EC 415: Homework 4

Due by Friday 04/09/2021 6:00PM

Professor David Starobinski

Michael Kremer
kremerme@bu.edu

Exercise 4.21

Suppose that the noise in improvesnr.m is replaced with narrowband noise (as discussed in Section 4.1.3). Investigate the improvements in SNR

a. when the narrowband interference occurs outside the 3000 to 4000 Hz passband,

b. when the narrowband interference occurs inside the 3000 to 4000 Hz passband.

For part (a) use $n = 0.1 * (\cos(2 * pi * f1 * t) + \cos(2 * \pi * f_2 * t))$ to model narrowband noise around the frequencies f_1 and f_2. Choose $f_1 = 2000$ Hz and $f_2 = 5000$Hz.
For part (b) use $n = 0.1 * \cos(2 * \pi * f3 * t)$ to model narrowband noise around the frequency f_3. Choose f_3 = 3500 Hz.

Solution

a. TODO

b. TODO

Exercise 5.9

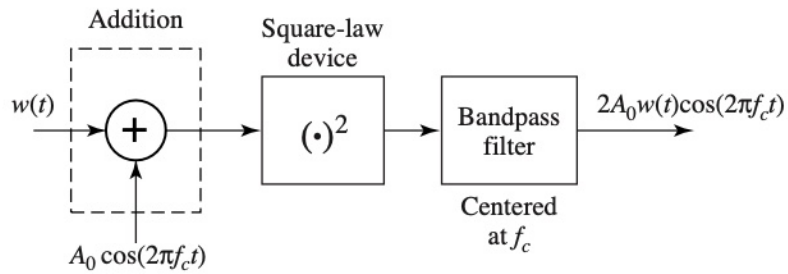

Figure 5.8 The square-law mixing transmitter of Exercises 5.9 through 5.11.

Figure 1: Figure 5.8

Consider the system shown in Figure 5.8. Show that the output of the system is $2A_0 w(t)\cos(2\pi f_c t)$, as indicated.

Solution

TODO

Exercise 5.12

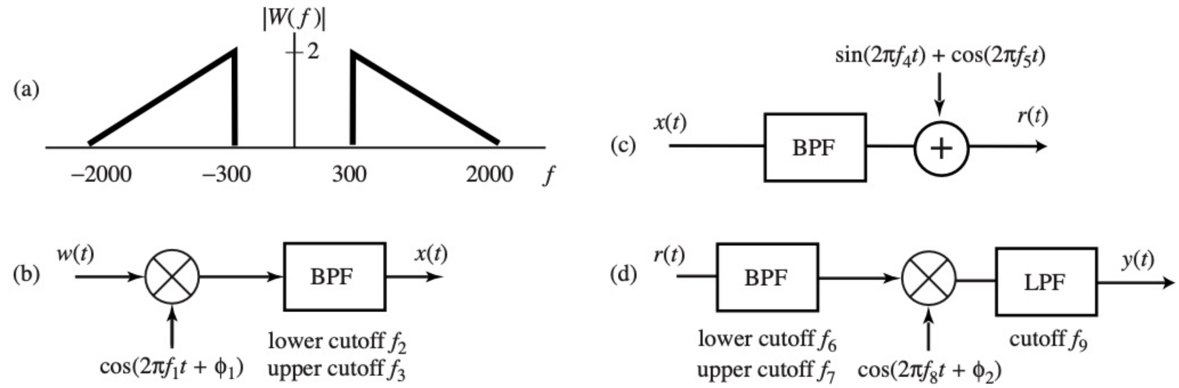

Figure 5.9 The transmission system for Exercise 5.12: (a) the magnitude spectrum of the message, (b) the transmitter, (c) the channel, and (d) the receiver.

