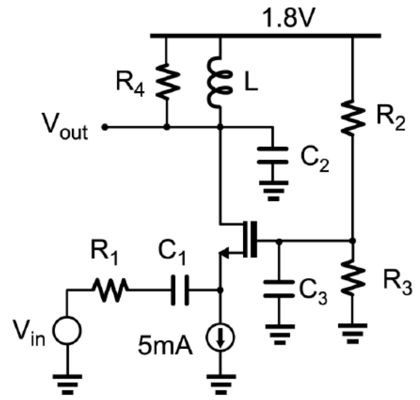
Tutorial T10

T10.1 Let us consider the LNA in figure, where $R_1 = 50\Omega$, $C_1 = 1\text{nF}$, $L = 1\text{nH}$, $R_2 = 2\text{k}\Omega$, $R_3 = 8\text{k}\Omega$ and the MOSFET has threshold $V_T = 0.5\text{V}$, $\frac{1}{2}\mu C_{OX} = 0.2\text{mA/V}^2$ and $\frac{\gamma}{\alpha} = \frac{2}{3}$.



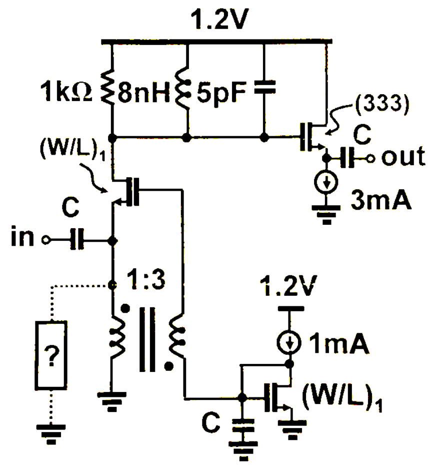
a) Derive the bias point of the circuit. Considering an operating frequency $f_0 = 3.3\text{GHz}$ and $C_3 = 30\text{pF}$, size R_4, C_2 and $\left(\frac{W}{L}\right)$ of the transistor to guarantee: (i) input matching, (ii) maximum gain and (iii) noise figure of 2.7dB.

b) Please modify the circuit by connecting C_2 between the output node and gate of the transistor. Find the new values for C_2, C_3 and $\left(\frac{W}{L}\right)$ to obtain a noise figure of 1.2dB at $f_0 = 3.3\text{GHz}$, while still guaranteeing input matching.

c) Evaluate the "*transducer power gain*" of the stage in dB.

[Sol. a) (W/L) = 100, C_2 = 2.33pF, R_4 = 1024Ω; b) (W/L) = 434, C_2 = 2.4pF, C_3 = 89.6pF; c) G_P = 13dB]

T10.2 Let us consider the LNA in figure, where $C = 1\text{nF}$ and the MOSFETs have threshold $V_T = 0.5\text{V}$, $\frac{1}{2}\mu C_{OX} = 0.1\text{mA/V}^2$ and $\frac{\gamma}{\alpha} = 2$.



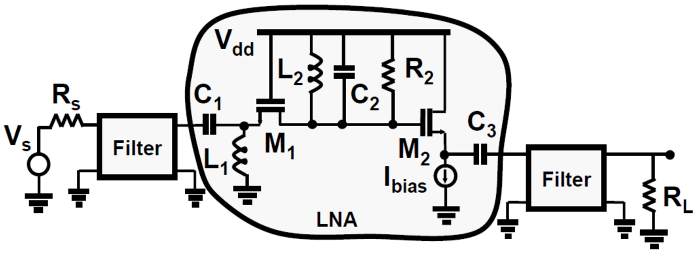
a) Neglecting the unknown component (marked by the "?" sign), and assuming the transformer to be ideal, size $\left(\frac{W}{L}\right)_1$ to obtain input matching to 50Ω at $f_0 = 2.5GHz$.

b) Evaluate the noise figure NF referred to a source resistance of 50Ω, at $f_0 = 2.5GHz$ and considering all noise sources.

c) Assuming the transformer to be non-ideal with coupling coefficient $k = 1$, and $L_{11} = 1\text{nH}$, $L_{22} = 9\text{nH}$ the inductances of the primary and secondary winding, respectively. Choose the unknown component (marked by the "?" sign) which maintains input matching to 50 Ω?

[Sol. a) g_{m1} = 5mS, $(W/L)_1$ = 62.5; b) NF = 2.35dB; c) C_2 = 4pF]

9.3. Let us consider the circuit in figure, where the MOSFETs have threshold $V_T = 0.5\text{V}$, $\frac{1}{2}\mu C_{OX} = 0.1\text{mA/V}^2$, $\frac{\gamma}{\alpha} = \frac{2}{3}$.



L_{filter}=2dB
R_s = R_L= 50Ω
V_{dd}=2.5V
C_1 = 100pF
L_1 =40nH
$(W/L)_1$=50
C_2 =1pF
L_2=6.35nH
R_2 =1kΩ
C_3=100pF
$(W/L)_2$=67
I_{bias}=15mA

a) Derive the bias point of the circuit. Evaluate "*available power gain*" G_A and noise figure NF_{LNA} for the LNA section.

b) Calculate the power delivered to the load R_L, assuming: (i) input available power $P_s = -90\text{dBm}$, (ii) available power loss of the filters $L = 2\text{dB}$ at 2GHz, and (iii) 50Ω input and output impedance of the filters at 2GHz.

c) Compute the overall NF_{TOT} at 2GHz.

[Sol. a) g_{m1} = 20mS, g_{m2} = 20mS, G_A = 20dB, NF_{LNA} = 2.72dB; b) Pout = -74dBm; c) NF_{TOT} = 4.74dB]