Solution of

Digital Transmission

(According to data communications and networking 5th edition forouzan)

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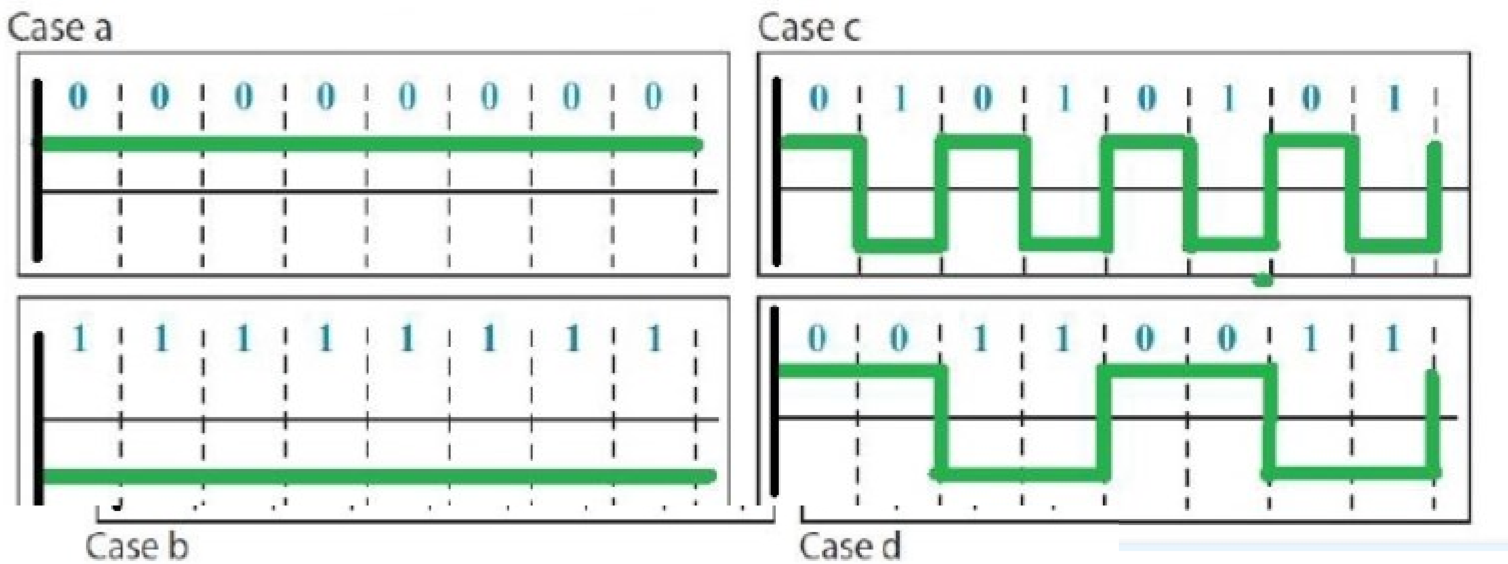
15. Draw the graph of the NRZ-L scheme using each of the following data streams, assuming that the last signal level has been positive. From the graphs, guess the bandwidth for this scheme using the average number of changes in the signal level.
Compare your guess with the corresponding entry in Table 4.1.