Figure 2: Figure 5.9

Consider the transmission system of Figure 5.9. The message signal $w(t)$ has the magnitude spectrum shown in part (a). The transmitter in part (b) produces the transmitted signal x(t), which passes through the channel in part (c). The channel scales the signal and adds narrowband interferers to create the received signal r(t). The transmitter and channel parameters are 1 = 0.3 radians, f1 = 24.1 kHz, f2 = 23.9 kHz, f3 = 27.5 kHz, f4 = 29.3 kHz, and f5 = 22.6 kHz. The receiver processing r(t) is shown in Figure 5.9(d). All bandpass and lowpass filters are considered ideal, with a gain of unity in the passband and zero in the stopband.

a. Sketch $|R(f)|$ for 30 kHz $\leq$ f $\leq$ 30 kHz. Clearly indicate the amplitudes and frequencies of key points in the sketch.

b. Assume that ϕ_2 is chosen to maximize the magnitude of $y(t)$ and reflects the value of ϕ_1 and the delays imposed by the two ideal bandpass filters that form the received signal $r(t)$. Select the receiver parameters f_6, f_7, f_8, and f_9, so the receiver output $y(t)$ is a scaled version of $w(t)$.

Solution

TODO

Exercise 5.16

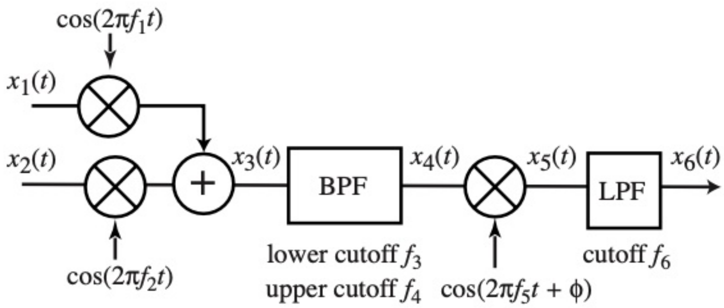

Figure 5.11 The transmission system of Exercise 5.16.

Figure 3: Figure 5.11

Consider the scheme shown in Figure 5.11. The absolute band- width of the baseband signal x_1 is 6 MHz and that of the baseband signal $x_2(t)$ is 4MHz, $f_1 = 164$MHz, $f_2 = 154$MHz, $f_3 = 148$MHz, $f_4 = 160$MHz, $f_5 = 80$MHz, $\phi = \pi/2$,and $f_6 = 82$MHz.

a. What is the absolute bandwidth of $x_3(t)$?

b. What is the absolute bandwidth of $x_5(t)$?

c. What is the absolute bandwidth of $x_6(t)$?

d. What is the maximum frequency in $x_3(t)$?

e. What is the maximum frequency in $x_5(t)$?

Solution

a. TODO

b. TODO

c. TODO

d. TODO

e. TODO

Question 5

Consider the last line of AMlarge.m (see Listing 5.1):
$envv = (\pi/2) * filter(b, 1, abs(v));$
Why is the output of the filter multiplied by the constant $\pi/2$? Justify your answer.

Solution

TODO

Question 6

The attached qam_hw.mat file is a QAM passband signal that is the sum of two modulated messages w_1 and w_2. These messages were respectively modulated using cosine and sine functions, with carrier signal f = 1000 Hz. The sampling period is T = 1/10000s and the total duration of the signal is 0.3s. Note that these parameters are all the same as in the file AM.m (listing 5.2 in the textbook). Plot the following:

1. The modulated signal v.
2. The demodulated signals (before the LPF) x_1 and x_2.
3. The recovered signals (after the LPF) m_1 and m_2.

Hints:

1. To load the QAM signal , use the command: load($'qam\_hw.mat','v'$);
2. Use the same LPF parameters as in AM.m.
3. The x-axis should be [0, 0.3] for all the plots.
4. For the signal v, the y-axis should be [11,11].
5. For the signal x_1 and m_1, the y-axis should be [5,10].
6. For the signals x_2 and m_2, the y-axis should be [10,1].

Solution

1. TODO
2. TODO
3. TODO