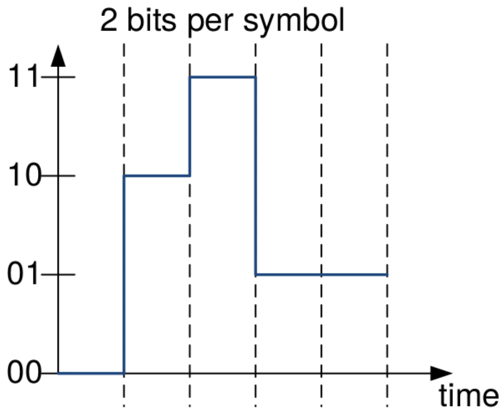
1 Bit Rate and Baud Rate

Consider a transmission over a channel with symbols transmitted every $T = 1ms$. The number of different symbols is 4, according to below illustration.



1. Calculate the baud rate and the bit rate of the example above.

2. Consider a different example with a bit rate of 128 *Mbps* and a baud rate of 16 *million symbols per second*. Determine the number of different symbols and the number of bits accordingly.

   Hint: $y = z \cdot log_b(x) \Leftrightarrow x = b^{\frac{y}{z}}$

2 Nyquist Rate

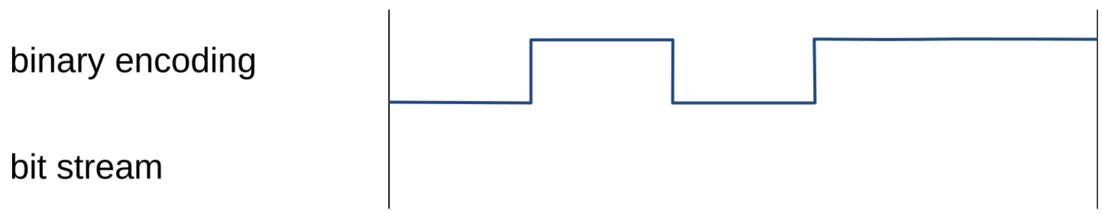
Consider a bandwidth-limited but otherwise perfect channel with bandwidth [0, B = 4 kHz]. Per baud one bit (0/1) is transfered to the receiver.

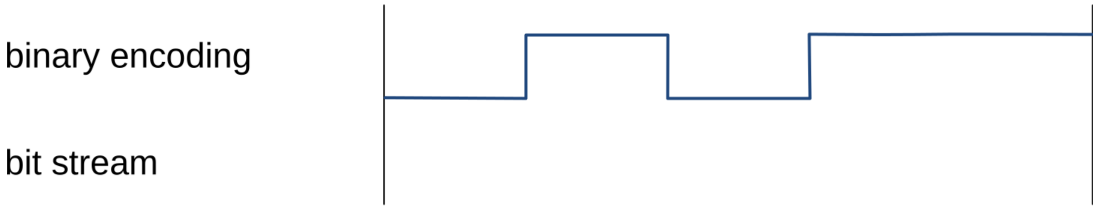
1. Determine the maximum data rate at which transmitted bits can be recovered correctly at the receiver.

2. Assume that the available bandwidth B drops to 1 kHz and to 250 Hz, (i.e., to $^1/_4B$). Additional discrete levels V can be introduced with the goal to compensate the lower available bandwidth and to sustain the maximum data rate. In this case, which component in above equation, (i) the number of bits or (ii) the number of discrete levels, needs to be multiplied by 4 (according to the $^1/_4$ B) to achieve an equal data rate?

