Midterm Exam

March 6, 9:10-10:30am

Name: ______________________________

(50 points total)

PROBLEM 1: Consider the common source amplifier shown in Fig. 1. [**12 points**]

(a) Calculate the noise factor of this circuit, assuming it is driven by a source with an output impedance of R_S. For the transistor, include C_{gs} in the small signal model. You may neglect induced gate noise, $1/f$ noise, r_o, and all other small signal capacitances. [**10**]

(b) Now assume that the amplifier is being designed to operate at the frequency ω_c, and C_{gd} is no longer small enough to be neglected. We have connected an inductor from the gate to the drain of $M1$ to increase the reverse isolation. How should the inductor be sized? [**2**]

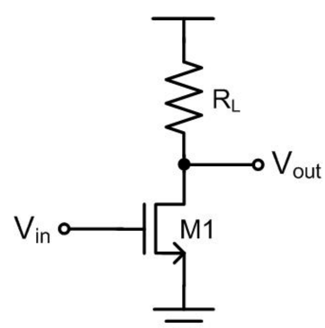

Figure 1: Common source amplifier schematic for Problem 1.

PROBLEM 1 (cont'd)

PROBLEM 2: Consider the matching network shown in Fig. 2, consisting of two inductors and one capacitor. [**12 points**]

(a) If R_L is 50 Ω, choose values for C, L_1, and L_2 so that R_{IN} is 10 Ω at $\omega = 5 \times 10^9$ rad/s (hint: more than one solution is possible). [**10**]

(b) What advantages (if any) does this matching network have over a standard L-match? [**2**]

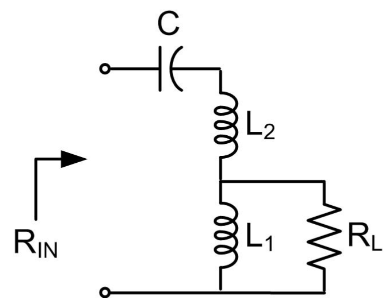

Figure 2: Matching network for Problem 2.

Problem 3: Your manager has asked you to evaluate the linearity of an RF front end. You know that for a signal input power of -30 dBm the power of the fundamental component at the output is -10 dBm, and for two tones with an input power of -30 dBm, the IM3 components have a power of -70 dBm at the output. [**12 points**]

(a) What is the gain of the system? [**1**]

(b) Using the plot in Fig. 3, calculate the IIP3 for the system. Draw in the relevant curves, and label the IP3 point on the plot. [**3**]

(c) If the bandwidth of the system is 10 MHz, the noise figure is 14 dB, what is the input referred noise floor (hint: this was contained in the formula given in class for the sensitivity)? What is the output referred noise floor? [**5**]

(d) Draw the output referred noise floor into the plot in Fig. 3, and mark the SFDR. What is the SFDR for this system? [**3**]

