The University of Queensland
School of Information Technology & Electrical Engineering

COMS3100/7100 Introduction to Communications
Semester 1, 2011

Assignment 3 (updated 20/4/11)

Due date: 5pm, Thursday, 12th May.
Where to submit: through the Faculty of EAIT (Hawken Building 50) assignment chute.
Note: All assignments require a cover sheet
(available from http://www.eng.uq.edu.au/courses.asp)

This assignment counts **5%** towards your Final mark for COMS3100/7100.

Question 1 (10 Marks): You have been assigned the task of evaluating the design of a superhetrodyne receiver by performing a numerical simulation. The three aspects you have been asked to concentrate on are:

a) **Front-end RF filter**: specifically, compare the image rejection performance of having no RF filter to having a 3^{rd} order Butterworth low-pass filter;
b) **Intermediate frequency (IF)**: specifically, compare the image rejection performance when using an IF of 455 kHz and 2000 kHz;
c) **IF filter**: specifically, this will be fixed as a 2^{nd} order Butterworth band-pass filter.

It is recommended that you use Matlab to simulate these four alternative designs and make recommendations based on the resultant magnitude of the (unwanted) image frequency to a desired test input sinusoid of $f_c =$ 620 kHz.

Hints: For your simulation it is recommended that you:

- Utilize high-side conversion, i.e., $f_{LO} = f_{IF} + f_c$;
- Set the cut-off frequencies of the band-pass IF filter at $f_{IF} \pm 5$ kHz and when required set the cut-off frequency of the RF low-pass filter to around 2.5 MHz;
- Utilize the Matlab functions: **butter** to design and **filter** to apply both the RF and IF filters. Note: Butterworth filters are infinite impulse response (IIR) and so cannot be applied using **conv**;
- Evaluate the frequency range 500 kHz to 3 MHz in steps of at most 10 kHz. To evaluate the response of the receiver at each frequency, input one sinusoid at a time and measure the magnitude of the output of the IF filter at the intermediate frequency. You could also note that you can improve the efficiency of your simulation by dividing all frequencies by a common factor, e.g., 1000 provided that you remember that sample times will now be measured in ms (rather than seconds);
- Select a sampling frequency, f_s, that is greater than twice the highest frequency you evaluate. Also simulate enough samples of your received signals to minimize the "window" effect, e.g., $N > f_c$;

Question 2 (10 Marks): You have now been asked to simulate the two direct conversion (DC) receivers of Figures. 7.1-3 and 7.1-4 in Carlson and shown over the page. These figures illustrate the receiver output from two single-tone single sideband (SSB) signals: one *desired* signal transmitting at the upper sideband and one *undesired/interfering* signal transmitted at the lower sideband. It is required that you simulate both of these receivers to show that the lower sideband will be rejected by the circuit of 7.1-4, but that interference will occur for the circuit of 7.1-3. For test purposes, input two equal amplitude signals at f_c = 1000 Hz: the lower single sideband (LSSB) with a 20 Hz message; and an upper single sideband (USSB) with a 10 Hz message.

Hints: For your simulation it is recommended that you:

- Plot the receiver input (amplitude) spectrum and the time domain output of the two receivers;
- Utilize a third order Butterworth low-pass filter with bandwidth 50 Hz in both receivers;
- Select the sampling frequency, f_s, and number of samples to analyse, N as per Question 1;
- There are a number of ways of implementing a 90° phase shift in Matlab,
    - e.g., **x90 = imag(hilbert(x));**

