In the Name of God

Communication Systems (25751-1)
Quiz 04

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Exam Duration: 90 minutes

***Remark**: All sub-problems in this quiz have 10 points.*

Problem 1

Consider the simple DSB[1] modulation and demodulation system depicted in figure 1 (f_c is much greater that W). Note that there is a *phase mismatch* (ϕ) between the two oscillators in the modulation and demodulation blocks.

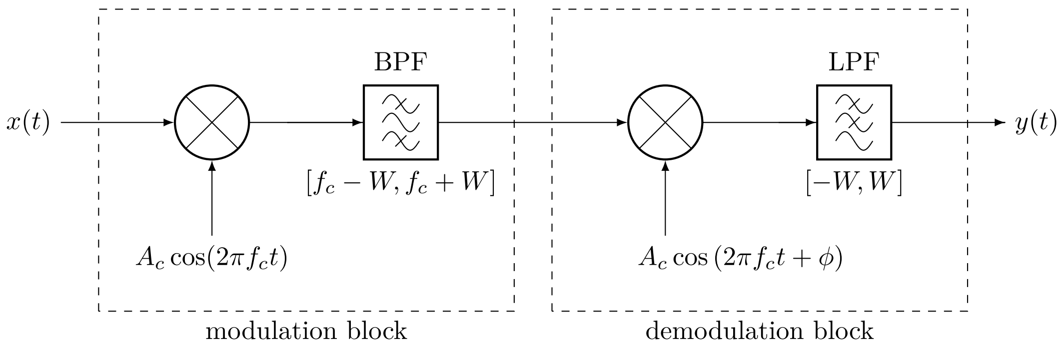

Figure 1

1. Let $m(t)$ be a signal of bandwidth W. Find $y(t)$, the output of the system when $m(t)$ is the input to the system.
2. Define the *mismatch attenuation factor* $\gamma(\phi)$ as:
$$\gamma(\phi) = \frac{y(t) \text{ when the phase mismatch is } \phi}{y(t) \text{ when there is no phase mismatch}}$$
Find $\gamma(\phi)$. What are the worst values of ϕ?
3. In practice, we do not know the exact value of ϕ (if we knew that, we would design a simple compensatory system and this problem would never really happen). As a result, we have to consider a random distribution for the values of ϕ. For this part, let Φ be a random phase, uniformly distributed over the range $[-\theta, \theta]$. Thus, $\gamma(\Phi)$ will also be a random variable. Find $\mathbb{E}[\gamma(\Phi)]$, the expected value of the mismatch attenuation factor.
4. We intend to make sure that $\mathbb{E}[\gamma(\Phi)] \geq 0.95$. Find θ^*, the largest value of θ for which this constraint holds (For the sake of simplicity, you may estimate 0.95 with $3/\pi$).
5. If we happen to know the exact value of the phase mismatch as $\phi = \dfrac{2\theta^*}{3}$, does the constraint $\gamma(\phi) \geq 0.95$ hold? If not, is this a contradiction with the previous part? Explain why.

[1] Double Sideband

Problem 2

In this problem, we are going to design a VSB[2] modulation system.

1. Let $h_1(t)$ be the impulse response of a filter, given below in time-domain:

$$h_1(t) = A\frac{e^{-2\pi|t|}}{t}$$

where $A = \frac{-\pi}{8}$. Find and plot $H_1(f)$, the frequency response of $h_1(t)$.

2. Let $h_2(t)$ be the impulse response of another filter, given below:

$$h_2(t) = h_1(t) * \operatorname{sinc}\left(\frac{\pi t}{2}\right)$$

Find and plot $H_2(f)$, the frequency response of $h_2(t)$.

3. Now consider the system shown in figure 2. Let $h_3(t)$ be the output of this system when $h_2(t)$ is the input to the system. Plot $H_3(f)$, the frequency response of $h_3(t)$.
Also consider the following values for the parameters in figure 2:

$$A_c = 2 \quad , \quad W = \frac{\pi}{4} \quad , \quad f_c > \pi$$

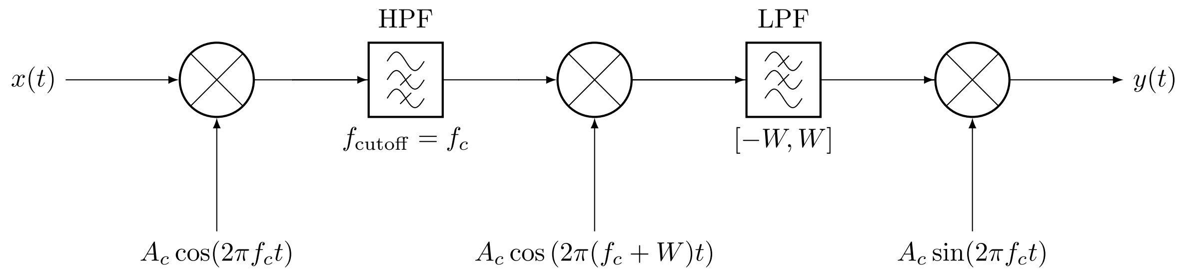

Figure 2

4. Let $h_4(t)$ be the impulse response of a band-pass filter whose bandwidth and central frequency are π and $f_c + \frac{\pi}{2}$, respectively. Also define $h_{\text{VSB}}(t) = h_3(t) + h_4(t)$. Plot $H_{\text{VSB}}(f)$, the frequency response of $h_{\text{VSB}}(t)$.

5. Consider the system shown in figure 3. Let $x(t)$ be a signal whose Fourier transform is $X(f) = \Lambda(f/\pi)$. Find $y(t)$, the output of this system. (A_c and f_c are the same as part 3)

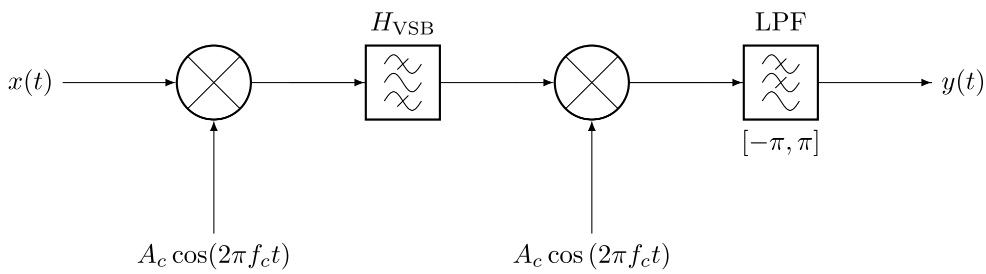

Figure 3

[2] Vestigial Sideband