a. 00000000
b. 11111111
c. 01010101
d. 00110011

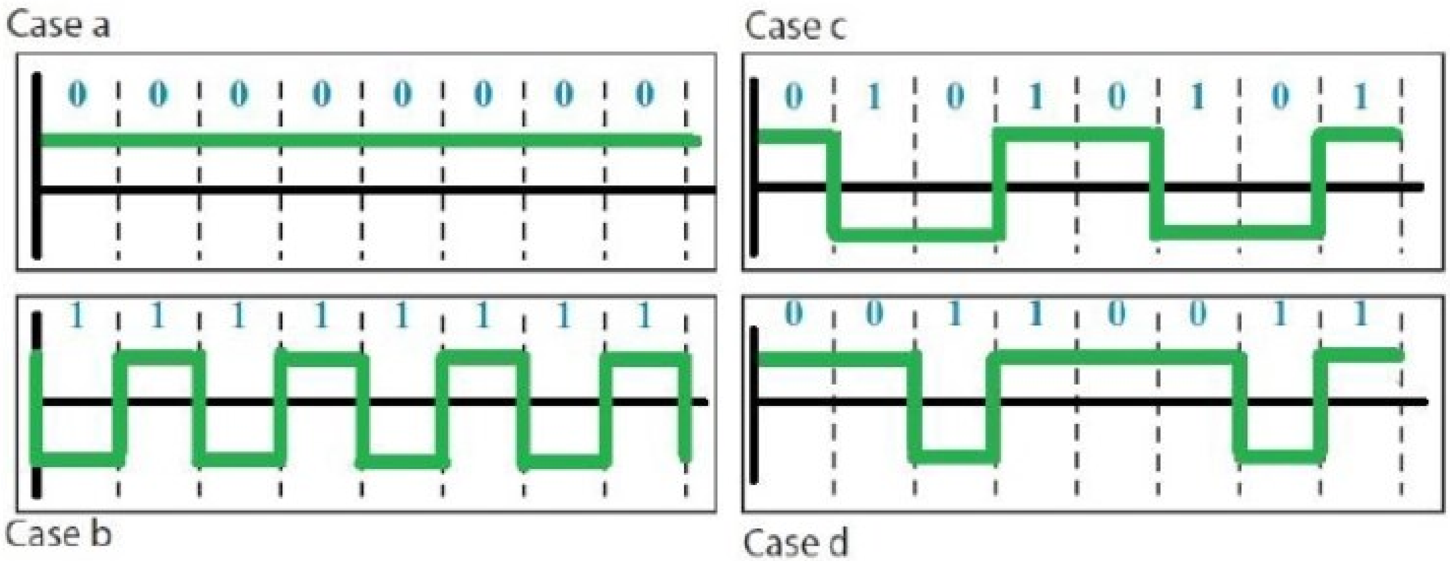
Ans:



Average Number of Changes = (0 + 0 + 8 + 4) / 4 = 3 for N = 8
∴ bandwidth, B → (3 / 8) N

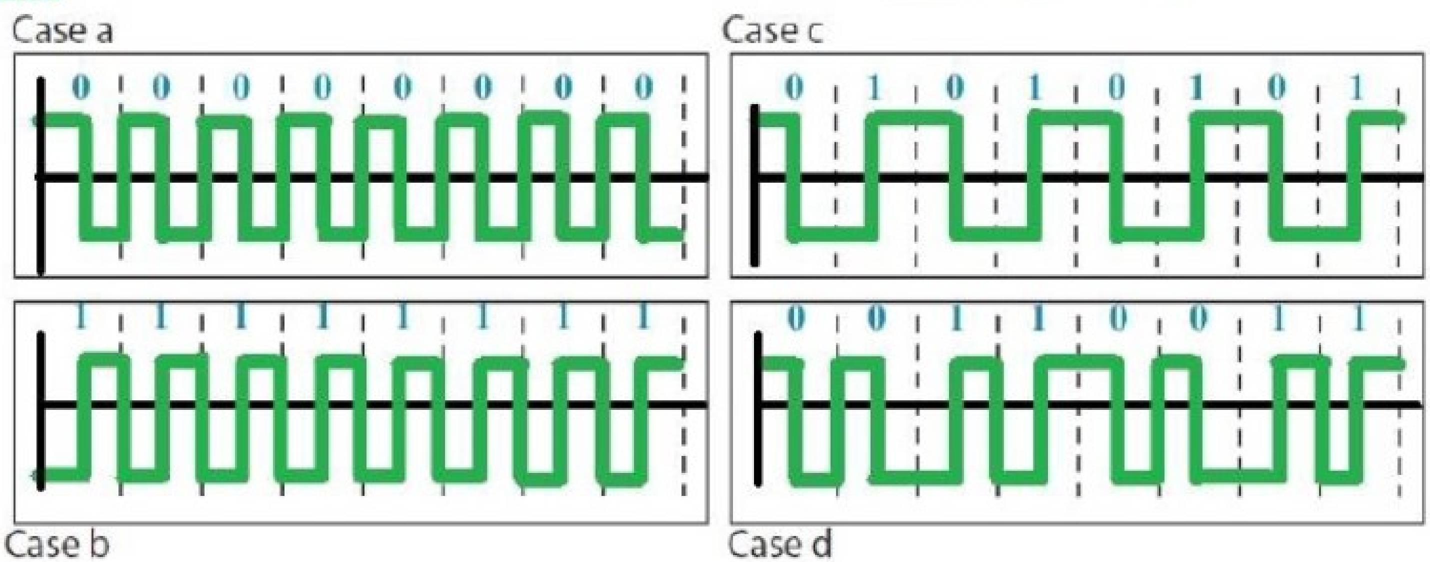
Repeat Exercise 15 for the NRZ-I scheme.