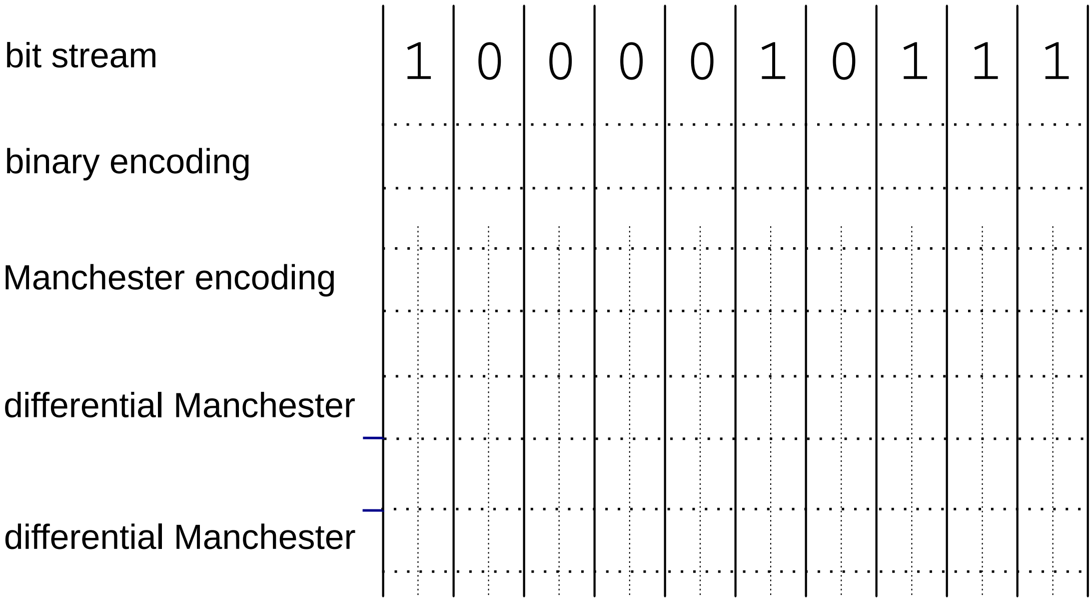
3 Line Coding

1. A receiver needs to decode the below signal and to retrieve the original bit stream as transmitted by the sender. The illustration shows two traces with a duration of 1 ms. The clock signal was (i) f = 10 kHz in the first case and (ii) f = 5 kHz in the second case. Reconstruct the received bit stream(s).





2. Consider below bit stream and a sender that uses different encoding methods to send out this data. Sketch the transmitted signal and use (i) binary encoding, (ii) Manchester encoding, and (iii), (iv) differential Manchester encoding. Take into account the different initial signal levels for (iii) and (iv).



3. Consider the given bit stream 1000010111 was sent encoded in binary encoding, Manchester encoding and differential Manchester encoding. Unfortunately the connections of the UTP cable are swapped at receiver side. What bit stream will the receiver decode? Complete the following table.

Bit stream at sender	1 0 0 0 0 1 0 1 1 1
Bit stream received - binary encoding	
Bit stream received - Manchester encoding	
Bit stream received - differential Manchester encoding	

4. Determine the baud rate and the bit rate for (ii) Manchester encoding and assume that the duration of the trace is 80 ms.

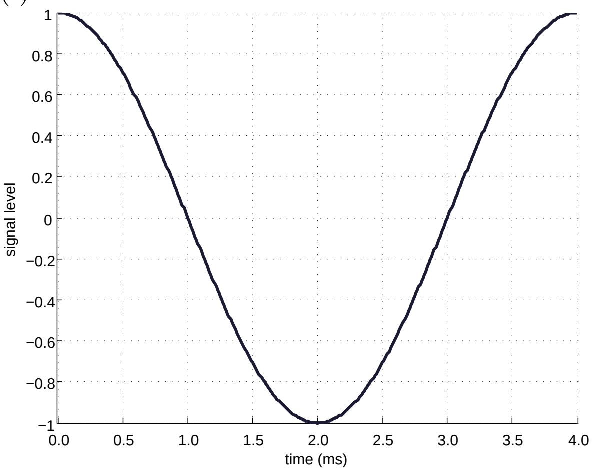
5. Can the clock signal reliably be recovered from the received signal? Are there sequences that could yield an incorrect clock signal for (ii) Manchester encoding and (iii/iv) differential Manchester encoding?

4 Modulation Schemes

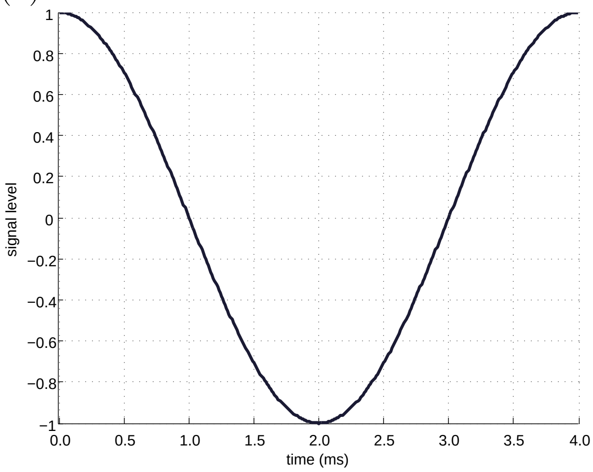
1. Below graphs show three times the following cosine function: s(t) = a $\cdot$ $cos(2\pi ft+\phi)$ with amplitude a = 1, frequency f = 250 Hz, and phase $\phi = 0$. Add to these graphs the same function with changed parameters: amplitude, frequency, phase - each two additional graphs.

