Homework 4

Communication Systems - I (EE 341), Autumn 2021

[1] The following problems from “Communication Systems” by Haykin and Moher, 5th ed., Chapter 7: 7.1, 7.3, 7.7, 7.8, 7.9, 7.12, 7.14, 7.15, 7.18, 7.20, 7.21 and 7.22 on pp. 275-277.

[2] A transmitter transmits an AM signal with a carrier frequency of 1500 kHz. When an inexpensive superheterodyne radio receiver (which has a poor selectivity in its RF-stage bandpass filter) is tuned to 1500 kHz, the signal is heard loud and clear. This same signal is also heard (not as well) at another dial setting. State, with reasons, at what frequency you will hear this station. The intermediate frequency (IF) is 455 kHz.

[3]

Figure P-3 shows the idealized spectrum of a message signal $m(t)$. The signal is sampled at a rate equal to 1 kHz using flat-top pulses, with each pulse being of unit amplitude and duration 0.5 ms. Determine and sketch the spectrum of the resulting PAM signal.

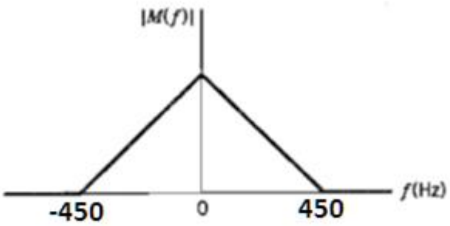

Figure P-3

[4]

A speech signal has a total duration of 10 s. It is sampled at the rate of 8 kHz and then encoded. The signal-to-(quantization) noise ratio is required to be 40 dB. Calculate the minimum storage capacity needed to accommodate this digitized speech signal.

[5]

Assume that a Gaussian-distributed random variable with zero mean and unit varaince is applied to a uniform quantizer of midrise type.

(a) What is the probability that the amplitude of the input lies outside the range -4 to +4?

(b) Using the result of part (a), show that the output signal-to-noise ratio of the quantizer is given by

$$(\text{SNR})_O = 6R - 7.2 \text{ dB}$$

where R is the number of bits per sample. Specifically, you may assume that the quantizer input extends from -4 to $+4$.

[6]

Suppose $x(t)$ has the spectrum in **Figure P-6** with $f_u = 25$ kHz and $W = 10$ kHz. Sketch $x_\delta(f)$ for $f_s = 60$, 45, and 25 kHz. Comment in each case on the possible reconstruction of $x(t)$ from $x_\delta(t)$.

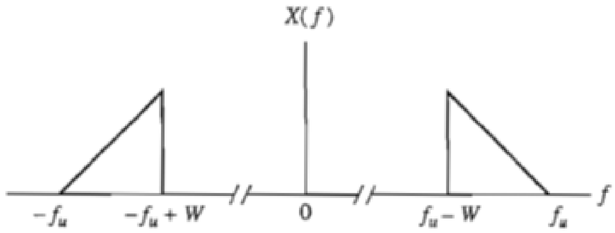

Figure P-6