

IUG - Faculty of Engineering
Department of Computer Engineering
Data communications Lab
Summer 2022-2023



Data Communications

Lab 6

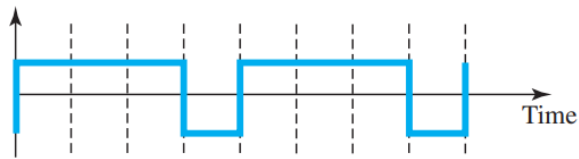
Chapter 4-part2:

Digital Transmission

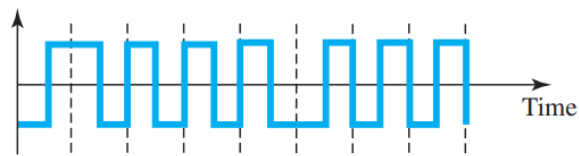
Abdullah Idris Ouda

P4-9. Find the 8-bit data stream for each case depicted in Figure 4.36.

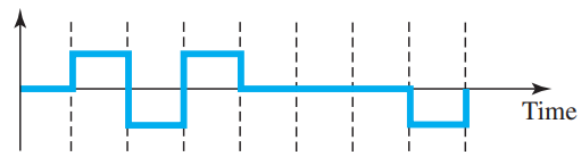
Figure 4.36 Problem P4-9



a. NRZ-I



b. differential Manchester

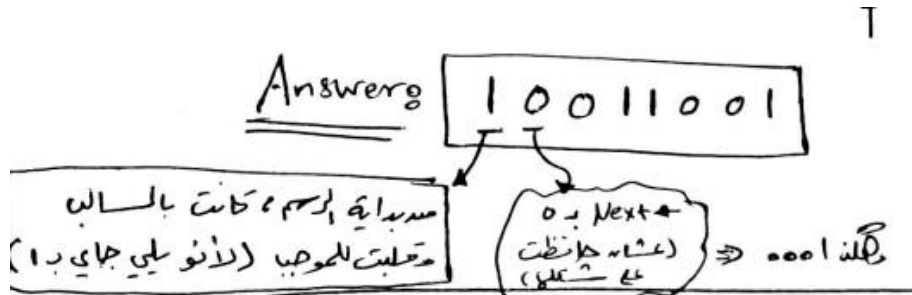


c. AMI

Solution:

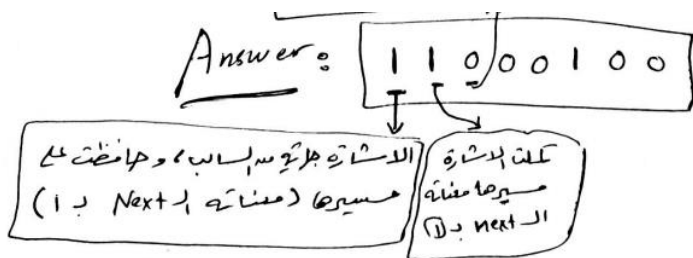
1- NRZ-I:

If the next bit is 0, then No inversion ,If the next bit is 1, then inversion



2- Differential Manchester

○ No inversion: Next bit is 1 ● Inversion: Next bit is 0



3- AMI

Bit (0): **Zero**

Bit (1): **+ve then -ve and so on ..**

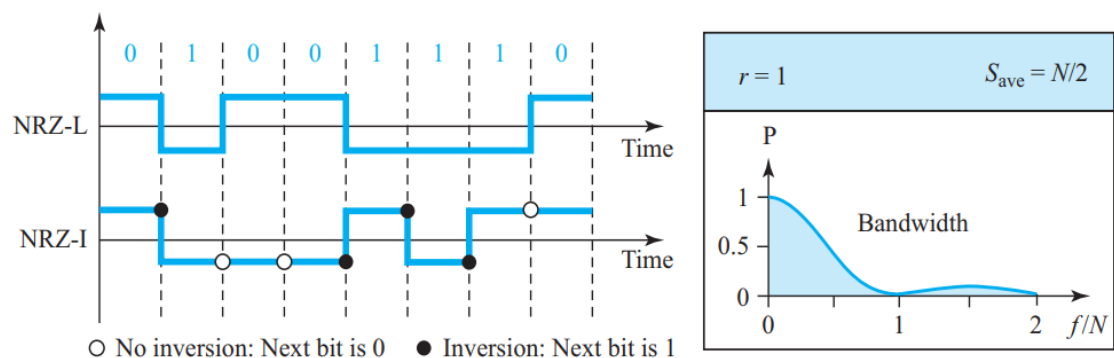
→ Answer:

0 1 1 1 0 0 0 1

P4-10. An NRZ-I signal has a data rate of 100 Kbps. Using Figure 4.6, calculate the value of the normalized energy (P) for frequencies at 0 Hz, 50 KHz, and 100 KHz.

Solution:

Figure 4.6 Polar NRZ-L and NRZ-I schemes



The data rate is 100 Kbps. For each case, we first need to calculate the value f/N . We then use Figure 4.6 in the text to find P (energy per Hz).

All calculations are approximations.

