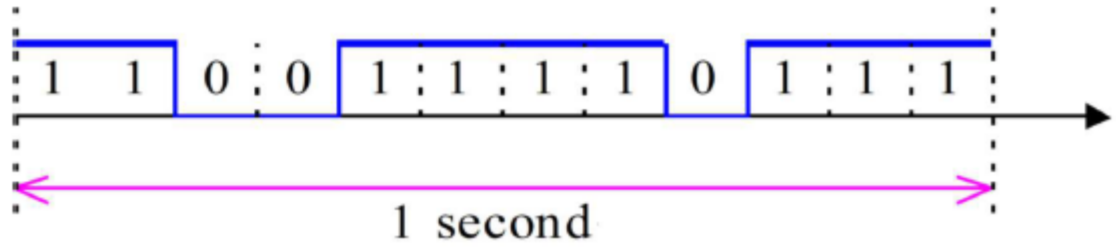
TD N°1: Physical Layer

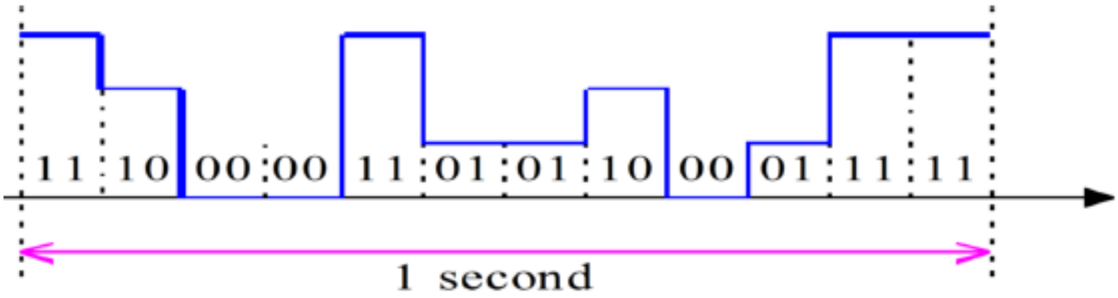
Question 1

Give the data rate and the Baud rate in the following examples

Sequence 1



Sequence 2



Solution 1 :

Baud rate refers to the number of signal or symbol changes that occur per second. A symbol is one of several voltage, frequency, or phase changes.

Bit Rate is speed of data transmission expressed in bits per second (bits/s or bps).

Sequence 1

Baud rate : 12 Signals/sec. If N is the number of bits per symbol, then the number of required symbols is $S = 2^N$. N = 1 then S = 2. Thus, the bit rate is: R = baud rate x $\log_2 S$ = 12 bps

Sequence 2

Baud rate : 12 Signals/sec. If N is the number of bits per symbol, then the number of required symbols is $S = 2^N$. N = 2 then S = 4. Thus, the bit rate is: R = baud rate x $\log_2 S$ = 24

Question 2

On a transmission link, 500 characters are sent per second. Each character is represented over 8 bits (ASCII is used). The transmission quality is considered good if the destination can receive 4 harmonics (components) of the signal.

1. What is the fundamental frequency of the signal generated when sending the sequence?

2. What is the bandwidth needed for having a good-quality transmission?

Solution 2 :

1. 500 characters are sent per second, then the fundamental frequency is 500 Hz.
2. The transmission quality is considered good if the destination can receive 4 harmonics (components) of the signal then, then the bandwidth is at least 4*fundamental frequency = 2000 Hz.

Question 3

1. What is the baud rate needed to have 3000 bps knowing that the signals transmitted are binary?

2. What is the minimal Signal-to-Noise ratio (S/N) in decibels to obtain this data rate knowing that the channel bandwidth is 1 kHz?

3. What is baud rate needed if a 4-levels signal is used instead of a binary signal?

Solution 2 :

1. the signals transmitted are binary, then baud rate equals bit rate = 3000
2. Apply Shannon: Max data rate = Band width * $\log_2(1+S/N)$
   a. $3000 = 1000 \log_2(1+S/N)$
   b. $1 + S/N = 2^3 = 8$. $S/N = 7$
   c. $S/N_{dB} = 10\text{Log}_{10}S/N = 8{,}4$
1. if a 4-levels signal is used, we know that R = baud rate x $\log_2 S$, then baud rate = R/2 = 1500.

Question 4 [data rate / number of levels]

We have a channel with a 1 MHz bandwidth. The SNR for this channel is 63; what is the appropriate bit rate and number of signal level?

Solution:

First use Shannon formula to find the upper limit on the channel's data-rate

$$C = B \log_2(1 + SNR) = 10^6 \log_2(1 + 63) = 10^6 \log_2(64) = 6 \text{ Mbps}$$

Although the Shannon formula gives us 6 Mbps, this is the upper limit. For better performance choose something lower, e.g. 4 Mbps.

Then use the Nyquist formula to find the number of signal levels.

$$C = 2 \cdot B \cdot \log_2 M \ \text{[bps]}$$

$$4 \text{ Mbps} = 2 \times 1 \text{ MHz} \times \log_2 L \ \rightarrow \ L = 4$$

Question 5

A transmission medium is characterized by its cutoff frequencies: 60 kHz and 108 kHz and an S/N of 40 dB.

1. What is the maximal data rate that can be provided by this medium?

2. Same question if S/N is 80dB?

Solution 5 :

1. Apply Shannon
   a. The Bandwidth is the diff between cutoff frequencies = 48 kHz.
   b. maximal data rate = Band width * $\log_2(1+S/N)$ = 48 * $\log_2(41)$ = 48*5.36 = 257 Kbps
2. maximal data rate = Band width * $\log_2(1+S/N)$ = 48 * $\log_2(81)$ = 48*6.4= 307 Kbps