

Homework Assignment #2 – due in BRKI 368 at 5 pm Wednesday, Oct. 8, 2014

Instructions, notes, and hints:

You may make reasonable assumptions and approximations in order to compensate for missing information, if any. Provide the details of all solutions, including important intermediate steps. You will not receive credit if you do not show your work.

Prob. 5.1-4: Assume that all time quantities are given in seconds and all radian frequencies are given in rad/s.

Prob. 5.2-2: Assume that the unit is seconds on the time axis in Fig. P.5.1-5.

Prob. 5.2-7: When commenting on the spectrum of $m(t)$, include what effect, if any, its frequency content has on the results.

Assignment:

Probs. 5.1-4, 5.2-2, and 5.2-7, plus the following additional problems:

1. As explained in the textbook, two widely used methods for generating single sideband (SSB) signals are the filter method and the phasing method. A third method, called the Weaver method, is mentioned only briefly. The figure on the next page shows how the Weaver method is implemented. The low-pass filter labeled $f < B$ has a cut-off frequency equal to the bandwidth limit B (in Hz) of $m(t)$. The first oscillator frequency f_1 is also equal to B . The second oscillator frequency f_2 is typically much greater than f_1 . A key advantage of the method is that it does not require the wide baseband signal to be phase-shifted as in the phasing method; another is that it does not require difficult-to-build highly selective filters with tiny percentage bandwidths as in the filter method. The Weaver method is therefore especially well suited for generating SSB signals in the VHF range and above.

Suppose that the applied message signal has the form $m(t) = A \cos \omega_m t$, where ω_m is a relatively low baseband frequency and is less than or equal to some bandwidth B . The various labeled signals in the upper signal path would have the following time-domain forms:

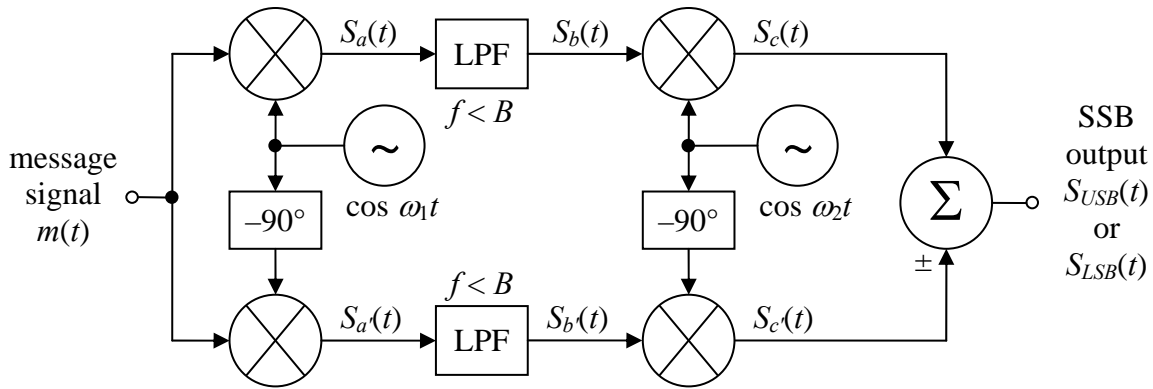
$$S_a(t) = \frac{A}{2} [\cos(\omega_m + \omega_1)t + \cos(\omega_m - \omega_1)t]$$

$$S_b(t) = \frac{A}{2} \cos(\omega_m - \omega_1)t$$

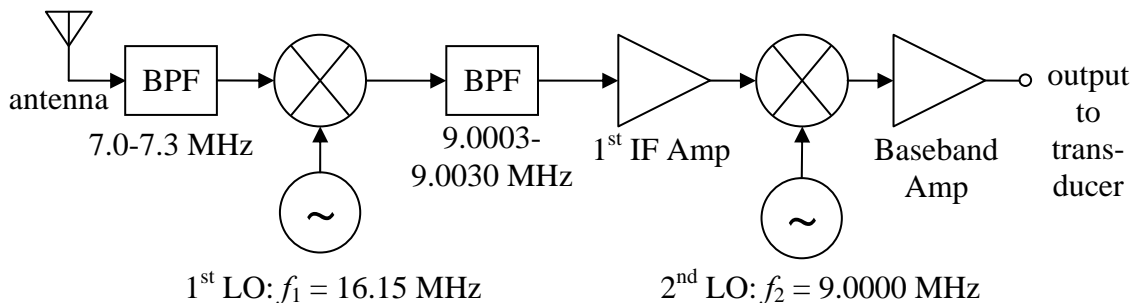
$$S_c(t) = \frac{A}{2} \cos(\omega_m - \omega_1)t \cos \omega_2 t = \frac{A}{4} [\cos(\omega_m - \omega_1 + \omega_2)t + \cos(\omega_m - \omega_1 - \omega_2)t]$$

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- Find the expressions for the time-domain signals $S_a(t)$, $S_b(t)$ and $S_c(t)$.
- Determine which sideband (USB or LSB) is associated with adding $S_c(t)$ and $S_c'(t)$ together, and which is associated with subtracting them.
- If a message signal has a bandwidth $B = 6$ kHz, to what frequencies f_1 and f_2 should the two oscillators be set and what operation (addition or subtraction) should the summing junction perform to generate a USB signal with a carrier frequency of 144.200 MHz and an upper limit of 144.206 MHz?



- The diagram below depicts a typical receiver architecture for detecting single sideband signals. Depending on the setting of the beat frequency oscillator's (BFO) frequency, either USB or LSB can be demodulated.
 - Which sideband (USB or LSB) is the receiver shown below currently set up to demodulate, and what is the carrier frequency of the signal being detected? Make sure that the baseband signal's spectrum is not inverted! That is, make sure that the low-frequency components of the baseband signal are not shifted to the upper end of its spectrum and vice versa.
 - To what frequency should f_2 be set in order to demodulate the opposite sideband of signals in the 7.0-7.3 MHz range?



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3. The diagram below depicts a possible architecture for a tunable frequency synthesizer (digitally controlled oscillator) based on two PLL circuits. The 100-kHz oscillator is a very stable crystal controlled type. The blocks labeled with division amounts are frequency dividers, which are nonlinear circuits that produce at their output a signal with a frequency equal to the input frequency divided by the indicated amount. In the case of the dividers within the two PLL loops, N_1 and N_2 are user-selectable integer values between 1 and 10. The low-pass filter labeled $f < f_c$ and the high-pass filter labeled $f > f_c$ each have a cut-off frequency equal to the crystal oscillator frequency of $f_c = 100$ kHz.

- What is the output frequency f_o when $N_1 = 3$ and $N_2 = 7$?
- Determine the frequency range and frequency tuning increment.

