ECEN 665 (ESS) **Due: November 2, 2009**
Fall 2008

HOMEWORK ASSIGNMENT #4

Problem 1. This problem deals with the design of linear LNA, The Table shown below includes the results of several recently proposed LNAs. Design a LNA that has better FOM using also 0.35µm CMOS technology. The frequency is 900MHz and the NF<1.8dB.

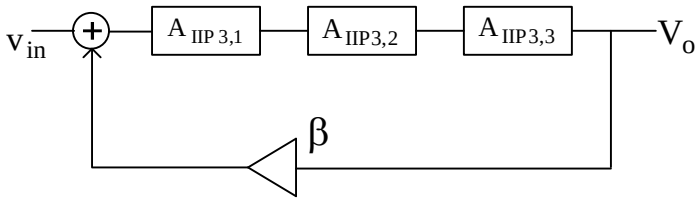
Work	Technology	Freq GHz	S21 dB	NF dB	IIP3 dBm	P_{dc} mW	FOM
[2]	0.25µm CMOS	0.9	14.6	1.8	10.5	5.4	117
[3]	0.35µm CMOS	0.9	2.5	2.8	18	45	3
[6]	0.18µm CMOS	3	6.5	1.9	15	8.9	29
[7]	0.6µm GaAs	0.9	17	1.6	8.5	12.7	63
[8]	0.25µm CMOS	2.2	14.9	3	16.1	23.5	54
[9]	0.35µm CMOS	0.9	10	2.8	15.6	21.1	19
[12]	0.5µm SiGe	0.88	15.7	1.4	11.7	11.7	124
[14]	0.25µm CMOS	0.9	15.5	1.65	22	24.2	503
This Work	0.35µm CMOS	0.9	11	2.95	21	22.5	92
De-em bedded	0.35µm CMOS	0.9	18.5	1.76	21	22.5	793

1) S. Ganesan, E. Sánchez-Sinencio and J. Silva-Martinez, "A High Linear Low Noise Amplifier", *IEEE Transactions on Microwave Theory and Techniques*, Volume 54, Issue 12, pp. 4079-4085, Dec. 2006.
2) X. Fan, H. Zhang, and E. Sánchez-Sinencio, "A Noise Reduction and Linearity Improvement Technique for a Differential Cascode LNA. *IEEE Journal of Solid State Circuits*, Volume 43, No. 3, pp. 588-599, March 1008.

Problem 2. Derive the following expression:

$$\frac{1}{A_{IIP3}^2} \cong \frac{1}{A_{IIP3,1}^2} + \frac{G_1^2}{A_{IIP3,2}^2} + \frac{G_1^2 G_2^2}{A_{IIP3,3}^2}$$

And also obtain the corresponding $\frac{1}{A_{IIP3}^2}$ if the 3 cascade block are connected in a negative feedback with a linear β block.



Problem 3. Assume the I/O characteristics of a low noise amplifier (LNA) is given by

$$y_{out}(t) - a_1 x(t) + a_2 x^2(t) + a_3 x^3(t)$$

Where x(t) and $y_{out}(t)$ are the input and output, respectively. Assume that the input has the form:

$$x(t) = A_r \cos\omega_r t + A_1 \cos\omega_w t + A_2 \cos\omega_2 t$$

Obtain the frequency components and their magnitudes at the output of the LNA. Provide a table with the magnitudes and frequency components at the LNA output for A_1=A_2=A.