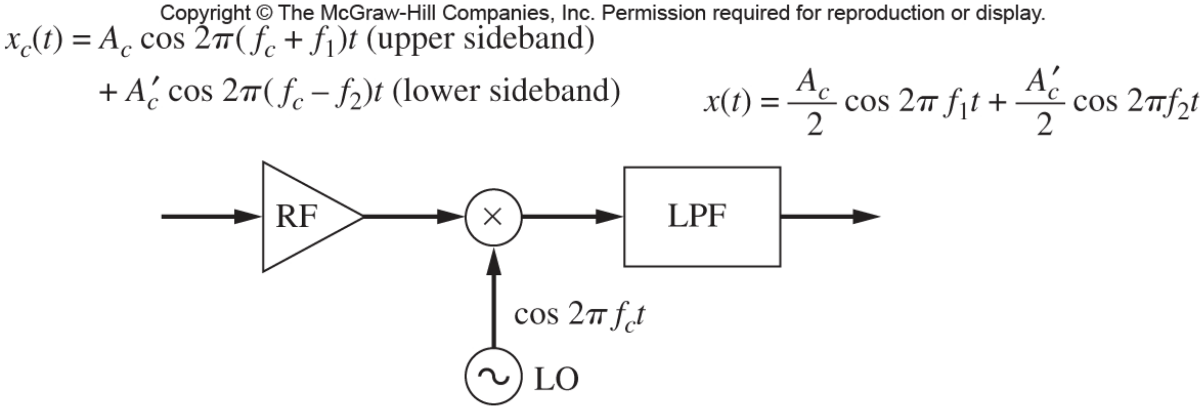

Figure 7.1-3: Direct conversion (DC) receiver.

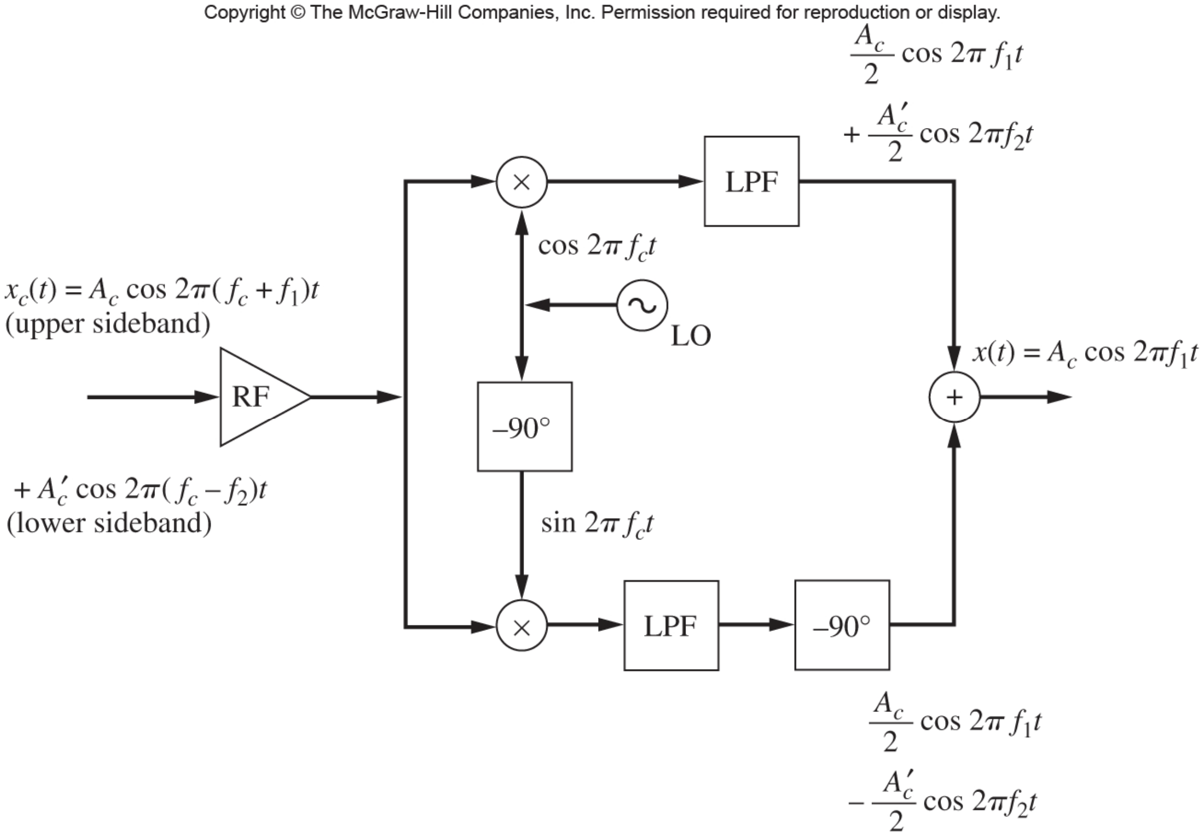

Figure 7.1-4: DC receiver with opposite sideband rejection.