Special Manpower Development Program in VLSI Design
IEP : Radio Frequency Integrated Circuit Design

shanthi@ee.iitm.ac.in

November 23, 2006

1 Problem 1 (Use MATLAB)

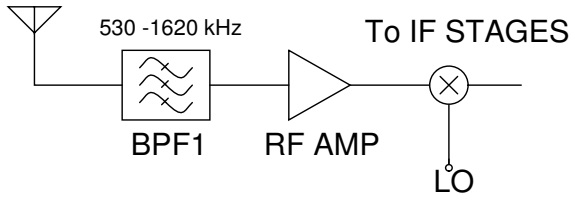

Figure 1: Front-end of an AM radio

The front end of an AM radio designed to receive the Medium-Wave band (530-1620 kHz) is shown in Figure 1. In this frequency band, called the broadcast-AM band, radio stations (in North America) transmit at carrier frequencies spaced 10 kHz apart. Assume that the antenna and the RF filter effectively eliminate all frequencies other than the desired band. The IF frequency is chosen to be 455 kHz. The LO frequency is tuned so that the desired station translates to the IF frequency. The RF amplifier and the LO-port of the mixer can be assumed to have nonlinearities upto and including the third order.

1. Draw the mixer spur chart for the desired frequency band for both high-side and low-side LO frequencies. From this exercise, does it make sense to use a low side LO when receiver spurious response is concerned ?
2. Assuming a high-side LO, determine the possible spurious frequencies when the receiver is tuned to 910 kHz.
3. Assuming a high-side LO, determine the possible tuning frequencies that might be adversely affected when a strong interfering tone at 1 MHz is present at the antenna.
4. Comment on the choice of 455 kHz as the IF frequency. Why not 450 kHz ? Or 460 kHz?

2 Problem 2 (Use a Spread Sheet)

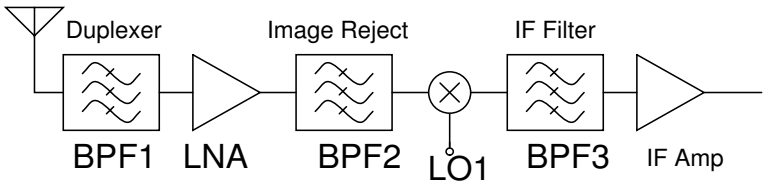

Figure 2: RF frontend of a PCS receiver.

Consider a portion of the RF front-end for a PCS receiver, shown in Figure 2. The receive frequency band is 1930-1990 MHz, with a channel bandwidth of 1.23 MHz. The minimum input power, as specified by the standard is -104 dBm. The specifications of the individual blocks are as follows.

- The duplexer is a 14th order passive Butterworth filter, with 3-dB frequencies of 1920 MHz and 2000 MHz. The passband loss is 2 dB.
- The LNA has a noise figure of 1.4 dB and a gain of 16 dB.
- The image reject filter is a 4th order Butterworth filter, with with 3-dB frequencies of 1920 MHz and 2000 MHz. The passband loss is 2.5 dB.
- The first IF frequency is chosen to be 183 MHz, with a high side LO.
- The RF mixer has a conversion gain of 14.5 dB and a noise figure of 7.8 dB.
- The IF filter is a 10 pole passive Butterworth filter, with a bandwidth of 1.5 MHz. The pass-band loss is 8 dB.
- The IF amplifier, which in reality must be a variable gain stage, is simplified here to have a gain of 35 dB and a noise figure of 6.4 dB.

1. What is the most likely spurious frequency ? (As usual, assume the mixer RF and LO ports to have nonlinearities (upto and including) order 3.)
2. Use a spread-sheet to draw a level diagram tracing the signal and noise powers down the receiver chain. What is the noise-figure of the receiver ?
3. Plot the relative strengths of an interferer located at the center of the image band, as one travels down the signal chain.