Ans:
Average Number of Changes = (0 + 9 + 4 + 4) / 4 = 4.25 for N = 8
∴ bandwidth, B → (4.25 / 8) N



Repeat Exercise 15 for the Manchester scheme.

Ans:

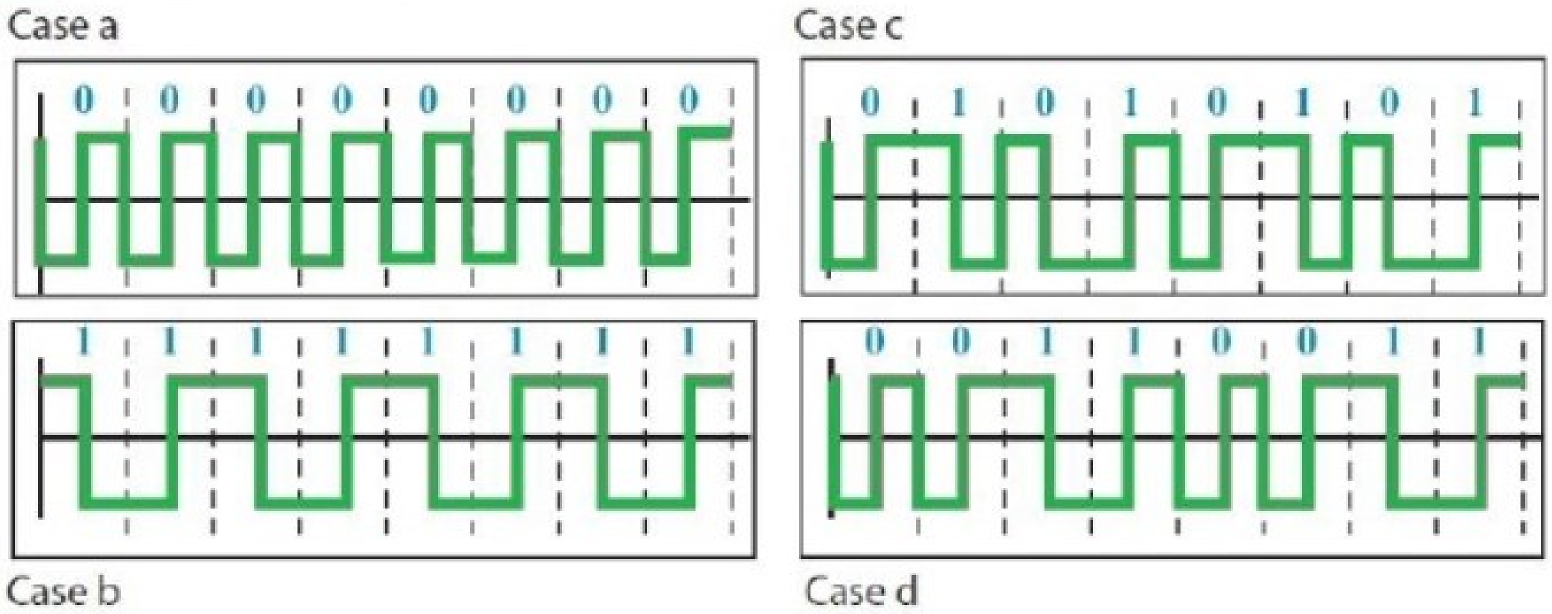


Average Number of Changes = (15 + 15 + 8 + 12) / 4 = 12.5 for N = 8

∴ bandwidth, B → (12.5 / 8) N

Repeat Exercise 15 for the differential Manchester scheme.