   (i) 0.5x amplitude and 0x amplitude
   (ii) 0.5x frequency and 2x frequency
   (iii) phase = 0.25π and 0.5π .

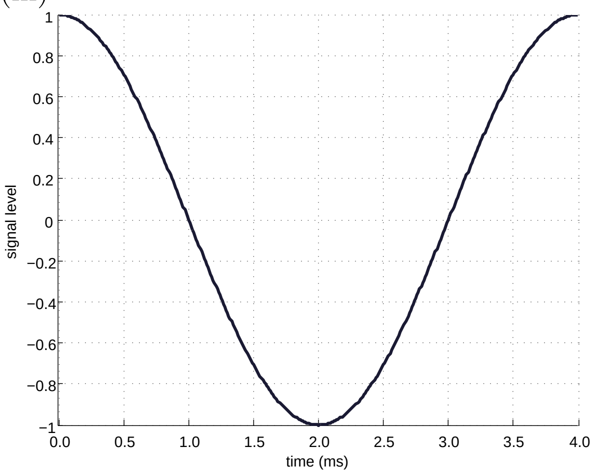
(i)



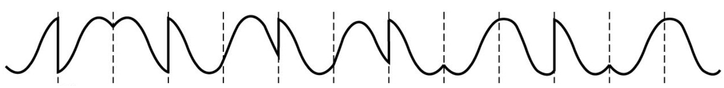
(ii)



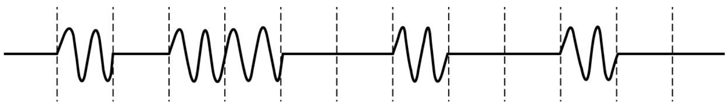
(iii)



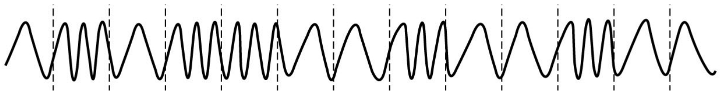
2. Name the basic modulation schemes used in the following three examples:



_ _ _ _ _ _ Shift Keying (_ S K)

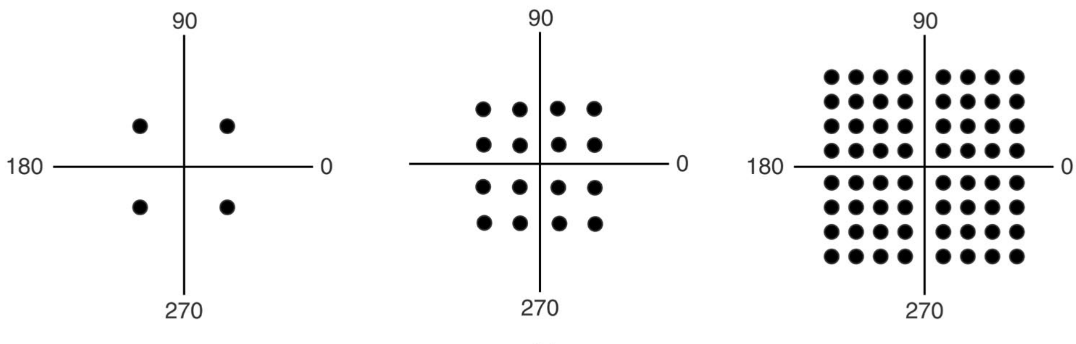


_ _ _ _ _ _ Shift Keying (_ S K)



_ _ _ _ _ _ Shift Keying (_ S K)

3. Which higher order modulation schemes are shown here and how many bits can be transmitted per symbol with these schemes?



(a) (b) (c)

5 Flag Bytes with Bit Stuffing

1. Given is the flag 01111110 and the below payload bit pattern.

   0111011001111111

   How does the transmitted bit stream look like if the given pattern is divided into two frames of equal size (before stuffing)?

2. The following bit stream has been received.

   01111110111101111100011111100111111011111010011010001111110

   Given the flag 01111110, what does the payload bit pattern look like?