UNIVERSITY OF MORATUWA

Faculty of Information Technology

BSc Hons in Artificial Intelligence

Semester 3

IN1501 - Data Communication

Tutorial 02: Signal Encoding[Digital to Digital]

Time Allowed: 2 hours

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1. Short Answer Question
    a. Which digital encoding technique has zero DC component but requires double the bandwidth of NRZ?
    b. Indicate a limitation fo NRZ-I ?
    c. Which encoding uses voltage transition as data rather than voltage level?
    d. Which encoding technique is self-clocking without additional synchronization bits?
    e. A digital signal encoded using Manchester has a bit rate of 10 Mbps. what is its minimum signal rate?
    f. In Bipolar AMI, which data pattern causes synchronization loss?
    g. Which encoding is most immune to polarity inversion errors?
    h. Which scheme results in the highest bandwidth requirement for the same bit rate?
    i. In Differential Manchester, what does a transition at the beginning of the bit interval indicates?
    j. Which encoding technique allows error detection by violation of rules?
    k. Which scheme produces a non-zero average voltage over time?
    l. For a fixed bit rate, which encoding results in the largest number of signal elements?
    m. Why are unipolar schemes rarely used in modern networks?
    n. Which encoding scheme is best suited for long-distance transmission and why?
    o. Which encoding technique was historically used in Token Ring networks?
    p. Which encoding minimizes baseline wandering?
    q. A digital signal with abrupt transitions theoretically requires
    r. Which encoding technique converts 1s into alternating positive and negative voltages?
    s. Which encoding is most affected by low-frequency noise?
    t. Which of the following schemes does NOT require a separate clock signal?
    u. Explain why NRZ-L is unsuitable for long-distance communication links.
    v. Compare NRZ-L and NRZ-I in terms of synchronization and noise immunity.
    w. Explain how Manchester encoding achieves synchronization.
    x. Why does Bipolar AMI eliminate the DC component but still suffer from synchronization issues?
    y. Define signal rate and distinguish it from bit rate.

z. Explain why digital signals theoretically require infinite bandwidth.
aa. State two advantages and one disadvantage of Differential Manchester encoding.
bb. Explain baseline wandering and identify which encoding techniques reduce it.
cc. Why are transitions important in digital-to-digital encoding?
dd. Explain why encoding choice affects bandwidth efficiency.

2. Calculate the answers.
   a. A digital signal uses NRZ-L encoding with a bit rate of 5 Mbps. Calculate the minimum signal rate.
   b. A Manchester-encoded signal has a bit rate of 2 Mbps.
      i. Find the signal rate.
      ii. Explain why it differs from NRZ.
   c. A digital signal has 16 discrete voltage levels. Calculate the number of bits per signal element.
   d. A bit interval is 0.25 μs. Calculate the bit rate.
   e. A data stream of 10110001 is transmitted using NRZ-I. Assume initial voltage is positive.
      i. Draw and explain the waveform.
   f. A binary sequence 11001010 is encoded using Manchester encoding. Draw the waveform and explain transitions.
   g. A Bipolar AMI signal transmits the bit stream 11110000.
      i. Identify the synchronization issue.
      ii. Suggest a solution.
   h. A channel supports a bandwidth of 3 MHz.
      i. Determine whether Manchester encoding at 1 Mbps is feasible.
      ii. Justify your answer mathematically.
   i. A digital signal is transmitted at 8 Mbps using Differential Manchester encoding.
      i. Calculate the minimum bandwidth required.
   j. A system designer must choose between NRZ-I and Manchester for a noisy channel. Compare required bandwidth and synchronization reliability with calculations.

① a. Manchester encoding

b. loss of synchronization

c. NRZ-I

d. Manchester

e. Minimum signal rate = 2 x 10 Mbps = 20 baud

f. Bipolar AMI

g. Differential Manchester

h. Manchester encoding

i. It indicates zero

j. Bipolar AMI

k. Unipolar NRZ

l. Manchester Encoding

m. Because it has a DC component
suffer from baseline wandering
offer poor synchronization

n. Differential Manchester
Becaus it is self clocking
resistant to noise
immune to polarity inversion

o. Differential Manchester

p. Manchester encoding

q. Requires infinite bandwidth

r. Bipolar AMI

s. NRZ-L

t. Manchester encoding

u. Because long runs of identical bits cause loss of synchronization.
And also it suffers from baseline wandering.

v. NRZ-L : Poor synchronization, more noise-sensitive

NRZ-I : Better noise immunity but poor synchronization for long 0s

w. Manchester encoding achieves synchronization by ensuring a transition in the middle of every bit.

x. Bipolar AMI removes DC by altering pulse polarity, but it still suffer from synchronization issues because long runs of zeros create no transition for clock recovery.