Ans:



Average Number of Changes = (16 + 8 + 12 + 12) / 4 = 12 for N = 8

∴ bandwidth, B → (12 / 8) N

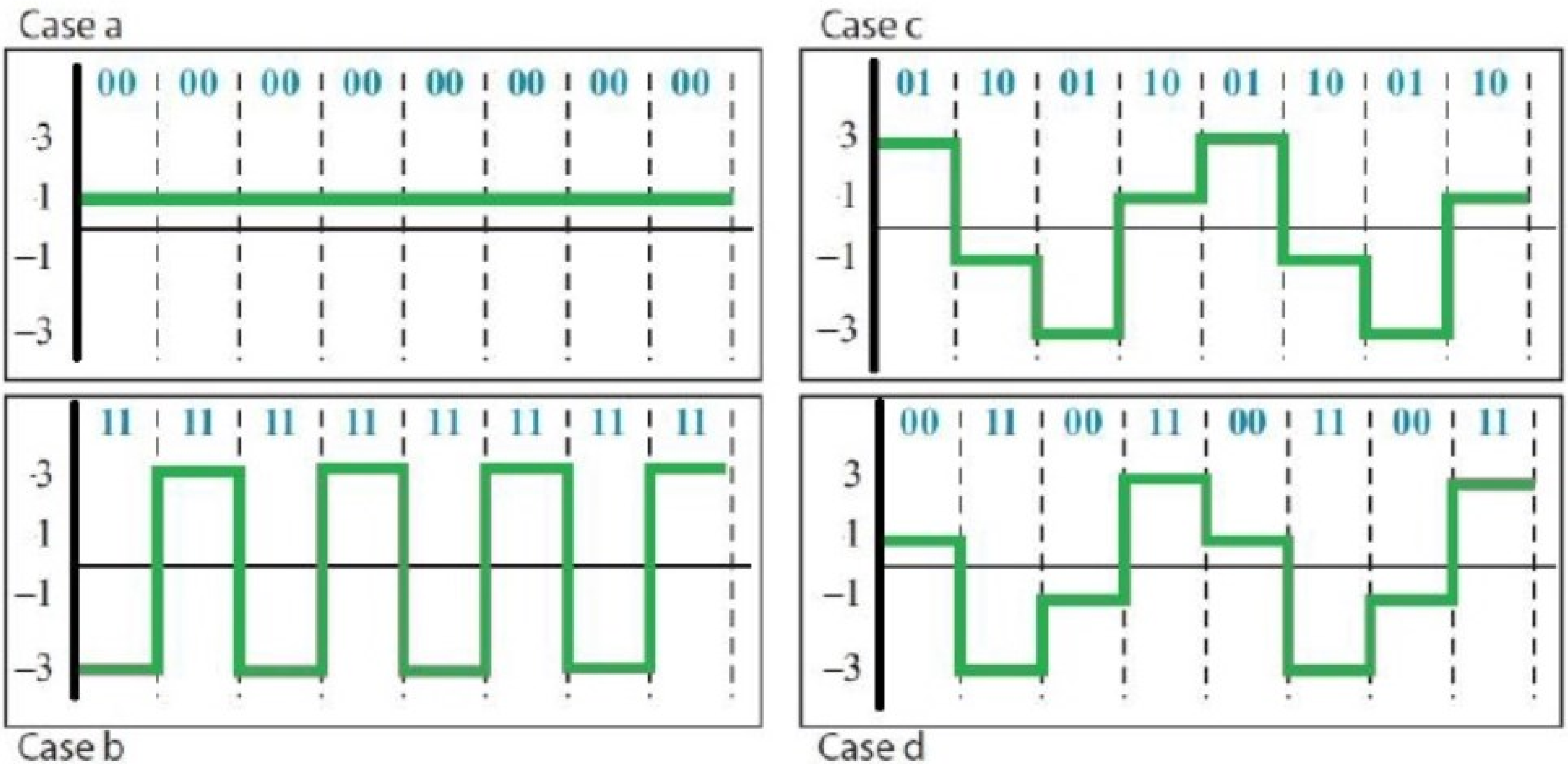
19. Repeat Exercise 15 for the 2B 1Q scheme, but use the following data streams.

