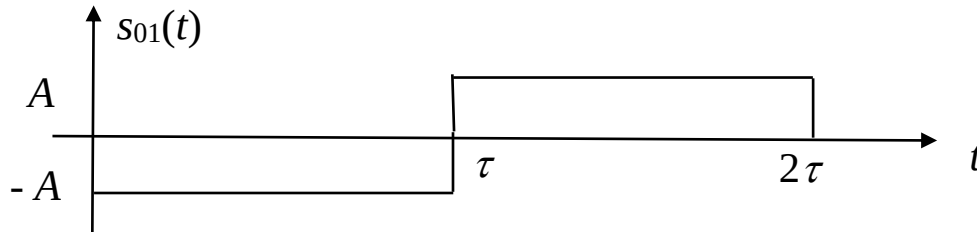
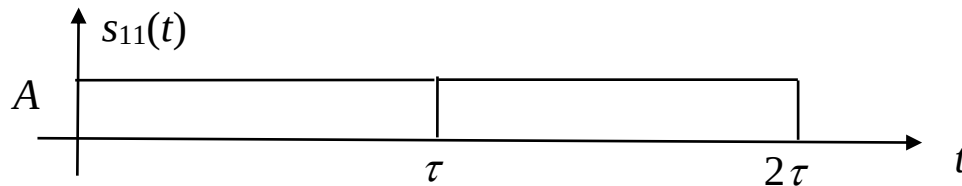


EE 3008. Baseband Modulation Tutorial Questions

Q1) A sequence “01” is represented by the following signal. Find the energy spectrum of this signal.



Q2) A sequence “11” is represented by the following signal. Find the energy spectrum of this signal.



Q3) Consider a binary PAM waveform of two bits, in which “1” is represented by a positive rectangular pulse of amplitude A and width τ , and “0” by a negative one. Assume that each bit has the same probability of being a “1” or “0”.

- (a) Plot all the four possible waveforms representing “00”, “01”, “10” and “11”, respectively.
- (b) Determine the average energy spectrum for each waveform in (a).
- (c) Find the power spectrum of transmitting for each possible bit combination of 00, 01, 10, and 11.
- (d) Show that the average power spectrum for two bits is the same as that for a single bit.

Q4) Still consider the binary PAM waveform in Q3.

- (a) Plot the energy spectrum of each waveform in Q3(a).
- (b) Plot the average energy spectrum.
- (c) Plot the average power spectrum.

Note: The *average power spectrum* is defined as

$$\text{Average Power Spectrum} = \frac{\text{Energy Spectrum of a series of pulses}}{\text{Time to transmit the series of pulses}}.$$

(a) Let $f_0=2$. Roughly sketch $f(t)$ and mark the key values.

(b) Consider a band-pass communication scheme in which $\pm f(t)$ represent “1” and “0” respectively. The first bit is transmitted using $\pm f(t)$, the second bit using $\pm f(t-2)$, the third bit using $\pm f(t-4)$, and so on. Find the average power spectrum of this scheme.

(Note: It can be shown that $S(f) = \text{sinc}^2(\pi f)$.)

Q10) Consider a system with rate 20k/s based on rectangular pulses.

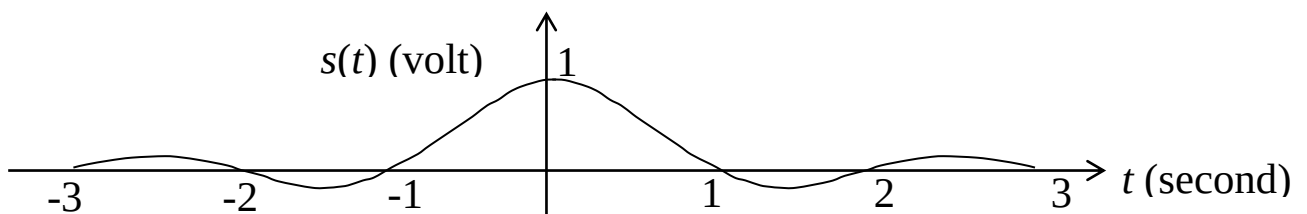
(a) What is the maximum pulse duration?

(b) A low-pass filter is used before transmission. What is the bandwidth of the low-pass filter if we want to preserve 90% of energy?

(c) A low-pass filter is used before transmission. What is the bandwidth of the low-pass filter if we want to preserve 95% of energy?

Q11) Consider a communication system with bandwidth of 4kHz based on binary rectangular pulses. A low-pass filter is used at the transmitter. Determine the maximum transmission rate if we want to preserve, respectively, 90% and 95% in-band energy.

Q12) Consider a baseband communication scheme in which information bit “0” is represented by a pulse $s(t)$ and “1” by $-s(t)$. The first bit is transmitted using $\pm s(t)$, the second bit using $\pm s(t-1)$, the third bit using $\pm s(t-2)$, and so on. (See the figure below for $s(t)$.)



(a) Find the information rate of the scheme.

(b) Consider a new scheme using $s(at)$ (a being a positive number) as the basic pulse shape (so that the transmitted signals are now $\pm s(at)$, $\pm s(at-1)$, $\pm s(at-2)$...). Find the information rate of the new scheme.

(c) Find the bandwidth of the new scheme in (b).

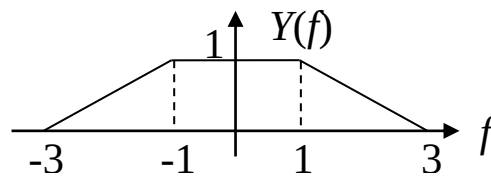
Q13) Consider the data pattern “100011010” transmitted at a rate of 100,000 bits/sec. Let pulse amplitudes be +1 and −1 volts.

- (a) Assume rectangular pulses of optimum width.
 - (1) Draw the transmitted waveform for the data.
 - (2) Draw the average normalized power spectral density for a transmitted waveform representing a general sequence of data.
 - (3) Calculate the minimum bandwidth needed for the system if accuracy requirements dictate that at least 95% of the signal’s average power must be in-band.
- (b) Assume sinc-shaped pulses of optimum width.
 - (1) Plot the transmitted waveform for the data.
 - (2) Draw the average normalized power spectral density for a transmitted waveform representing a general sequence of data.
 - (3) Calculate the minimum bandwidth needed for the channel.

Q14) A Fourier transform pair of $s(t)$ and $S(f)$ is given below.

$$\begin{array}{c} \text{1} \\ \uparrow \\ \text{ } s(t) \\ \text{ } \nearrow \quad \searrow \\ \text{ } -1 \quad \quad 1 \\ \text{ } \leftarrow \quad \rightarrow \\ \text{ } t \end{array} \quad \Leftrightarrow \quad S(f) = \frac{\sin^2(\pi f)}{(\pi f)^2} = \text{sinc}^2(\pi f)$$

Given $Y(f)$ below, find the mathematical expression of the time-domain signal $y(t)$. (**Note:** No need to draw the signal.)



Q15) Consider an on-off system based on rectangular pulses for “on” with rate = 10^6 b/s. The amplitude of the pulse for “on” is $A = \sqrt{2}/2$ V.

- (a) Sketch the average power spectrum of the signal. You should mark the key values in both x-axis and y-axis.
- (b) What is the average energy for each bit (with 1Ω loading resistor)?

Q16) Write a program to compute the distortion power resulting from limiting the spectrum of a rectangular pulse to the first-zero.