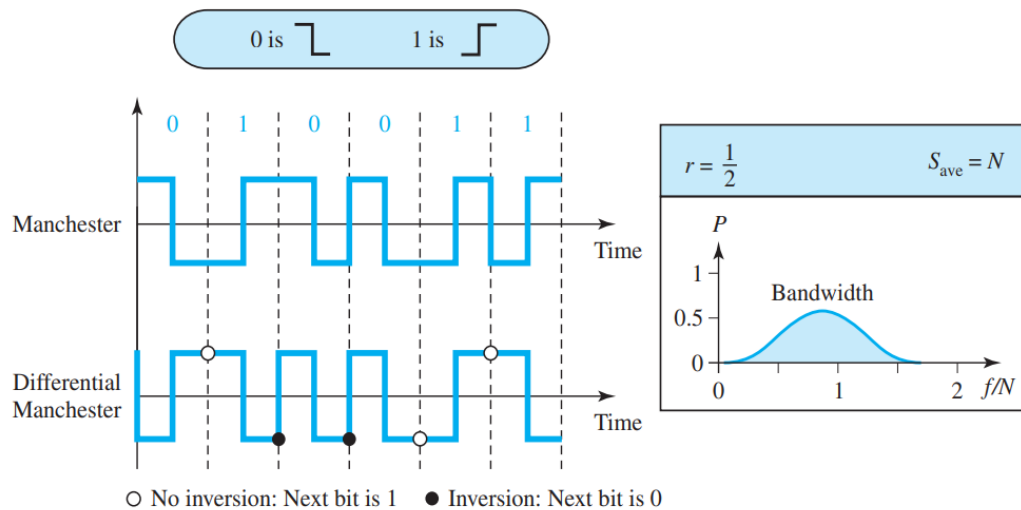
a. $f/N = 0/100 = 0 \rightarrow P = 1.0$

b. $f/N = 50/100 = 1/2 \rightarrow P = 0.5$

c. $f/N = 100/100 = 1 \rightarrow P = 0.0$

P4-11. A Manchester signal has a data rate of 100 Kbps. Using Figure 4.8, calculate the value of the normalized energy (P) for frequencies at 0 Hz, 50 KHz, 100 KHz.

Figure 4.8 Polar biphase: Manchester and differential Manchester schemes



Solution:

The data rate is 100 Kbps. For each case, we first need to calculate the value f/N . We then use **Figure 4.8 in the text to find P** (energy per Hz). All calculations are approximations.

- $f/N = 0/100 = 0 \rightarrow P = 0.0$
- $f/N = 50/100 = 1/2 \rightarrow P = 0.3$
- $f/N = 100/100 = 1 \rightarrow P = 0.4$

P4-12. The input stream to a 4B/5B block encoder is

0100 0000 0000 0000 0000 0001

Answer the following questions:

- What is the output stream?
- What is the length of the longest consecutive sequence of 0s in the input?
- What is the length of the longest consecutive sequence of 0s in the output?

Solution:

- The output stream is **01010 11110 11110 11110 11110 01001**. (using Table 4.2)
- The maximum length of consecutive 0s in the input stream is **21**.
- The maximum length of consecutive 0s in the output stream is **2**

P4-13. How many invalid (unused) code sequences can we have in 5B/6B encoding?
How many in 3B/4B encoding?

Solution:

.In 5B/6B, we have $2^5 = 32$ data sequences and $2^6 = 64$ code sequences

The number of unused code sequences is $64 - 32 = 32$. In 3B/4B, we have $2^3 = 8$ data

.sequences and $2^4 = 16$ code sequences. The number of unused code sequences is $16 - 8 = 8$

P4-14. What is the result of scrambling the sequence 11100000000000 using each of the following scrambling techniques? Assume that the last non-zero signal level has been positive.

a. B8ZS

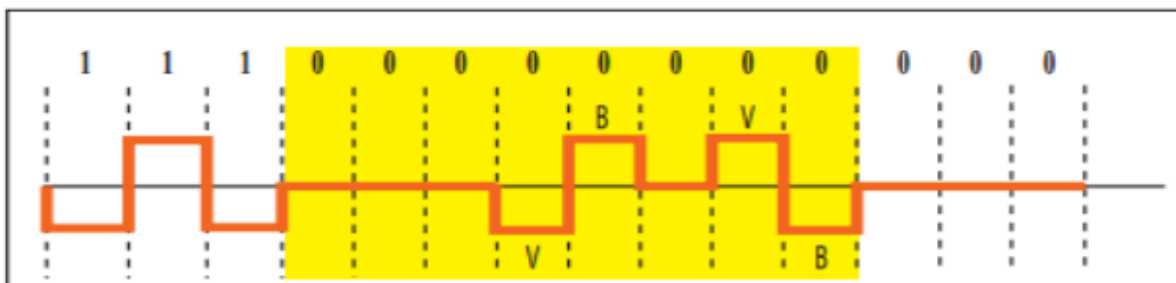
b. HDB3 (The number of nonzero pulses is odd after the last substitution.)

Solution:

a.

B8ZS substitutes eight consecutive zeros with 000VB0VB.