a. 0000000000000000

b. 1111111111111111

c. 0101010101010101

d. 0011001100110011



Average Number of Changes = (0 + 7 + 7 + 7) / 4 = 5.25 for N = 16

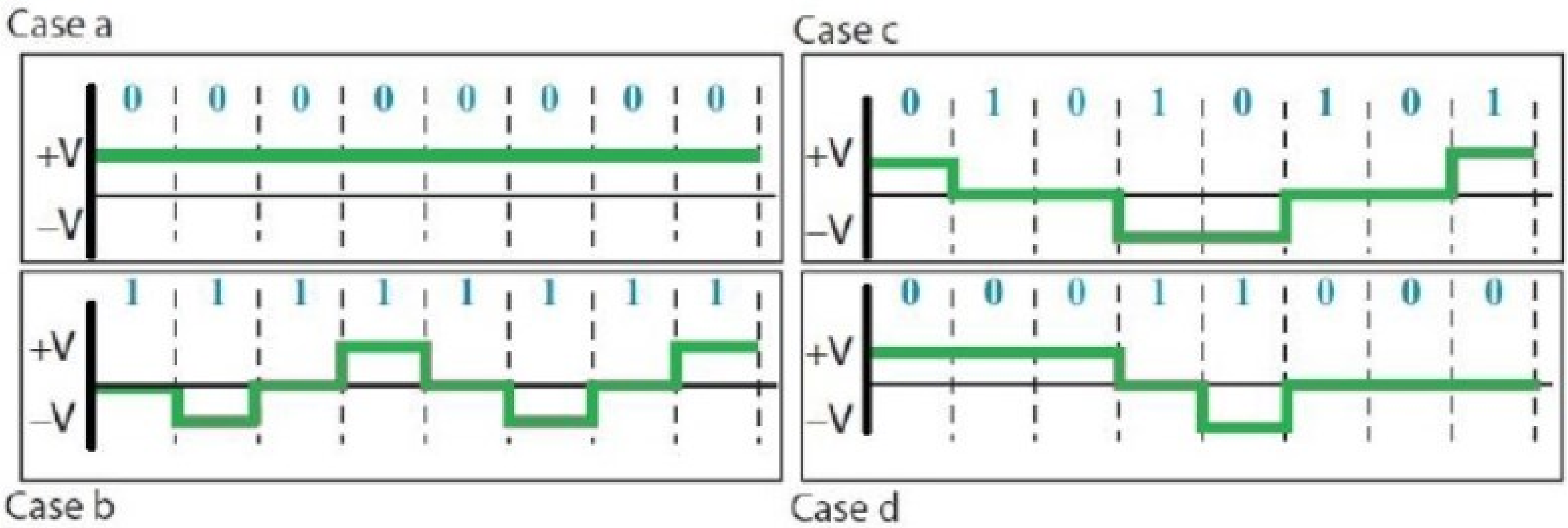
∴ bandwidth, B → (5.25 / 8) N

20. Repeat Exercise 15 for the MLT-3 scheme, but use the following data streams.

a. 00000000 c. 01010101

b. 11111111 d. 00011000

Ans:

