EXAMINATION IN

TSEK03

RADIO FREQUENCY INTEGRATED CIRCUITS

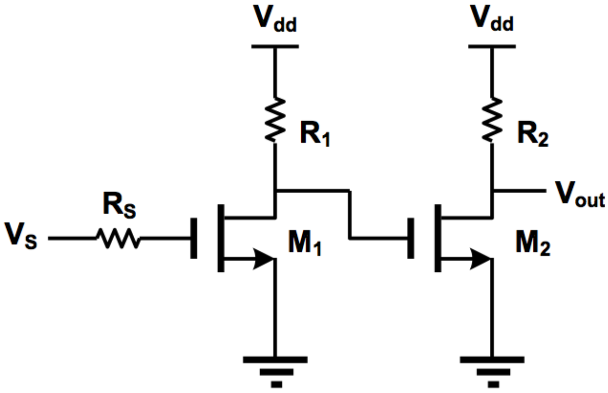
Date:	2017-03-14
Time:	8-12
Location:	TER2
Tools:	Calculator, Dictionary
Teachers:	Ted Johansson (070-6270237) alt. 1223 Oscar Morales (070-4023671)

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!

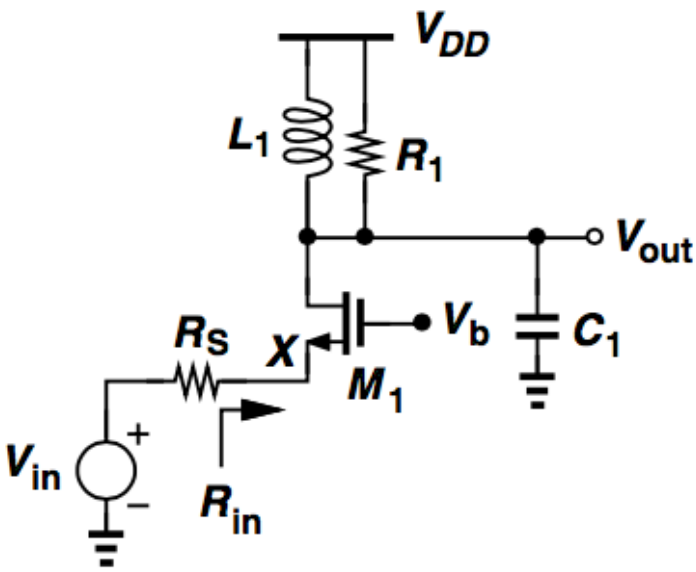
1.

A two-stage amplifier is shown below. Derive the noise factor of this amplifier. Consider only the thermal noise sources and ignore the gate and 1/f noise of the transistors. Assume that R_1 and R_2 are noiseless, ignore all the parasitics, and neglect channel-length modulation. (4 p)



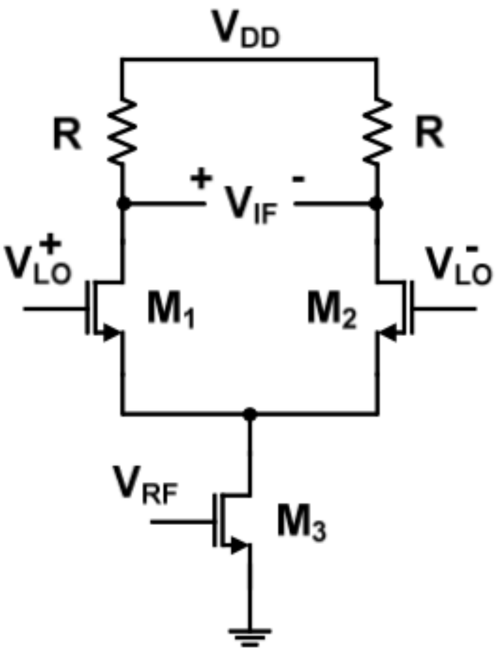
2.

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 single-balanced mixer is shown below. Assume that the switching transistors M_1 and M_2 are ideal switches with zero on-resistance and there is no CLM.



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

b. Derive an expression for the noise factor of this mixer. (3 p)

Assume the switching transistors do not generate noise. The total noise is contributed by transistor M_3, load resistors R and source resistor R_S connected to the RF input (not shown in the figure). Consider only the thermal noise sources and ignore the gate noise of the transistor.

Hints:

i) $\overline{i_{n,M}^2} = 4kT\gamma g_m$

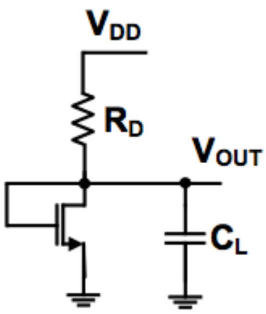
ii) $V_{LO}(t) = \frac{4}{\pi}\cos\omega_{LO}(t) - \frac{4}{3\pi}\cos 3\omega_{LO}(t) + \frac{4}{5\pi}\cos 5\omega_{LO}(t) - ...$

4.

