EXAMINATION IN

TSEK03

RADIO FREQUENCY INTEGRATED CIRCUITS

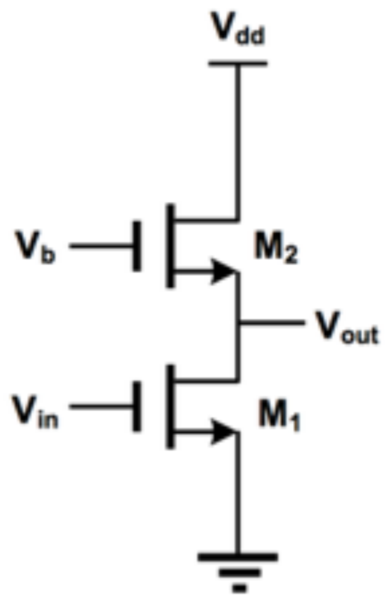
Date:	2016-03-21
Time:	8-12
Location:	TER4
Tools:	Calculator, Dictionary
Teachers:	Ted Johansson (070-6270237) alt. 1223

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 cascode amplifier stage is shown in the figure. Assume that both transistors are long-channel devices, V_b is the bias voltage for M_2, $gm_1 \neq gm_2$ and $\lambda = 0$.



a. Determine the input-referred noise voltage. (4 p)
Consider only the thermal noise sources and ignore the gate noise of the transistors.

b. How should the W/L ratio of M_2 be selected to minimize the noise? (1 p)

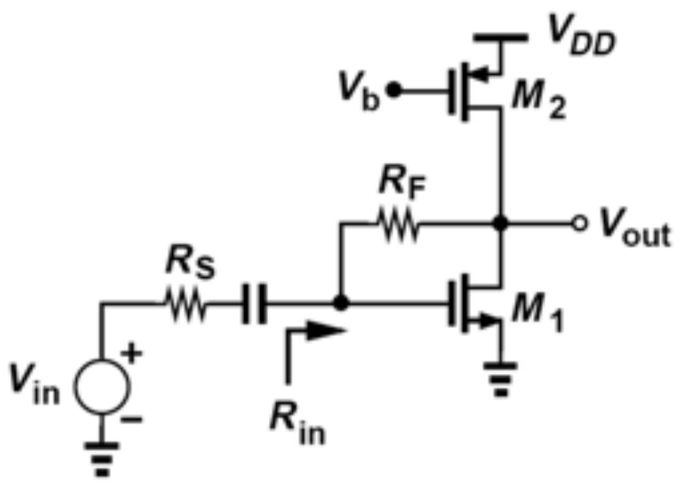
2.

A common-source low noise amplifier (LNA) with feedback is shown in the figure below. R_S is the input source resistance. Assume that the transistors are long-channel devices and $\lambda = 0$.

a. Determine the input impedance (R_{in}) of the LNA. (1 p)

b. Calculate the voltage gain, A = V_{out}/V_{in}, of the LNA after matching if $R_F = 10^*R_S$. (2 p)

c. Derive an expression for the output noise of the LNA contributed by R_S after matching. Assume $R_F >> R_S$. (2 p)



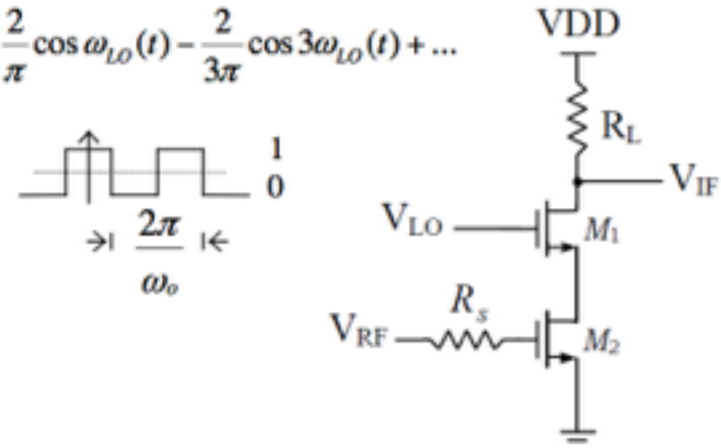
3.

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)

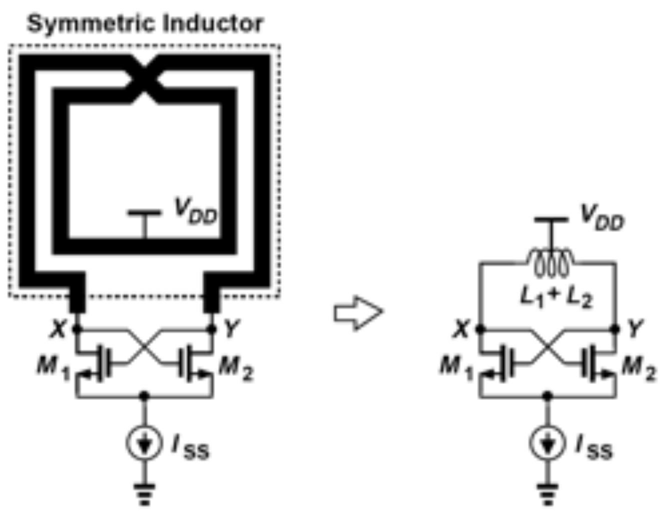
$$i_{LO}(t) = \frac{1}{2} + \frac{2}{\pi}\cos\omega_{LO}(t) - \frac{2}{3\pi}\cos 3\omega_{LO}(t) + \ldots$$



4.

The symmetric inductor in the figure below has a value of 2 nH (from port X to port Y) and a Q of 8 at 2.45 GHz. $M_1 = M_2$.

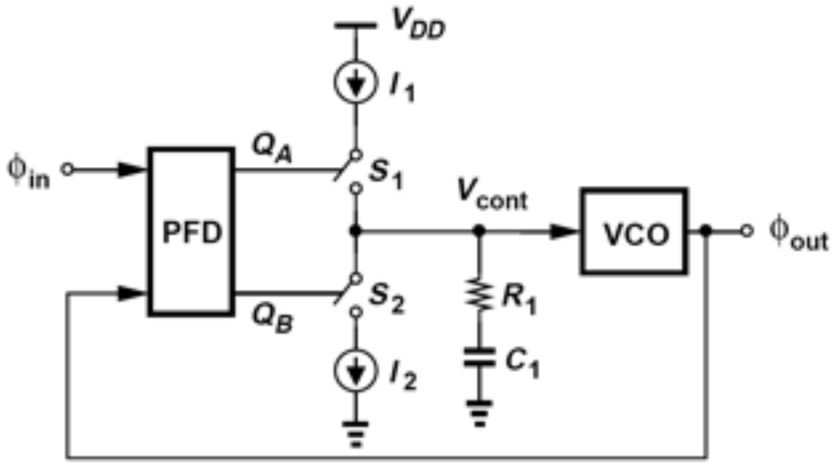
a. What is the minimum required transconductance of M_1 and M_2 to guarantee startup? (2 p)



b. State and explain Barkhausen's criteria for oscillators. (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. The following table lists three different properties for the A, B, C, D, and E power amplifier classes and their typical values. Identify the power amplifier class for each column. (2.5 p)

Maximum drain efficiency [%]	78.5	100	100	100	50
Peak drain voltage [*V_{DD}]	2	2	3.6	1	2
Normalized power output capability [Pout/(max V and I)]	0.125	0.125	0.098	0.32	0.125
Power Amplifer Class					

b. What is "conduction angle" wrt. power amplifiers? (0.5 p)