Y. Bit rate : Number of bits transmitted per second (bps)

Signal rate : Number of signal elements per second (baud)

z. Because instantaneous transitions contain infinitely high frequencies.

aa. Advantages → Self clocking

Immune to polarity inversion

Disadvantages → Needs more bandwidth

bb. Baseline wandering means a gradual shift in the signal's average voltage level

Encoding techniques like Manchester, Differential Manchester and Bipolar AMI reduce it.

cc. Because they enable clock recovery and help to maintain synchronization.

dd. As different schemes uses different number of signal changes per bit encoding choice affects bandwidth efficiency.

2. a. bit rate = 5 Mbps

For 1 bit per signal element

Mininum signal rate = 1×5 = $\underline{\underline{5 \text{ Mbaud}}}$

b. bit rate = 2 Mbps

i) signal rate = $2 \times$ bit rate

$= 2 \times 2 = \underline{\underline{4 \text{ Mbaud}}}$

ii) NRZ is for 1 signal element per bit but in Manchester it is 2 signal elements per bit.

c. 16 discrete voltage levels

Bits = $\log_2(16) = 4$

$\underline{\underline{4 \text{ bits}}}$ per signal element

d. Bit interval = $0.25\ \mu s$

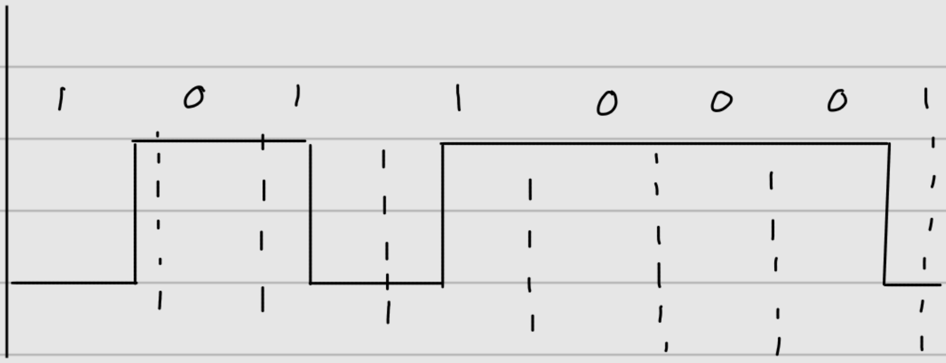
Bit rate = 1 / Bit interval

$= 1 / 0.25 \times 10^{-6}$

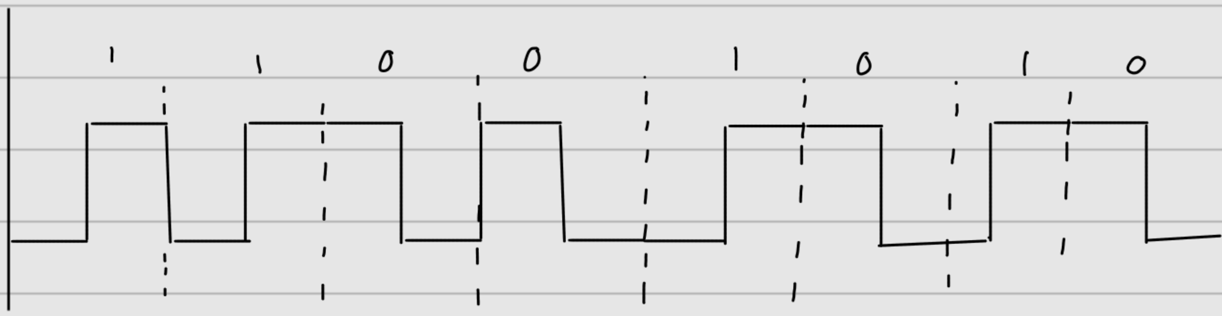
$= 4 \times 10^{6}$

$= \underline{\underline{4 \text{ Mbps}}}$

e.



f



g. i. Issue is long runs of zeros

ii. B8ZS

HDB3

h. Channel bandwidth = 3 MHz

i.

Bandwidth $\approx$ Signal rate = 2 × Bit rate

= 2 × 1 Mbps

= 2 MHz

ii 2 MHz < 3 MHz

∴ Yes it is feasible.

i. bit rate = 8 Mbps

2 signal elements per bit.

Signal rate = 2 x bit rate
= 2 x 8 = 16 Mbaud

Minimum bandwidth = signal rate
= 16 MHz

j.

NRZ	Manchester
Poor synchronization	Excellent synchronization
Signal rate = bit rate (R)	Signal rate = 2 x bit rate (2R)
Bandwidth = R	Bandwidth = 2R
ex: bit rate = 5 Mbps	
Bandwidth = 5 MHz	Bandwidth = 10 MHz
synchronization reliability is low	synchronization reliability is high.

∴ Manchester is suitable for noisy channels, even though it costs it twice the bandwidth