Tutorial 3: Mixer

Problem 1

Consider the active mixer shown in the figure below where the LO has abrupt edges and a 50% duty cycle. Also, channel-length modulation and body effect are negligible. The load resistors exhibit mismatch, but the circuit is otherwise symmetric. Assume $M1$ carries a bias current of I_{SS}. Determine the output offset voltage.

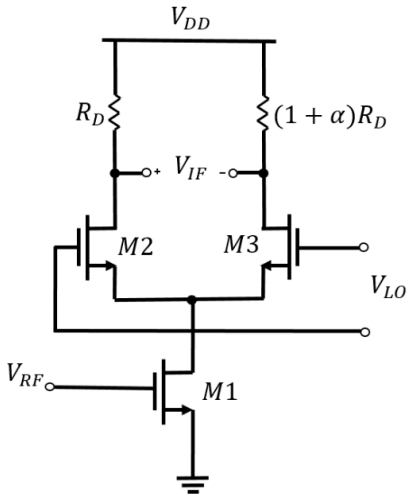


Fig. 1. Active mixer with load mismatch

Problem 2

Shown below is the front-end of a 1.8-GHz receiver. The LO frequency is chosen to be 900 MHz and the load inductors and capacitances resonate with a quality factor Q at IF. Assume $M1$ is biased at a current $I1$, and the mixer and LO are perfectly symmetric. Also assume $M2$ and $M3$ are ideal switches (they switch abruptly and completely). Compute (a) the measured level of the 900-MHz at the output in the absence of an RF signal, (b) the LO-IF feedthrough with the presence only of the gate-drain capacitance C_{GD}. Neglect gate-source and gate-bulk capacitance.

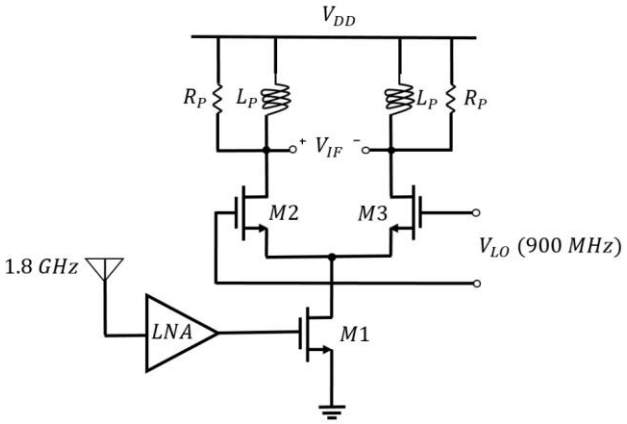


Fig. 2. Receiver front-end

Problem 3

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.

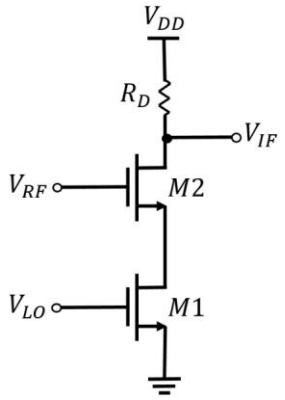
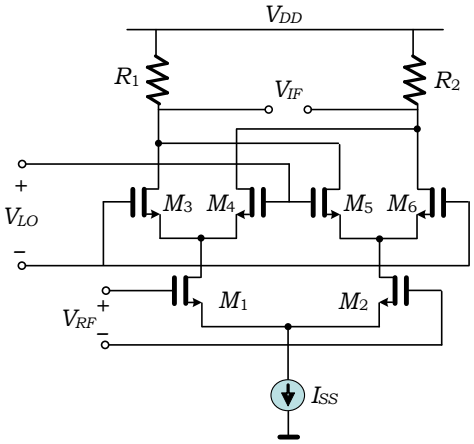


Fig. 3. Dual-gate mixer

a) Assume that $M1$ is an ideal switch. Determine the frequency components which appear at the mixer IF port.
b) Assume when $M1$ is on, it has an on-resistance of R_{on1}. Compute the voltage conversion gain of the circuit. Assume $M2$ does not enter the triode region and denote its transconductance by g_{m2}.
c) Assume when $M1$ is an ideal switch. Compute the voltage conversion gain of the circuit.

Homework 1

Gilbert mixer and its variants are one of the most popular types of mixers used in today's designs due to its good conversion gain, NF, linearity, and isolation.



a) Derive the expression for the conversion.
b) Derive the expression to identify the frequency components at the output spectrum of the mixer IF port.
c) Derive the expression for the noise figure.

Homework 2

In the circuit of Fig. 6.67 of the course book, we place a parallel RLC tank in series with the source of M_4 such that at resonance, the noise contribution of M_4 is reduced. Recalculate Eq. (6.116) if the tank provides an equivalent parallel resistance of R_p. (Bear in mind that R_p itself produces noise).