**Question 1.**  
  
Mathematically justify which among bi-polar signaling, on-off signaling and polar signaling is best for AC coupling.  
  
***Answer:***

We know

eq 1

On average, if we take one bit per symbol

2 bits per symbol

3 bits per symbol

In general

For , the product can be , or 0 . If there’s an equal number of combinations, then .

Acc to eq 1 we can write

for , regardless of . Hence, the PSD has a dc null, and this is best for ac coupling.

For on-off keying and polar signaling they have DC component.

**Question 2.**

Randomness of On-Off signaling disappears as variance gets lower. Mathematically justify the statement.

Answer

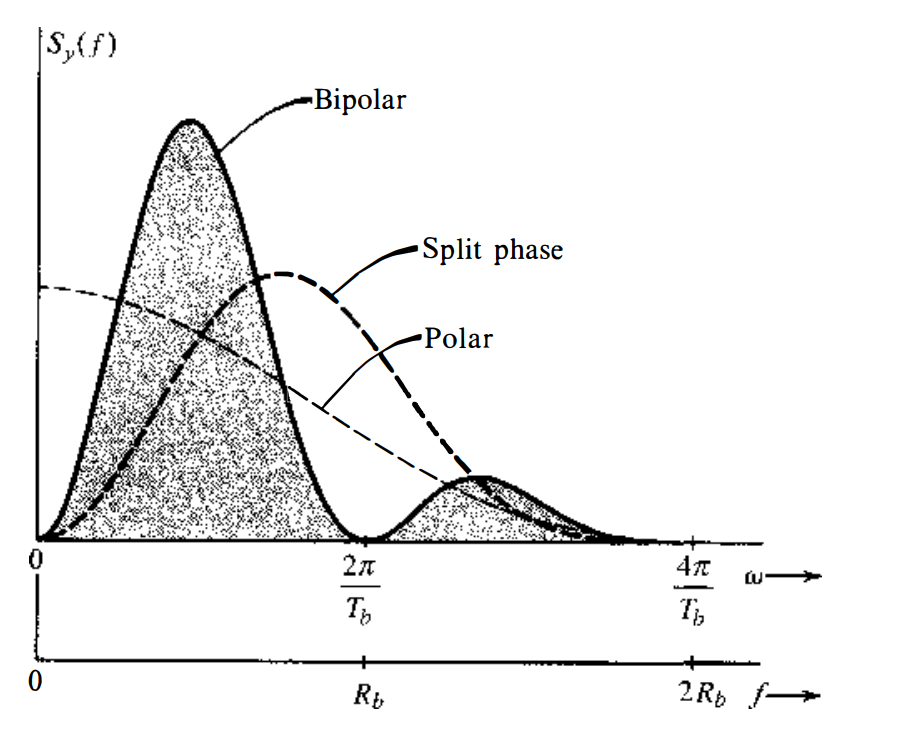
OOK  
 or

is the probability of happening ' '.  
This is a Bermoli RV  
So,   
 or   
So, randomness disappears if Variance gets lower and lower.

**Question 3.**

For BW critical communication, among bipolar and polar signaling which is the best assuming half-width rectangular pulse is used? Justify.

***Answer***

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Bipolar has the least bandwidth amongst these.

BW is defined by first non-dc null point for these signals.   
For polar the first non-dc null is at . so BW is

For bi-polar the first non-dc null is at . so BW is

**Question 4**

And It’s inverse is

the raised-cosine pulse spectrum as real-valued and therefore zero delay. But to make it more practical we describe with a linear phase characteristic over the frequency band .

Show that this modification of introduces a finite delay into its inverse Fourier transform, namely, the pulse shape .

***Answer:***  
(a) Let the linear phase be

where is delay to be determined. Then, the modified raised-cosine pulse spectrum is defined by

the time-shifting property, we have

Question 5  
  
What is the BW of T1 System for roll-off factor 1?

Answer:

the signal format for the T1 carrier system that is used to multiplex 24 independent voice inputs, which is based on an 8 -bit PCM word. The bit duration of the resulting time-division multiplexed signal (including a framing bit) is

The bit rate of the T1 system is

For , the Nyquist bandwidth of the T1 system is

which is the minimum transmission bandwidth of the T1 system for zero inter-symbol interference. However, a more realistic value for the transmission bandwidth is obtained by using a raised-cosine pulse spectrum with roll-off factor . In this case,

which is double the Nyquist bandwidth .

