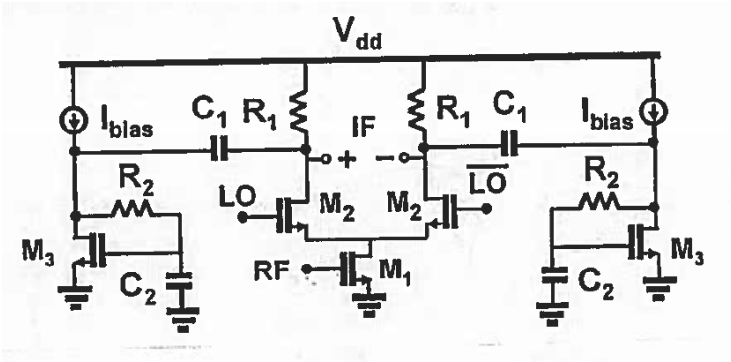
Tutorial T12

T12.1 Let us consider the down-conversion mixer in figure and assume that the MOSFETs have threshold $V_T = 0.5\text{V}$, constant $1/2\mu C_{OX} = 0.2\text{mA/V}^2$ and thermal noise coefficients $\gamma = 2/3$ and $\alpha = 1$. Let $V_{dd} = 2.5\text{V}$, $(W/L)_1 = 125$, $(W/L)_2 = 400$, $R_1 = 200\Omega$, $R_2 = 150\Omega$, $I_{bias} = 6\text{mA}$, $C_2 = 1\text{pF}$, $(W/L)_3 = 750$.

a) Set the value of C_1 which guarantees a resonance frequency (f_0) of 2GHz for the output network (R_2, C_1, C_2 and M_3).

b) Let us assume a sinusoidal wave with offset voltage of 1V and frequency $f_{RF} = 10\text{GHz}$ at the RF port, a square wave with offset voltage of 1.5V, single-ended zero-peak amplitude of 300mV, with frequency $f_{LO} = 8\text{GHz}$, at the LO port. Compute the conversion gain from RF to IF.

c) Consider now $f_{RF} = f_{LO} = 8\text{GHz}$. Compute the noise figure of the mixer considering all the noise sources, referred to a source resistance of $R_S = 50\Omega$ and assuming abrupt switching of theM2 pair.



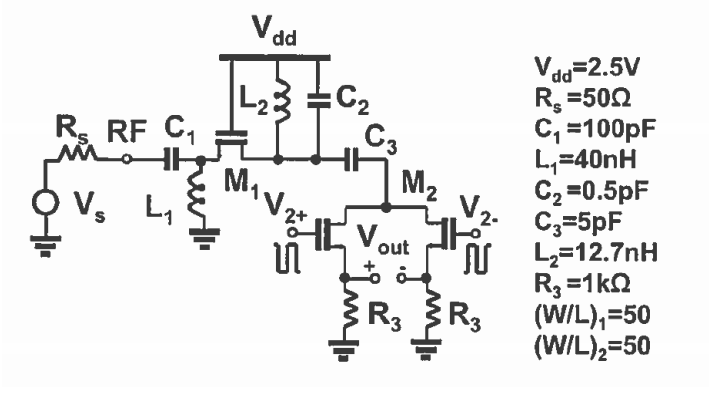
[Sol. a) C_1 = 2.5pF, b) A_v = -12dB, c) NF = 4.91 dB]

T12.2 Let V_s be a sinusoid at $f_{RF} = 2.0\text{GHz}$, and V_{2+} and V_{2-} two square-waves $0 - V_{dd}$ at $f_{LO} = 2.1\text{GHz}$. The MOSFETs have threshold $V_T = 0.5V$, constant $1/2\mu C_{OX} = 0.1mA/V^2$ and thermal noise coefficients $\gamma = 2/3$ and $\alpha = 1$.

a) Derive the bias point of the circuit. Evaluate the RF to IF conversion gain from the input V_{rf} to the output port V_{out}.

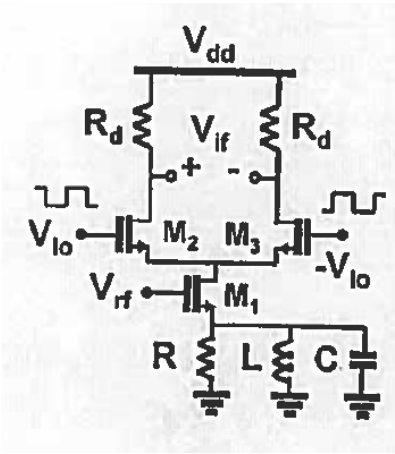
b) Calculate the power gain from the RF port to output port.

c) Compute the noise figure of the circuit referred to source resistance R_s, considering just the thermal noise of M1 and R_S.



[Sol. a) A_V = 22dB, b) G_P = 6dB, c) NF = 2.2dB].

T12.3 Let us consider the mixer in figure, where $V_{dd} = 2.5\text{V}$, $R_d = 200\Omega$. Let us assume that the MOSFETs have threshold $V_T = 0.5\text{V}$, constant $1/2\mu C_{\text{ox}} = 0.2\text{mA/V}^2$, and V_{rf} is a sinusoid with offset voltage of 1V. Let the impedance of the RLC network have its resonance frequency around the image frequency at $f_{IM} = (f_{LO} - f_{IF})$.



a) Derive the mathematical expression of the image rejection ratio of the stage, computing the ratio between the conversion gain of an input RF signal at $\text{f}_{\text{RF}} = (\text{f}_{LO} + \text{f}_{IF})$ and the conversion gain of an input RF signal at f_{IM}.

b) Size $(\text{W/L})_1$ and R to get IIR equal to 30dB and conversion gain at f_{RF} equal to 10dB.

[Sol. a) IRR = $(1+g_{m1}R)$; b) $(\text{W/L})_1 = 124$, R = 1.2kΩ]