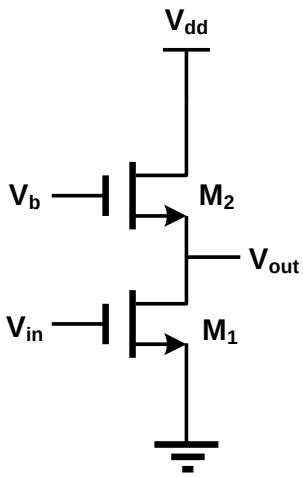
Tutorial 6: Repetition

Problem 1. Noise

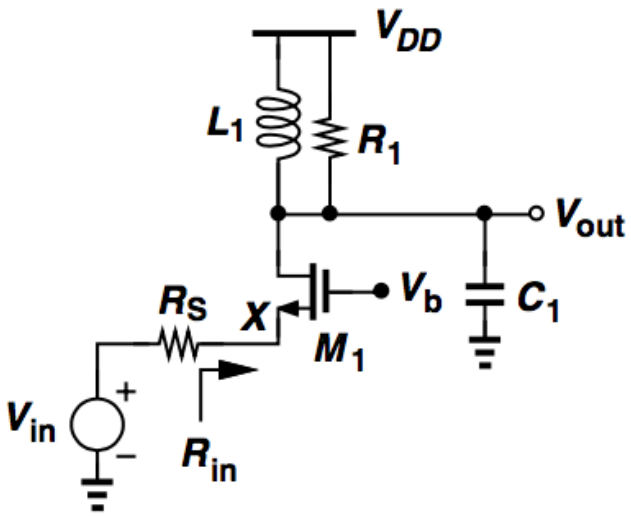
A cascode amplifier stage is shown in figure below. Assume that both transistors are long-channel devices and V_b is the bias voltage for M_2. Furthermore, assume that $gm_1 \neq gm_2$ and $\lambda \neq 0$.
Determine the input-referred noise voltage. Consider only the thermal noise sources and ignore the gate noise of the transistors.



A cascode stage.

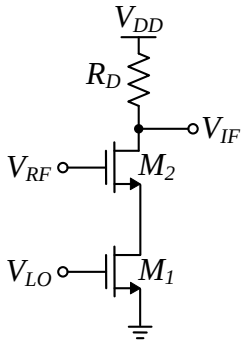
Problem 2. LNA

For the common-gate LNA shown below, matched to 50 Ohm, compute the noise figure at the output resonance frequency.



Problem 3. Mixer

The circuit shown below is a dual-gate mixer used in traditional microwave design. Assume abrupt edges and a 50 % duty cycle for the LO and neglect channel-length modulation and body effect. Also assume M1 is and ideal switch and has no noise contribution.



a) Compute the voltage conversion gain of the circuit.

b) Derive the expression for the noise figure of the mixer.

Problem 4. Oscillator

4) A negative-resistance oscillator operating at 2.4 GHz frequency is shown in Fig. 4. The resonant circuit is implemented using inductor $L = 5$ nH with $Q = 10$ and a variable capacitor C. Assume that we can neglect all parasitics associated with the transistors.

(a) What is the minimum width of two identical transistors M_1 and M_2 to ensure the oscillation? (2 p)

(b) How much should the variable capacitance C be varied to enable tuning from 2.4 GHz to 2.5 GHz? (1 p)

(c) For a capacitance corresponding to 2.4 GHz oscillation frequency, if an additional inductor of 5 nH is connected in parallel with the capacitor C, how much will the oscillation frequency change (in percentage)? (2 p)

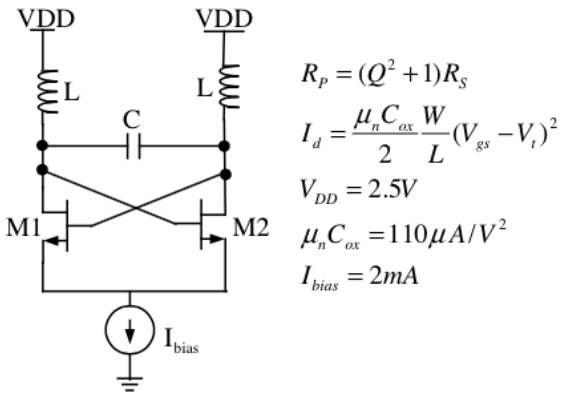


Fig. 4. A negative-resistance oscillator.