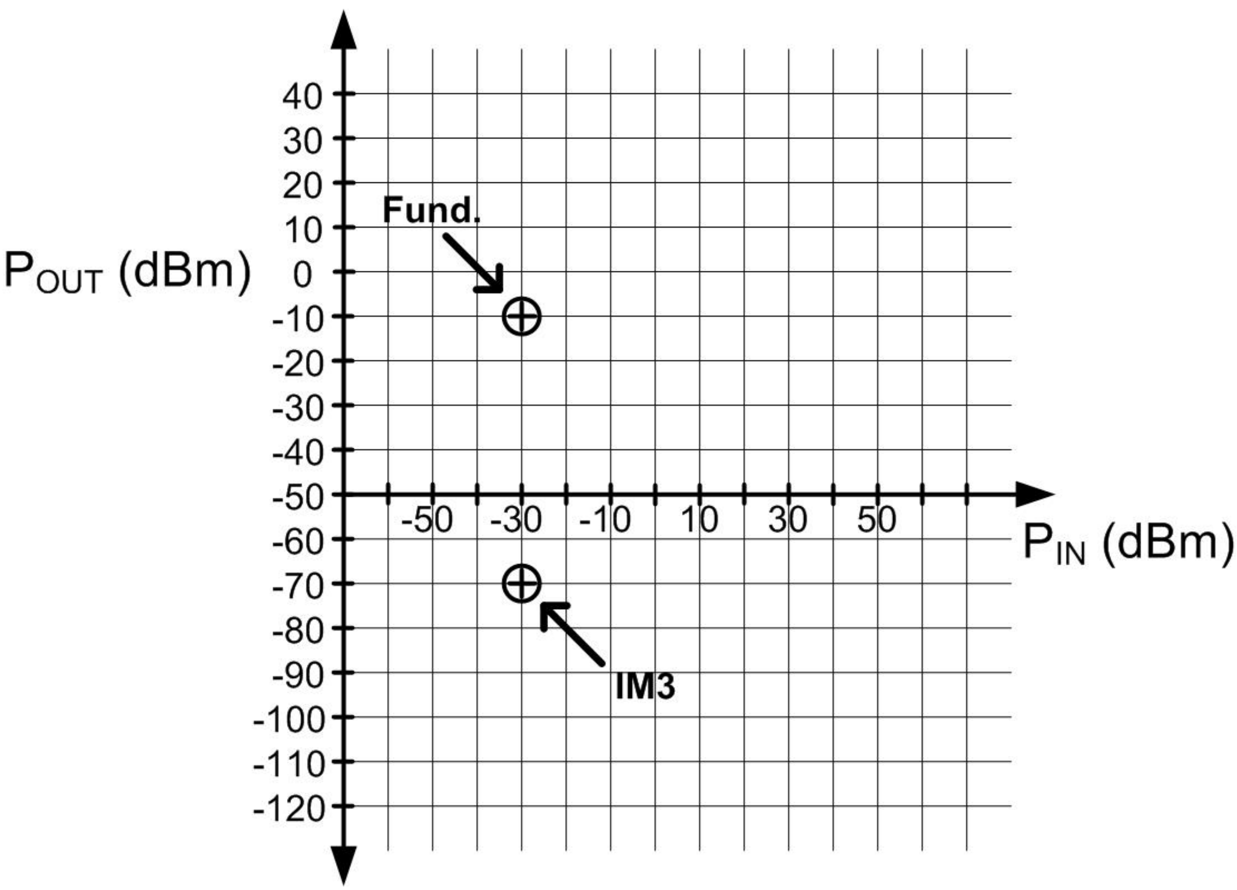

Figure 3: SFDR plot for Problem 3.

Problem 3 (cont'd)

PROBLEM 4: Shown in Fig. 4 is the down-conversion chain for an RF receiver. The incoming signal of interest is centered around $f_C = 900$ MHz, and low-side LO injection is used for down-conversion, with $f_{LO} = 850$ MHz. [**12 points**]

(a) What is the intermediate frequency (f_{IF}) for this system? [**1**]

(b) If the bandwidth of each channel is 2 MHz, what is the approximate Q required for the channel select filter? [**2**]

(c) What is the image frequency for the signal of interest? [**1**]

(d) Now assume that the specifications for each of the system blocks are as shown in Table 1. What is the noise figure of the down-conversion chain as a whole (note the distinction between the noise figure (NF, in dB) as provided in Table 1 and the noise factor also discussed in class (F, in linear units))? [**8**]

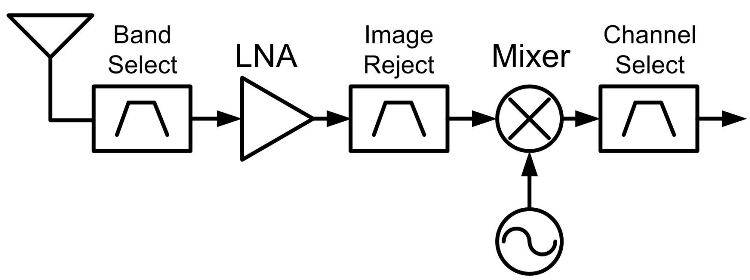

Figure 4: Down-conversion chain for Problem 4.

Component	Noise Figure (dB)	Available Power Gain (dB)
Band Select filter	0	-3
Low Noise Amplifier	3	20
Image Reject filter	0	-3
Mixer	10	0
Channel Select filter	0	-3

Table 1: Noise Figures and Available Power Gains for components in Fig. 4.

PROBLEM 4 (cont'd)

PROBLEM 5: Your boss has asked you to interview someone for a new position in the RFIC design group at your company. So far only one candidate has applied (see Fig. 5)? [**2 points**]

(a) Who is this man? [**1**]

(b) Would you trust him to design your RF front ends? [**1**]

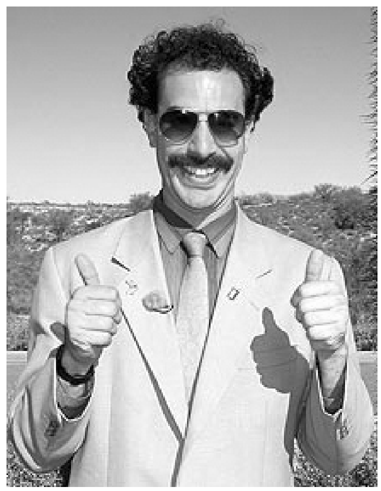

Figure 5: Job applicant for RFIC position.