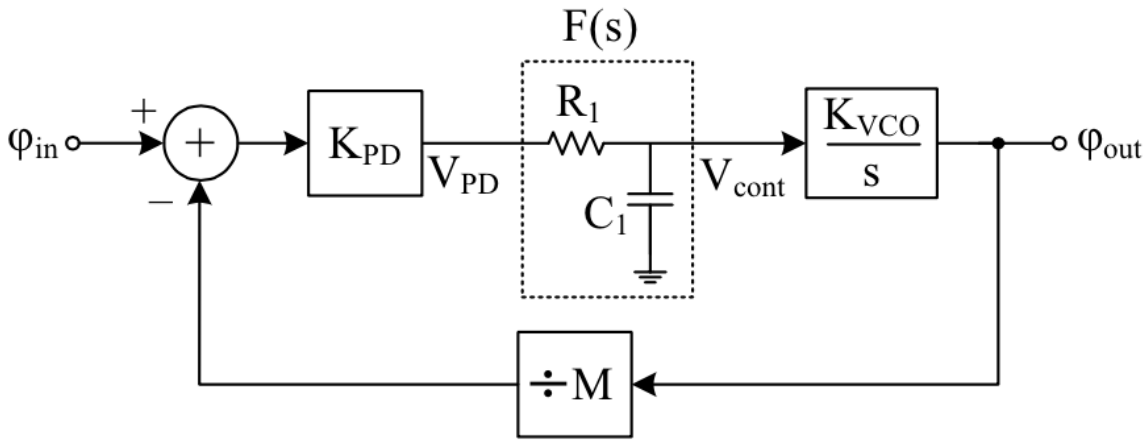
d) A class-C power amplifier can reach 100 % efficiency. Wow! What’s the catch? (catch = ”a hidden problem or disadvantage in an apparently ideal situation”) (0.5 p)

e) If a well-designed inductor has a Q-value of 10 in the WLAN 802.11ac 5 GHz band, estimate the Q when this inductor is used in the WLAN 802.11n 2.4 GHz band. (0.5 p)

f) Why are three-point oscillators less popular in RFIC design than cross-coupled oscillators? (0.5 p)

5.

For the frequency-multiplying PLL shown below, determine the:
a. closed-loop transfer function (2 p)
b. damping factor ζ (1 p)
c. natural frequency ω_n (1 p)
d. loop bandwidth (1 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)