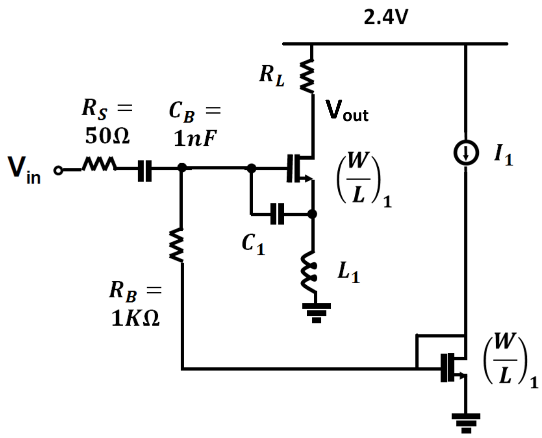
Tutorial T11

T11.1 Let us consider the LNA in figure, where the MOSFETs have threshold $V_T = 0.5\text{V}$, $\frac{1}{2}\mu C_{OX} = 0.1\text{mA/V}^2$, $\left(\frac{W}{L}\right)_1 = 100$ and $\frac{\gamma}{\alpha} = 2/3$.



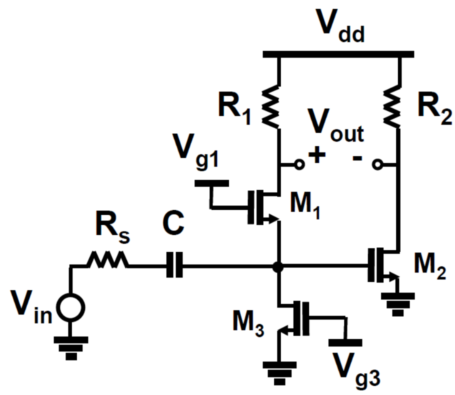
a) Derive the bias point of the circuit and the analytical expression of V_{out}/V_{in} at $f_0 = 2.4\text{GHz}$, assuming input matching.

b) Setting R_L = 600 Ω, size L_1, C_1 and I_1 to obtain (i) input matching and (ii) V_{out}/V_{in} equal to 12dB.

c) Evaluate the noise figure of the circuit at 2.4GHz, neglecting the noise of the bias transistor.

[Sol. b) L_1 = 5nH, C_1 = 0.88pF, I_1 = 1.95mA; c) Q = 1.5, NF = 3.92dB]

T11.2 Let us consider the LNA in figure, where $V_{dd} = 1.8\text{V}$, $V_{g1} = 1.2\text{V}$, $V_{g3} = 0.6\text{V}$, $R_s = 50\Omega$, $R_2 = 300\Omega$ $C = +\infty$, and the MOSFETs have threshold $V_T = 0.5\text{V}$, $\frac{1}{2}\mu C_{OX} = 0.2\text{mA/V}^2$ and $\frac{\gamma}{\alpha} = 2/3$.



a) Considering all noise sources (resistor thermal noise and MOS channel noise) and input matching, derive the expression for the noise figure. Are there any noise contributions that can be cancelled at the output?

b) Size R_1, $\left(\frac{W}{L}\right)_1$, $\left(\frac{W}{L}\right)_2$ and $\left(\frac{W}{L}\right)_3$ to guarantee a voltage gain $V_{out}/V_{in} = 19.3\text{dB}$ and noise figure $\text{NF} = 3.6\text{dB}$.

[Sol. a) $g_{m1}R_S = 1$, $\frac{R_1}{R_S} = g_{m2}R_2$, $\text{NF} = 1 + \frac{\gamma}{\alpha}\frac{R_2}{R_1} + \frac{\gamma}{\alpha}g_{m3}R_S + \frac{R_S}{R_1}\left(1 + \frac{R_2}{R_1}\right)$; b) $R_2 = 461\Omega$, $\left(\frac{W}{L}\right)_1 = 500$, $\left(\frac{W}{L}\right)_2 = 768$, $\left(\frac{W}{L}\right)_3 = 500$]

T11.3 Let us consider the LNA in figure, where $V_{dd} = 2.5\text{V}$, $R_s = 50\Omega$, $C = +\infty$, $I_2 = 1\text{mA}$, $R_1 = 1.5\text{k}\Omega$, and the MOSFETs have threshold $V_T = 0.5\text{V}$, $\frac{1}{2}\mu C_{OX} = 0.2\text{mA/V}^2$, $(W/L)_1 = 400$, $(W/L)_2 = 125$ and $\frac{\gamma}{\alpha} = 2/3$.

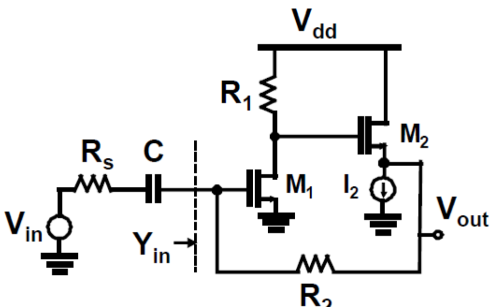


Fig. 1

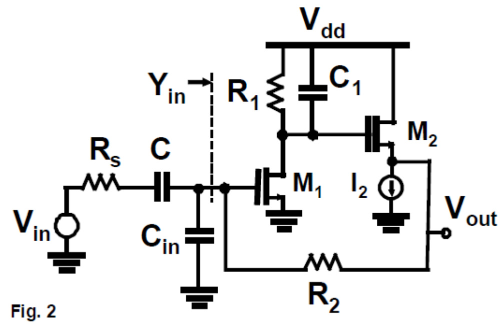


Fig. 2

a) Referring to the circuit in Fig. 1, derive its bias point and the expression for the input admittance Y_{in}. Size R_2 to ensure input matching.

b) Assuming input matching for the previous circuit, derive the expressions for voltage gain V_{out}/V_{in} and noise figure considering only thermal noise from R_2 and R_s.

c) Referring now to the circuit in Fig. 2, where $C_{in} = 1\text{pF}$, derive the expression for the input admittance Y_{in}. Under the assumption that $\omega \ll 1/R_1C_1$, size C_1 in order to preserve input matching.

[Sol. a) $R_2 = 1.15\text{k}\Omega$; b) $\frac{V_{out}}{V_{in}} = \frac{1}{2}\left(1 - \frac{R_2}{R_s}\right)$ = -11, NF = 0.7dB; c) $C_1 = 33\text{fF}$]