Homework 12

CSCI-UA.0480-005
Special Topics: Electrical Engineering for Computer Scientists
Prof. Rappaport
Extra Credit: will replace low HW and Quiz grade

Due: May 14, 2015 @ 8:00 AM

1. If $x[n] = \delta[n] + 4 \cdot \delta[n-1] + \delta[n-2]$ and $h[n] = \delta[n] + 2 \cdot \delta[n-1] + 4 \cdot \delta[n-2]$, sketch $x[n] * h[n]$.

2. If the frequency content of a signal is represented by the plot in Figure 1 below for sound pressure, and we wish to sample the signal with an Analog-to-Digital Converter (ADC), answer the following questions:

   a. Approximately, what should the minimum sampling rate be for the ADC in order to fully reconstruct the analog signal?

   b. What is the ideal cutoff frequency of the low-pass anti-aliasing filter that should be used to filter the analog signal before it is sampled?

   c. How many discrete levels can we sample with an 8 bit ADC?

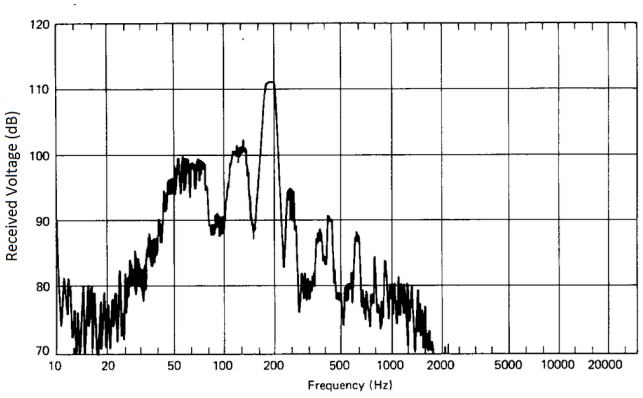

Figure 1

3. For a rectangular boxcar pulse of width 5 μs from -2.5 to 2.5 μs with a voltage level of 2 volts over this range, determine the Fourier Transform. Sketch the Fourier Transform, write down the equation, and be sure to identify the first zero crossings in the frequency domain. What is the bandwidth from 0 Hz to the first zero crossing? Write a simple

general equation that defines the first zero crossing bandwidth of a rectangular pulse having duration T. *This simple formula is why digital communications engineers can use a simple approximation that the bit rate is equal to the bandwidth.*

4. If a 2 Watt signal goes through an amplifier with 30 dB of gain, what is the resulting output power of the signal in Watts?

5. Our cellphones can generally detect wireless signals between -50 dBm and -120 dBm. Answer the following questions:

   a. What is -50 dBm in Watts? Hint: 0 dBm is equivalent to 1 mW. 30 dBm is equivalent to 1 Watt: $10^{\frac{30}{10}} = 1000$ mW $= 1$ W.

   b. What is the dynamic range in dB of our cellphones? (range over which we can detect signals: 0 dBm to 30 dBm is a dynamic range of 30 dB!).

   c. What is -120 dBm in milliwatts?

6. In Figure 2 below you are given the spectrum of a signal m(t) that has a bandwidth of 10 kHz at baseband, shown as M(f). The signal is mixed up to a carrier frequency of 770 kHz (WABC radio in New York City), then goes through a channel (a wire for simplicity), and is then demodulated back down to baseband and subsequently low-pass filtered. Write the equation and sketch the spectrum of the signal at points **1.**, **2.**, and **3.** in the Figure 2 below. You may write your expressions in terms of M(f).

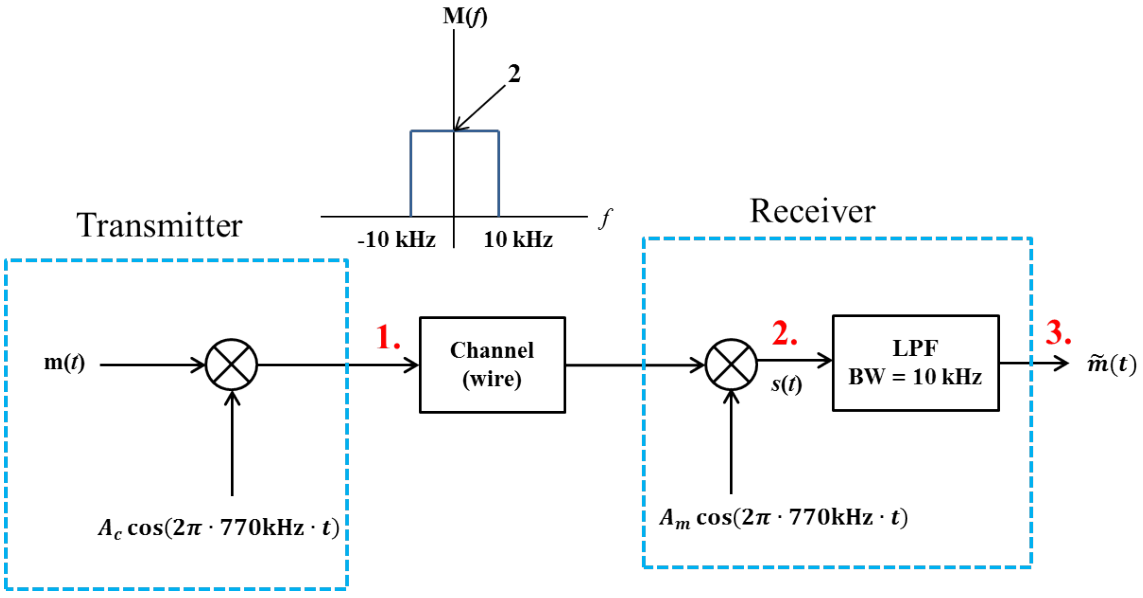

Figure 2