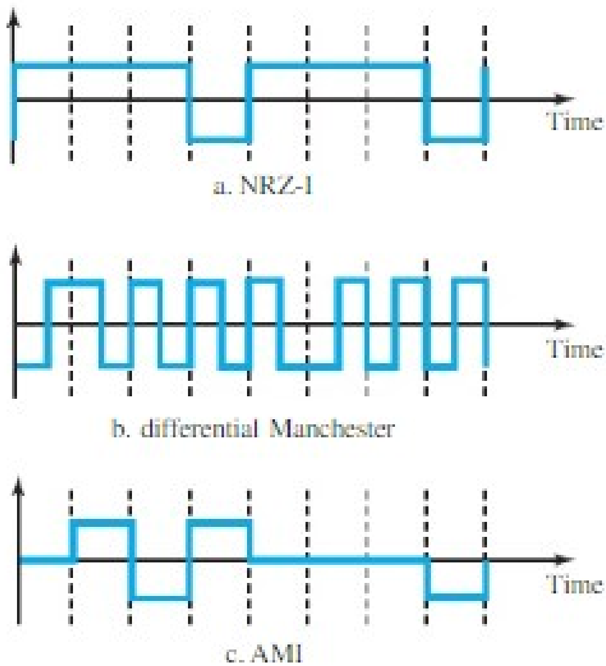


Average Number of Changes = (0 + 7 + 4 + 3) / 4 = 4.5 for N = 8

∴ bandwidth, B → (4.5 / 8) N

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

Figure 4.36 *Problem P4-9*



Ans: The 8 bit data stream can be found as

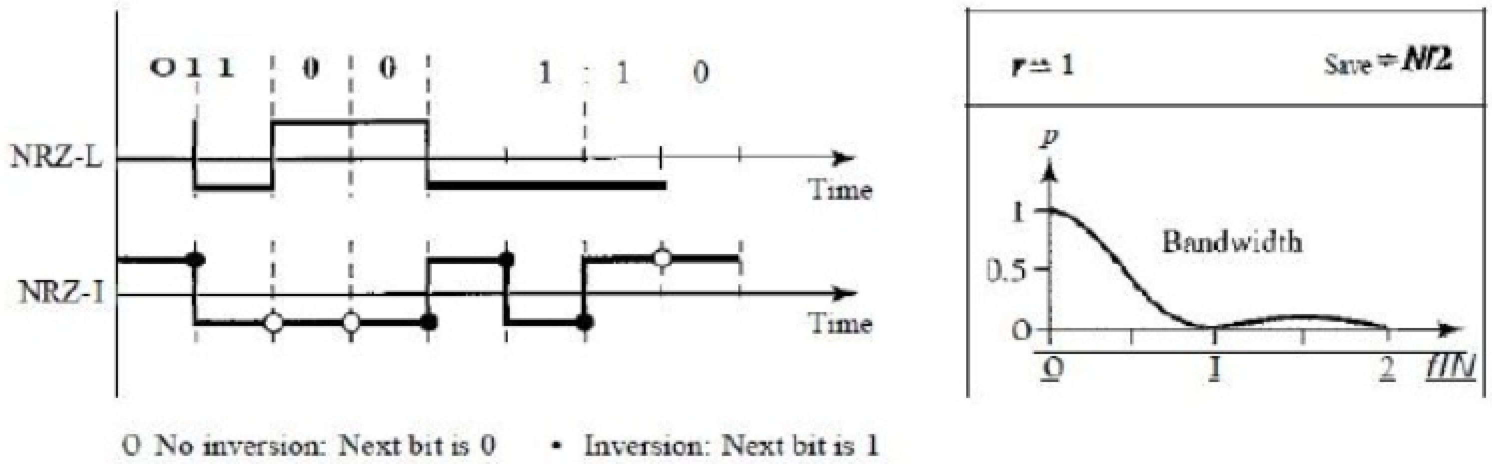
a. NRZ-I: 10011001.

b. Differential Manchester: 11000100.

c. AMI: 01110001.

22. 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.

Figure 4.6 *Polar NRZ-L and NRZ-I schemes*



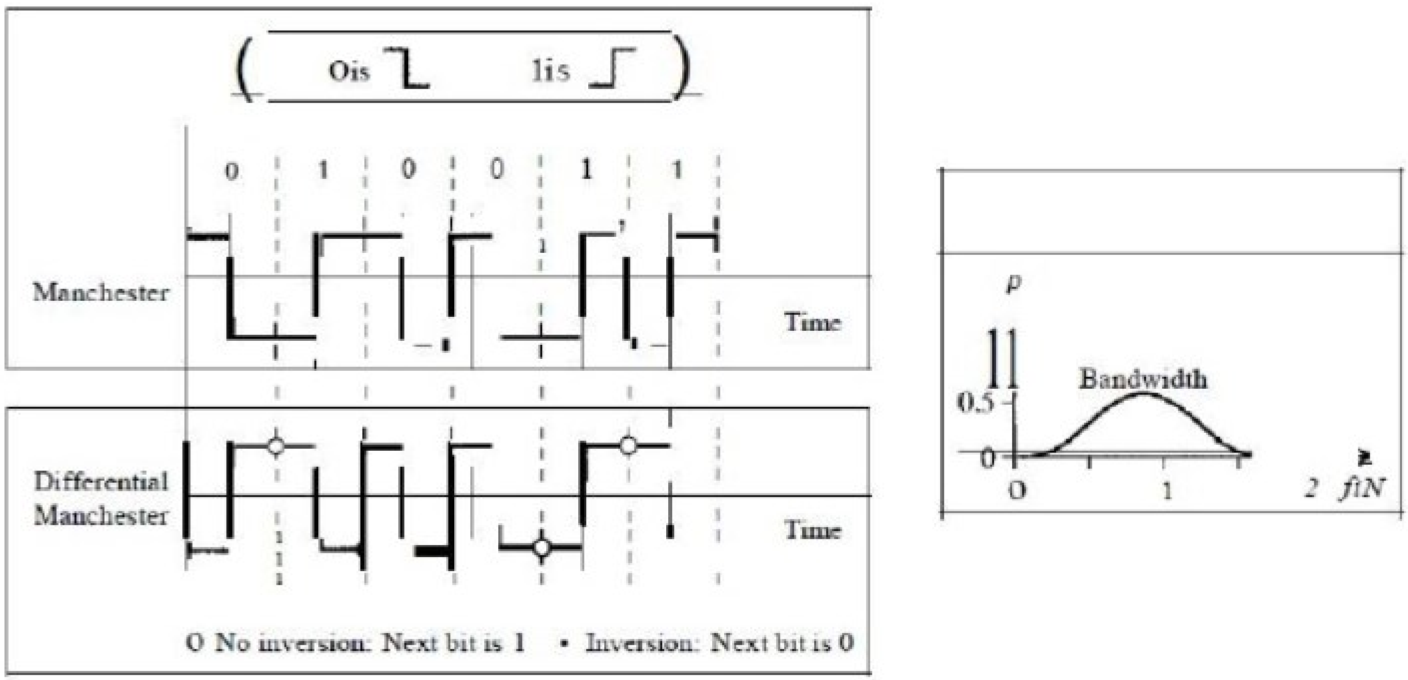
Ans:

