Homework #1

Due Mon., Jan. 11, 2010

1. An LNA with a relatively high input impedance exhibits a noise figure of NF₁ with respect to a source impedance of R_S . We tie a resistor of value R_S from the input of the LNA to (ac) ground so as to match the circuit to an antenna. [All noise figures in this problem are numeric (not logarithmic).]

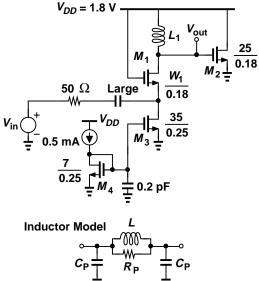
(a) Using Eq. (2.84), calculate the noise figure of the overall circuit with respect to a source impedance of R_S . (b) Repeat (a) but view the grounded resistor as R_P in Fig. 2.30(a) and use Friis' equation. Compare the results.

2. In this problem, we study the intermodulation behavior of a simple two-stage low-noise amplifier at 5.2 GHz. The model files can be found at http://www.ee.ucla.edu/ razavi/teaching.html for Cadence and HSPICE. (They are called 215a.scs and 215a.sp, respectively.)

(a) Consider the common-gate circuit shown here, where M_2 represents a typical load capacitance for now. Assuming $\lambda = 0$, compute the width of M_1 such that $g_{m1} + g_{mb1} = (50 \ \Omega)^{-1}$.

(b) Use simulations to determine the value of L_1 for resonance at 5.2 GHz. The inductor must be modeled as shown, where R_P is chosen to give a Q of 4 at the frequency of interest and $C_P = 10$ fF for every nanohenry of inductance.

(c) Now find the input resistance (i.e., the real part of the input impedance) by simulations and explain why it is not equal to 50 Ω . Adjust the width of M_1 to obtain a 50- Ω input resistance again.



(d) Using the shortcut method, compute the IIP_3 and voltage gain of the circuit at 5.2 GHz.

(e) Determine the IIP_3 and voltage gain of the stage shown on the right at 5.2 GHz. The role and modeling of L_2 are similar to those of L_1 .

(f) Now remove M_2 from the first stage, place the two stages in a cascade, and find the overall voltage gain and IIP_3 . How closely do these results agree with those obtained from parts (d) and (e) and Eq. (2.46) in the text? (Make sure you include the *loaded* gain of the first stage in the equation.) V_{DD} L_{2} $V_{in} \circ - \downarrow 25$ M_{2} $2.5 \text{mA} \qquad \downarrow 1 \text{ pF}$

(g) Does the input resistance of the first stage change when the second stage is added? Why?