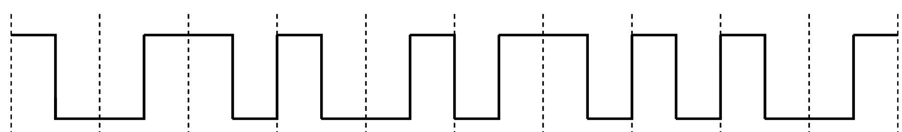
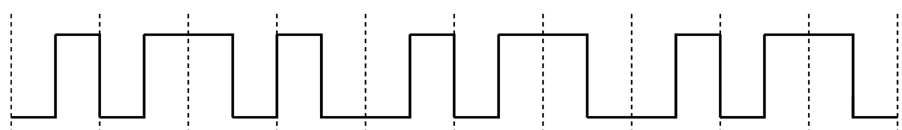
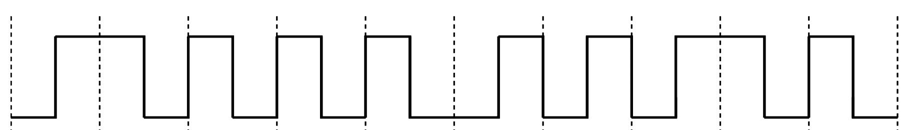
Exercise 1: Physical layer (OSI 1)

1. Calculate the bit rate for the following signals:
   a. A signal where the duration of a bit is 1 millisecond.
   b. A signal where the duration of a bit is 2 microseconds.

2. What is the duration of a bit in the following signals?
   a. A signal with bit rate 100 kbps.
   b. A signal with bit rate 2 Mbps.

3. Assume that we want to transmit a bit sequence consisting of 10 zeros. Code the sequence with the following line coding schemes:
   a. NRZ
   b. Manchester
   c. Differential Manchester

4. The wave forms shown below are Manchester coded bit sequences. Decode them!
   a.

   b.

   c.


5. Do exercise 4 again, now assuming that Differential Manchester has been used.

6. Assume that we want to transmit the binary sequence 0101110.
   a. Draw the wave form assuming Manchester encoding.
   b. Draw the wave form assuming Differential Manchester encoding.

   Assume in both cases that the first signal is a transfer from a high signal level to a low signal level, irrespective if it is a data signal or a clock signal.

7. A physical link with five connections is multiplexed with FDM. Each connection requires a channel with a bandwidth of 4 000 Hz. Between each channel there is a 200 Hz guard band. Calculate the minimum total bandwidth of the link.

8. A DVD video is compressed using MPEG-2 and in this problem the compression ratio will be estimated. The video is recorded at 25 frames per second and the maximum resolution is 720 X 576 pixels per frame. A pixel consists of three colours quantised using 8 bits. A normal movie of about 2 hours takes about 8 GB on the disk. Defining the compression ratio as uncompressed size divided by the compressed size, what is it for DVD video? If there would be no compression how long time can you record on a DVD?

9. An analog (real baseband) speech signal $s(t)$ is modulated up to $f_0=20$ kHz using
   $s_m(t)=s(t)*cos(2\ pi\ f_0\ t)$

   a. To down convert the signal the same modulation by cosinus can be used followed by an ideal low-pass filter. What would you set the breaking frequency to in the LP filter and what is the amplitude of the resulting signal?

   b. The signal can also be down converted using sampling and alisasing in the reconstruction. What would you set the sampling frequency to?

10. A real signal $x(t)$ is sampled into the sequence $x[n]$ and each sample quantized using a k bit linear quantiser. Letting the number of quantisation levels be $M=2^k$, the amplitude of the samples can be regarded as uniformly distributed in $[-Md/2, Md/2]$ where d is the quantisation resolution.

    a. Define the quantisation noise (distortion) as $d(x,x_Q)=(x-x_Q)^2$, and show that the average noise is
       $E[d(X,X_Q)]=d^2/12$

    b. Define the signal to quantisation noise ration as
       $SQNR=E[X^2]/ E[d(X,X_Q)]$
       Show that for each bit added to quantisation resolution the $SQNR$ decreases with approximately 6 dB.