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

23. 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*



Ans:
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.
a. f /N = 0/100 = 0 → P = 0.0
b. f /N = 50/100 = 1/2 → P = 0.3
c. f /N = 100/100 = 1 → P = 0.4
d. f /N = 150/100 = 1.5 → P = 0.0

24. The input stream to a 4B/5B block encoder is 0100 0000 0000 0000 0000 0001. Answer the following questions:
a. What is the output stream?
b. What is the length of the longest consecutive sequence of 0s in the input?
c. What is the length of the longest consecutive sequence of 0s in the output?
Ans: a. The output stream is 01010 11110 11110 11110 11110 01001.
b. The maximum length of consecutive 0s in the input stream is 21.
c. The maximum length of consecutive 0s in the output stream is 2.

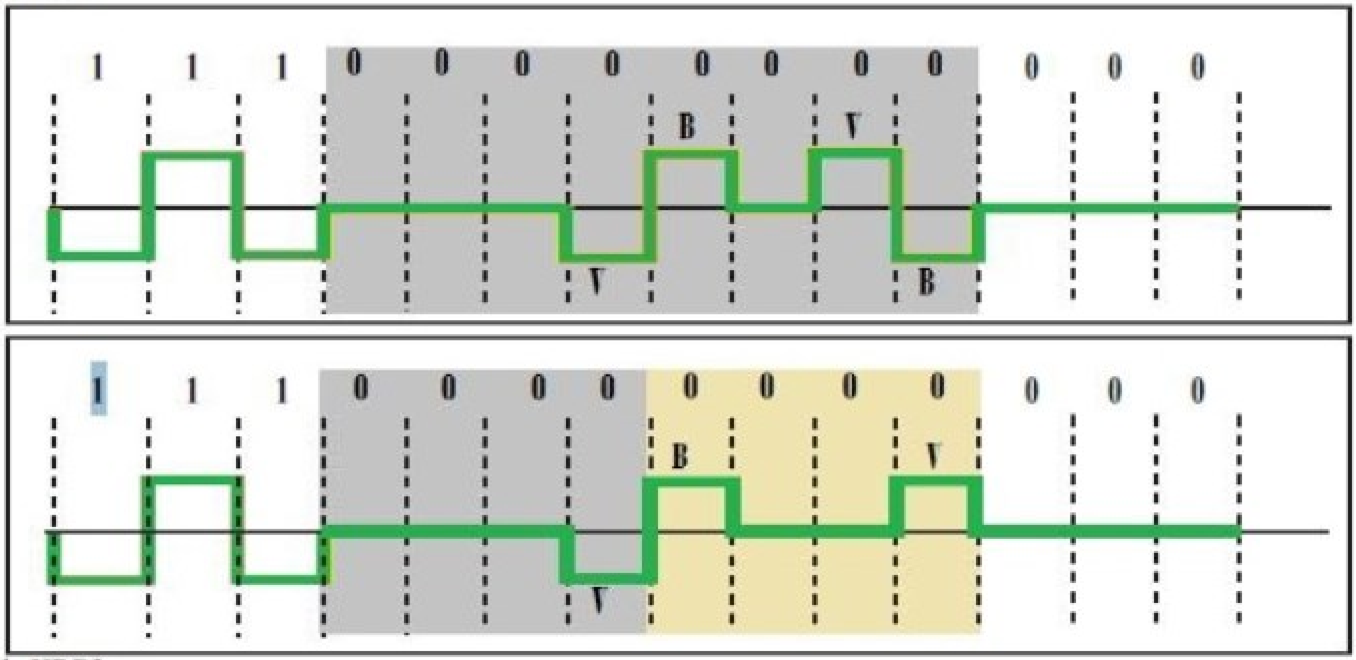
25. How many invalid (unused) code sequences can we have in 5B/6B encoding? How many in 3B/4B encoding?