Question 6  
  
A computer puts out binary data at the rate of 56 kilobits per second. The computer output is transmitted using a baseband binary PAM system that is designed to have a raised-cosine pulse spectrum. Determine the transmission bandwidth required for each of the following roll-off factors:  
(a)   
(b)   
(c)   
(d)

Answer:

The bandwidth of a raised cosine pulse spectrum is , where and . Thus . For a data rate of 56 kilobits per second, .  
(a) ,

(b) ,

(c)

(d)

Question 7

A binary PAM wave is to be transmitted over a low-pass channel with bandwidth of 75 kHz . The bit duration is . Find a raised-cosine pulse spectrum that satisfies these requirements.

Answer:

The raised cosine pulse bandwidth , where . For this channel, . For the given bit duration, . Then,

The design parameters of the required raised-cosine pulse spectrum are and .

Question 8:

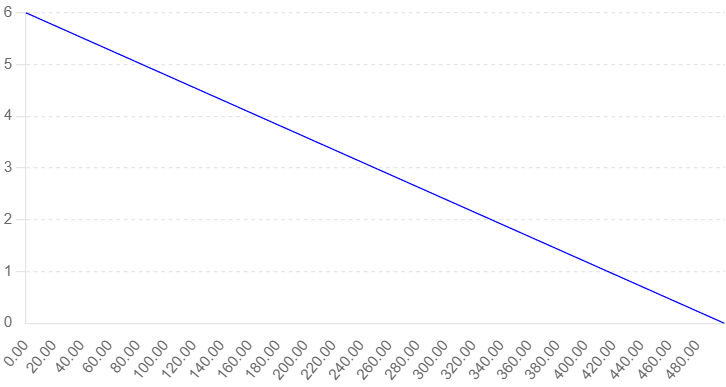
Consider a channel with bandwidth 3.0 kHz , which is available for data transmission using binary PAM. Plot the permissible bit (signaling) rate versus the excess bandwidth , if the roll-off factor varies from zero to unity, and that the criterion for zero inter-symbol interference is satisfied.

Answer:

The transmission bandwidth is related to the excess bandwidth by the formula

where . We may therefore express the bit rate as a function of the excess bandwidth as follows:

we see that the bit rate decreases linearly with the excess bandwidth for a fixed channel bandwidth . Specifically, with , the bit rate versus excess bandwidth graph takes the form shown in figure below. Note that the excess bandwidth attains its largest value when the roll-off factor equals unity, in which case .



Question 9  
You are given a channel of bandwidth 3.0 kHz . The requirement is to transmit data over the channel at the rate of 4.5 kilobits/s using binary PAM.  
(a) What is the maximum roll-off factor in the raised-cosine pulse spectrum that can accommodate this data transmission?  
(b) What is the corresponding excess bandwidth?

Answer:

We are given the following specifications:

(a) The transmission bandwidth is related to the roll-off factor by the formula

where

Therefore, with kilobits , we have

Hence, for the roll-off factor, we get

(b) The excess bandwidth is

Question 10

For a channel of bandwidth 3.0 kHz , the requirement is to transmit data over the channel at the rate of 4.5 kilobits/s using binary PAM.

given that each set of three successive binary digits in the computer output is coded into one of eight possible amplitude levels, and the resulting signal is transmitted by using an 8 -level PAM system designed to have a raised-cosine pulse spectrum.  
Answer:

The transmission bandwidth is maintained at the value

In using an 8-level PAM system, the signaling rate is raised to

However, the symbol rate is maintained at symbols/s. Hence,   
(a) The roll-off factor .  
(b) The excess bandwidth remains at .

Question 11  
An analog signal is sampled, quantized, and encoded into a binary PCM wave. The number of representation levels used is 128 . A synchronizing pulse is added at the end of each code word. The resulting PCM signal is transmitted over a channel of bandwidth 13 kHz using a quaternary PAM system with a raised-cosine pulse spectrum. The roll-off factor is unity.  
(a) Find the rate (in bits per second) at which information is transmitted through the channel.  
(b) Find the rate at which the analog signal is sampled. What is the maximum possible value for the highest frequency component of the analog signal?

Answer:  
  
The codeword consists of bits. With an additional bit added for synchronization, the overall codeword consists of 8 bits. The method of data transmission is quaternary (i.e., 4 -level) PAM, and the roll-off factor .  
(a) For binary PAM, the signaling rate is defined by

For and yields

The signaling rate of the quaternary PAM system is therefore

(b) Each element of the overall codeword of the PCM signal must fit into the bit duration

With each code-word consisting of 8 bits, the code-word occupies the duration

The sampling rate applied to the analog signal is therefore

The highest frequency component of the analog signal is therefore