

EE 3008 Chapter 5 Tutorial Questions

Q1) Consider data rate 10 kbps and carrier frequency 1MHz. Roughly sketch the amplitude spectrum for (a) BPSK modulation; and (b) On-off ASK modulation.

Q2) A BPSK has carrier signal $Ab\cos(2\pi 10^9 t)V$ where $b=+1$ and -1 . Let $A=10^{-2}$ and data rate = 10 kbps. The channel is AWGN with $N_0=2\times 10^{-9}$.

(a) Assume that a correlator receiver is used with reference signal $= \cos(2\pi 10^9 t)V$. Find the two output levels for the two input possibilities.

(b) Find E_b , and what is the BER?

(c) What is the BER if the transmission power is reduced by half?

Q3) A 4-ary ASK signal is expressed as $Ab\cos(2\pi f_0 t)V$, with $b= -3, -1, 1$ and 3 . Assume that $f_0 \gg 1$. The channel is AWGN with $N_0=2\times 10^{-5}$. The duration of each symbol is τ .

(a) Ignore noise. Find the correlator outputs with the reference signal $\cos(2\pi f_0 t)V$.

(b) What are the energy levels used to transmit the four symbols involved?

(c) What is E_s (average energy per symbol)? What is E_b ?

Q4) A binary message $m(t) = 1100\ 1100\ 1111\ 0010\ 0$ is transmitted using a DPSK transmitter. Find the signs of the transmitted symbols. (Assuming starting with $+$ and using the rule that same $\rightarrow 1$, different $\rightarrow 0$.)

Q5) Consider a communication channel with a bandwidth of 2400Hz. If QPSK technique is used, what is the possible transmission rate? (Assume that rectangular pulses are used in the baseband signals, and that 90% energy preservation is required.)

Q6) Consider a QPSK modulated system with the four possible symbols represented by

$$s_1(t) = A\sin(2\pi f_c t + 45^\circ) \quad \text{for "11";}$$

$$s_2(t) = A\sin(2\pi f_c t + 135^\circ) \quad \text{for "10";}$$

$$s_3(t) = A\sin(2\pi f_c t + 225^\circ) \quad \text{for "00";}$$

$$s_4(t) = A\sin(2\pi f_c t + 315^\circ) \quad \text{for "01".}$$

Suppose the data sequence "1101100001" is transmitted at a speed of 100,000 bits/sec with a carrier frequency $f_c = 150$ kHz.

(i) Plot the transmitted signal with respect to time t .

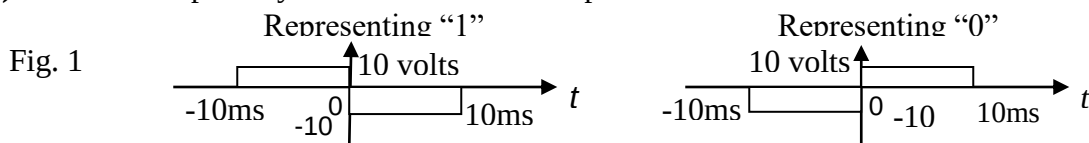
(ii) Express the four symbols as the addition of the in-phase component (a $\sin$ function) and the quadrature component (a $\cos$ function).

(iii) Based on (ii), show that the QPSK signal in (i) can be expressed by adding two BPSK signals. Plot these two BPSK signals.

Q7) Consider a BPSK signal in the form of $A\cos(2\pi f_c t)$ where $A = \pm 10$ mVolts and $f_c = 1$ GHz. The information rate is 10 kbps. The channel is AWGN with $N_0 = 2.5 \times 10^{-9}$ W/Hz. Find the BER of the system with an optimum receiver. You only need to represent the BER using Q -function.

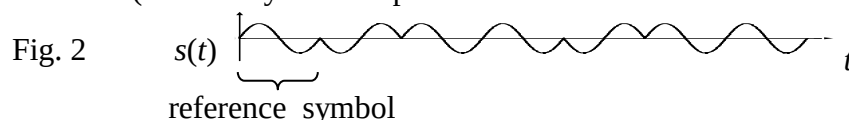
Q8) Consider a system to support an information rate of 100 Mb/s. What are required bandwidths, respectively, for BPSK, QPSK, 8PSK and 16QAM? Assume that rectangular pulses are used in the baseband signals, and that 90% in-band energy preservation is required.

Q9) Consider a bipolar system based on the two pulses shown below.

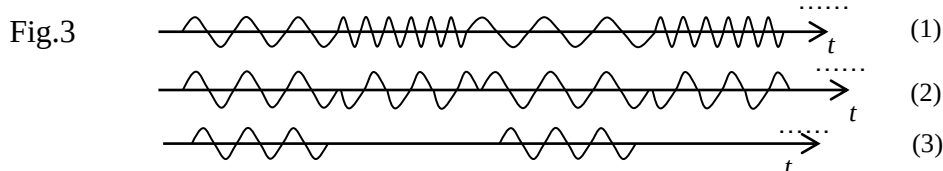


- Is an integration receiver applicable to this system? Why? Design a receiver for this system. (You should write down the detection rule for this receiver.)
- Calculate the error probability for the above system in an AWGN channel with $N_0 = 1$ J/s/Hz. Use the Q-function table.
- Determine the Fourier transform of these two pulses and plot the energy spectrum.
- A baseband sequence is generated using the above pulses function and then modulated by $\cos(2\pi f_0 t)$ where $f_0 = 10$ MHz. Determine the maximum data rate and average power spectrum of this system.

Q10) Consider a DPSK modulated signal $s(t)$ in Fig. 2. The first symbol is used as the reference. Find the information bits. (There may be multiple solutions. You should find all of them.)



Q11) (i) A digital sequence of “0101” is processed by three different modulators. Three output signals are given in Fig.3. Please identify the name of the three modulators. (**Note:** There may be multiple solutions for each question. You need to find as many possible solutions as you can.)



(ii) Consider output differential code: 1 1 -1 1 -1 -1 -1 1 -1 1 1 0 where the first bit 1 is used as reference. Determine the input information bits.

Hint: There are two possible solutions. You need to determine both.

Q12) A 16 QAM signal is given as $Ab_1\cos(2\pi f_0 t) + Ab_2\sin(2\pi f_0 t)$ V, with $b_1, b_2 = -3, -1, 1$ and 3 . Assume that $f_0 \gg 1$. Let $N_0 = 2 \times 10^{-5}$. The baseband symbol duration $\tau = 10^{-9}$ s.

- Design a receiver based on the QPSK receiver structure. Find the correlator outputs for the in-phase and quadrature branches.
- What are the energy levels used to transmit the 16 symbols involved?
- What is E_s (average energy per symbol)? What is E_b ?
- Assume rectangular pulse shape in the baseband with 90% in-band energy preservation. Find the bandwidth and data rate of the system in terms of τ .

Q13) Consider the impact of noise for the system in Q3).

- Show that the correlator output is (with $\sigma_\eta^2 = \tau N_0 / 4$):

$$y = 0.5Ab\tau + \eta.$$

- What is the symbol error rate (SER)?
- What is the bit error rate (BER) in terms of E_b/N_0 ?