Ans: In 5B/6B, we have 25 = 32 data sequences and 26 = 64 code sequences. The number of unused code sequences is 64 − 32 = 32. In 3B/4B, we have 23 = 8 data sequences and 24 = 16 code sequences. The number of unused code sequences is 16 − 8 = 8.

26. What is the result of scrambling the sequence 11100000000000 using one of the following scrambling techniques? Assume that the last non-zero signal level has been positive.
a. B8ZS
b. HDB3 (The number of nonzero pules is odd after the last substitution)

Ans: See this figure where the last non-zero signal is positive and the first bit is positive.

a. B8ZS



b. HDB3

27. 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?

Ans:

a. Here, Bandwidth = 200 KHz = 200000Hz.
We know that, in a low-pass signal, the minimum frequency = 0.
$\therefore f_{max} = 0 + 200000 = 200000$ Hz.
⇨ $f_s = 2 \times 200000 = 400000$ samples/s

b. Here, the lowest frequency = 100 KHz = 100000 Hz.
And, Bandwidth = 200 KHz = 200000Hz
$\therefore f_{max} = 100000 + 200000 = 300000$ Hz.
⇨ $f_s = 2 \times 300000 = 600000$ samples /s

28. We have sampled a low-pass signal with a bandwidth of 200 KHz using 1024 levels of quantization.
a. Calculate the bit rate of the digitized signal.
b. Calculate the SNR_{dB} for this signal.
c. Calculate the PCM bandwidth of this signal.

Ans:

a. Here, Bandwidth = 200 KHz = 200000Hz.
We know that, in a low-pass signal, the minimum frequency = 0
$\therefore f_{max} = 0 + 200000 = 200000$ Hz
⇨ $f_s = 2 \times 200000 = 400000$ samples/s

The number of bits per sample, and the bit rate are

$$n_b = \log_2 1024$$
$$= 10 \text{ bits/sample}$$
$$\therefore N = 400000 \times 10 = 4\times10^6 \text{ bps} = 4 \text{ Mbps}$$

b. We get, the value of $n_b = 10$.

$\therefore SNR_{dB} = 6.02 \times n_b + 1.76 = 61.96$

c. We get, the value of $n_b = 10$.

$\therefore$ The minimum bandwidth can be calculated as,

$$B_{PCM} = n_b \times B_{analog} = 10 \times 200000 = 2 \text{ MHz}$$

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

Ans: Here, bandwidth = 200 KHz = 200000 Hz

$\therefore$ The maximum data rate can be calculated as

$$N_{max} = 2 \times B \times n_b = 2 \times 200000 \times \log_2 4 = 8 \times 10^8 \text{ bps} = 800 \text{ Kbps.}$$

30. 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 SNR_{dB} ?

Ans: Given, Bandwidth = 20 KHz = 20000 Hz.

$\therefore f_{max} = 0 + 4 = 4$ KHz

$\Rightarrow \quad f_s = 2 \times 4 = 8000$ sample/s

We then calculate the number of bits per sample.

$\Rightarrow \quad n_b = 30000 / 8000 = 3.75$

We need to use the next integer $n_b = 4$. The value of SNR_{dB} is

$\therefore SNR_{dB} = 6.02 \times n_b + 1.72 = 25.8$

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

a. NRZ-L b. Manchester

c. MLT-3 d. 2B1Q

Ans: Here, bandwidth = 1 MHz = 1000 Hz

a. NRZ-L => $N = 2 \times B = 2 \times 1000 = 2000$ bps

b. Manchester => $N = 1 \times B = 1 \times 1000 = 1000$ bps

c. MLT-3 => $N = 3 \times B = 3 \times 1000 = 3000$ bps

d. 2B1Q => $N = 4 \times B = 4 \times 1000 = 4000$ bps

32. 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.

Ans:

a. For synchronous transmission, transmitted bits = $1000 \times 8 = 8000$ bits.

b. For asynchronous transmission, transmitted bits = $1000 \times 10 = 10000$ bits.

N.B. (8 bits + 1 stop bit & 1 start bit)

c. For case a, the redundancy is 0%.

For case b, we send 2000 extra for 8000 required bits. The redundancy is 25%.