The V means the same polarity as the polarity of the previous nonzero pulse; B means the polarity opposite to the polarity of the previous nonzero pulse.



P4-15. What is the Nyquist sampling rate for each of the following signals?

a. A low-pass signal with bandwidth of 200 KHz?

b. A band-pass signal with bandwidth of 200 KHz if the lowest frequency is 100 KHz?

Solution:

In a low-pass signal, the minimum frequency 0. Therefore, we have
 $f_{\max} = 0 + 200 = 200 \text{ KHz}$. $\rightarrow f_s = 2 \times 200,000 = 400,000 \text{ samples/s}$

In a bandpass signal, the maximum frequency is equal to the minimum frequency plus the bandwidth.
Therefore, we have
 $f_{\max} = 100 + 200 = 300 \text{ KHz}$. $\rightarrow f_s = 2 \times 300,000 = 600,000 \text{ samples /s}$

P4-16. We have sampled a low-pass signal with a bandwidth of 200 KHz using 1024 levels of quantization.

- Calculate the bit rate of the digitized signal.
- Calculate the SNR_{dB} for this signal.
- Calculate the PCM bandwidth of this signal.

Solution:

① bit rate of digitized signal.

Sol:

$$n_b = \log_2 L$$

$$N = f_s \times n_b$$

$\Rightarrow n_b$ (# bits per sample)

$$n_b = \log_2 1024 = 10 \text{ bits/sample}$$

$$\therefore \text{bit rate } (N) = f_s \times n_b$$

$$= 10 \times 400 \text{ k} = 4 \text{ Mb/s}$$

Side notes:

$$BW = f_{\max} - f_{\min}$$

$$200 = f_m - 0$$

$$f_m = 0 + 200 = 200$$

$\Rightarrow$ In low-pass $f_{\min} = 0$

$\Rightarrow f_{\max} = 0 + 200 \text{ k} = 200 \text{ k}$

$\Rightarrow f_s = 2 \times f_{\max} = 400 \text{ k Sample/sec}$

② SNR_{dB}.

Sol:

$$\text{SNR}_{\text{dB}} = 6.02 \times n_b + 1.76$$

$$= 6.02 \times 10 + 1.76$$

$$= 61.96 \text{ dB}$$

③ PCM ??

Sol:

$$\text{PCM} = n_b \times B_{\text{analog}}$$

$$= 10 \times 200 \text{ kHz}$$

$$= 2 \text{ MHz}$$

P4-17. What is the maximum data rate of a channel with a bandwidth of 200 KHz if we use four levels of digital signaling.

Solution:

$$N_{max} = 2 * BW * n_b$$

$$= 2 * 200K * \log_2 4 = 800Kbps$$

P4-18. An analog signal has a bandwidth of 20 KHz. If we sample this signal and send it through a 30 Kbps channel, what is the SNRdB?

Solution:

b

$$SNR_{dB} = 6.02 * n_b + 1.72$$

$$= 6.02 * 1 + 1.72 = 7.74 \text{ dB}$$

$$n_b = ??$$

$$f_{max} = 20K + 0 = 20KHz$$

$$f_s = 2 * f_{max} = 4000 \text{ sample/s}$$

$$n_b = \frac{\text{Bit Rate}}{\text{Sample Rate}} = \frac{\text{Bit Rate}}{f_s} \Rightarrow \begin{matrix} \text{no bit} \\ \text{rate} = f_s * n_b \end{matrix}$$

$$n_b = \frac{3000}{4000} = 0.75 \approx 1$$

P4-19. We have a baseband channel with a 1-MHz bandwidth. What is the data rate for this channel if we use each of the following line coding schemes?

a. NRZ-L

b. Manchester

c. MLT-3

d. 2B1Q

Solution:

DATA RATE :

$$\text{[a] NRZ-L : } \boxed{B = \frac{N}{2}} \Rightarrow N = 2 \times 1M = \boxed{2Mbps}$$

$$\text{[b] Manchester : } \boxed{B = N} \Rightarrow N = \boxed{1Mbps}$$

$$\text{[c] MLT : } \boxed{B = N/3} \Rightarrow N = \boxed{3 \times 1 = 3Mbps}$$

$$\text{[d] 2B1Q : } \boxed{B = N/4} \Rightarrow N = \boxed{4Mbps}$$

P4-20. We want to transmit 1000 characters with each character encoded as 8 bits.

a. Find the number of transmitted bits for synchronous transmission.

b. Find the number of transmitted bits for asynchronous transmission.

c. Find the redundancy percent in each case.

Solution:

① # bit for sync.

$$\underline{\text{Sol:}} \quad 1000 \times 8 = \boxed{8000 \text{ bits}}$$

② # bit for asyn.

$$\underline{\text{Sol:}} \quad (\text{start bit} + \text{data} + \text{end bit}) \Rightarrow 10 \text{ bit for each char.}$$

$$1000 \times 10 = \boxed{10000 \text{ bits}}$$

③ redundancy percent.

In ① : no redundancy bit.

$$\text{② : } \frac{2}{10} = \boxed{0.2}$$