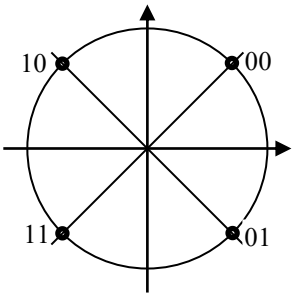
# Tutorial n°5
# QAM modulation and demodulation: example

A digital communications system uses a QPSK modulation with a bit rate equal to 2 Mbits/sec. The constellation of this 4-QAM modulation is shown in the figure below. The carrier frequency is equal to 10 MHz.




**Part 1: The TX side**

1- Give the set of baseband and bandpass waveforms used by the transmitter, knowing that a rectangular window is used for pulse shaping.

2- Let us consider the following sequence of bits: 0 1 0 0 1 0 1 1 1 0 01

Give the general expression of the generated baseband and bandpass waveforms, and plot those waveforms.

3- Plot the bloc diagram of the baseband circuit.

4- Plot the bloc diagram of the circuit used by the transmitter for frequency translation. Give the expression of its output in the frequency domain.

**Part 2: The RX side**

5- On the receiver side the RF signal should be converted back into baseband. Give the theoretical mathematical operations needed and the bloc diagram of the circuit that can be used for this frequency translation (a time domain development could be used).

6- Knowing that a thermal noise will be unavoidably added to the received signal, what are the circuits needed in order to get back the sequence of bits from the baseband signal. Thus, give the bloc diagram of the baseband part of the receiver and plot the signals at the output of each bloc in time domain.

7- Discuss the effects of timing imperfections in the receiver.

8- We suggest using a root-raised-cosine pulse shaping filter instead of the rectangular filter used before. What are the motivations behind the use of such filters?

9- How can we control system bandwidth efficiency with the raised-cosine filter?

10- If we choose a roll-off factor for the raised-cosine filter equal to 0.2, what is the bandwidth efficiency of the system? Is it possible to improve more bandwidth efficiency without changing roll-off factor? If yes, give some examples.