ECEU574 Wireless Communication Circuits — Spring, 04
Assignment 2 — Prof. Brady

1. (Superheterodyne Design). In this problem you will begin the design of a superheterodyne digital receiver for amplitude shift keying modulation. Figure 1 illustrates typical component blocks for a superheterodyne detector.

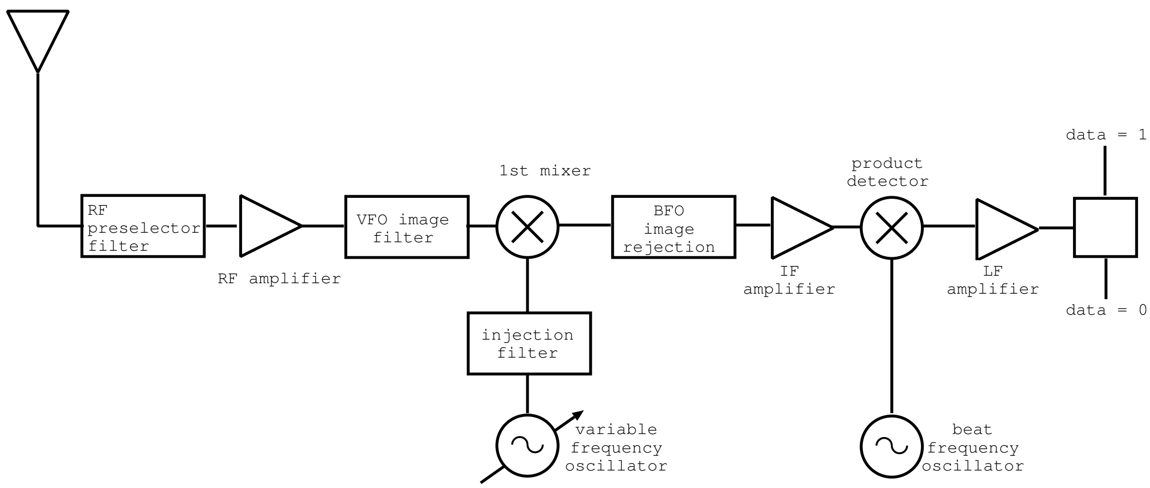

Figure 1: Superheterodyne receiver structure.

(a.) For part (a.) only, you may consider the RF preselector filter and the VFO image rejection filter as a single, combined filter. We will design them separately shortly. Further, assume in this part that all passband filters are ideal, with infinite attenuation in the stop bands and no distortion in the pass band. Consider all RF frequencies in the range $2.400GHz < f_{RF} < 2.485GHZ$, an intermediate frequency of $f_{IF} = 330.0MHz$, and two possible low frequencies, $f_{LF} = 1kHz$ or $f_{LF} = 30kHz$. For each possible low frequency, and high or low-side mixing (there are 8 possibilities), specify the following to four significant figures :

- the range of f_{VFO}
- the range of $f_{VFO,image}$
- f_{BFO}
- $f_{BFO,image}$
- the center frequency and maximum bandwidth of the RF passband filter (the combination of the RF preselector filter and the VFO image filter)
- the center frequency and maximum bandwidth of the BFO image rejection filter.

It is suggested that you list these results in a table, with column labels describing each of the items in the above list, and with row labels $X_1X_2X_3$, where each X_i is either H or L. Let $X_1 = H$ if f_{VFO} is higher than f_{RF} (for all RF frequencies), or $X_1 = L$ otherwise. Let X_2 be defined similarly for the product detector. Finally, let $X_3 = H$ if $f_{LF} = 30kHz$ and $X_3 = L$ otherwise. In addition to the table, you must clearly show your methodology. A tabular answer with no justification will receive no credit.

(b.) Which of the 8 possible designs permits passband filters with the largest bandwidths? If there are several possible answers, please choose just one of these designs. Provide a graphical description of the frequencies for this one design, including oscillator frequencies, (one) RF frequency, all image frequencies and passband filter templates. Indicate all variable frequencies with double horizontal arrows, as in class. Also, as in lecture, represent only positive frequency components.

(c.) The preselector filter has three basic functions:

1. to limit the bandwidth of spectrum reaching the RF amplifier,
2. to attenuate receiver spurious responses (image frequencies and 1/2 f_{IF} are most important), and
3. to suppress spectral components at the local oscillator frequencies and the IF frequency which originate in the receiver and are picked up by the antenna.

Graphically demonstrate why these spectral components must be suppressed, by following each through the receiver specified in (b.), from RF, through IF, to LF. For each spectral component [there are 6 components to consider from 2.) and 3.)], start with a copy of your graphical answer in (b.) and add the effects of that component. Make sure that you include all effects of each sinusoid, as each mixer doubles the number of effects.

(d.) The functions of the VFO image rejection filter are:

1. to attenuate receiver spurious response frequencies,
2. attenuate direct IF frequency pickup,
3. attenuate noise at the image frequency originating in or amplified by the RF amplifier, and
4. suppress second harmonic (at $2f_{RF}$) originating in the RF amplifier.

Why are spurious response frequencies and image frequencies rejected by both RF filters (compare the lists in (c.) and (d.))? How is the IF signal in (2.) picked up, exactly? Why would an amplifier produce a 'second harmonic'?

(e.) The functions of the injection filter are:

1. to attenuate wideband noise around the local oscillator frequency,
2. to attenuate the second harmonic of the local oscillator frequency.

For the design you chose, provide a center frequency and bandwidth for an injection filter.

(f.) Sketch a magnitude transfer function for the preselector filter and the VFO image rejection filter that each satisfies their tasks listed in (c.) or (d.), and whose product satisfies your overall design in (a.). Does the overall RF filter still have a passband filter response?