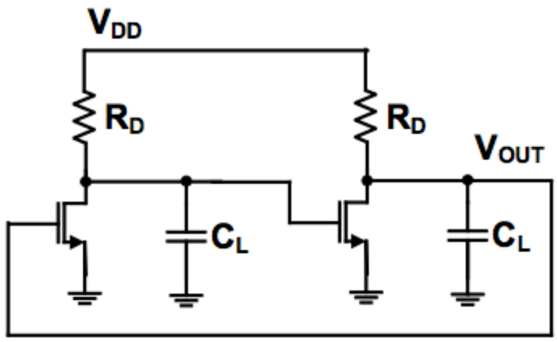
Which of the following circuits oscillate? (4p)

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

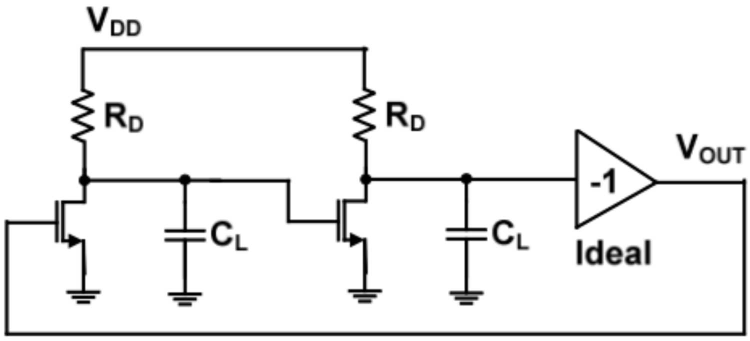
- DC shift,
- frequency dependent phase shift,
- open loop circuit poles,
- total phase shift,
- conclusion: no or possible oscillation.



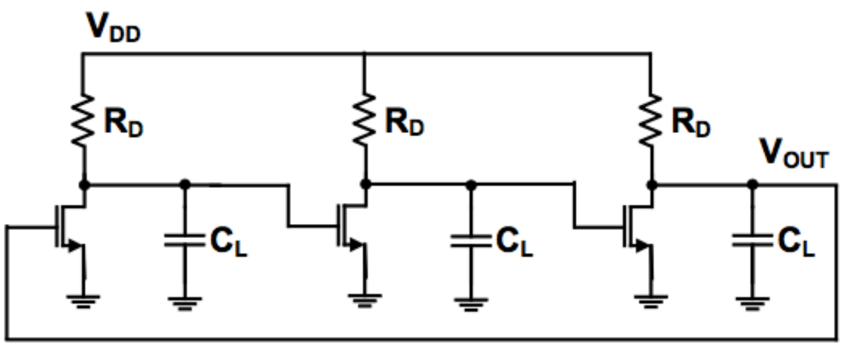
(a)



(b)



(c)



(d)

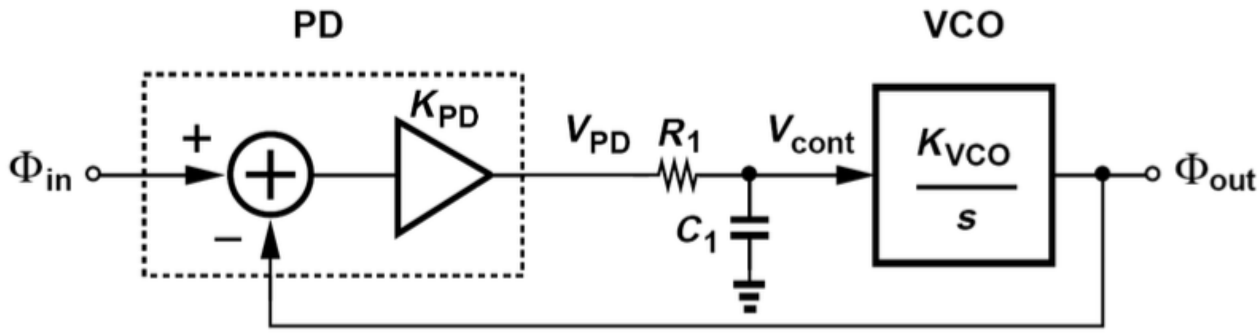
5.

A block level description of a PLL is shown below.

a. Derive an expression for the closed-loop transfer function, $H(s) = \Phi_{out}(s)/\Phi_{in}(s)$. (3 p)

b. What type of PLL is it? Motivate! (1 p)

c. Prove that for slow input phase variations, the output tracks the input. (1 p)



6.

A couple of power amplifier questions!

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

Please give short motivations for your answers.