# Communications Project for 4th year students

# Due Monday, 19 December 2022, 11:59PM

The purpose of the project is to get introduced to the simulation of the single and multicarrier communication systems. The following rules are applied:

1- The project team must be 1 or 2 students.
2- In case any part of any two projects is similar, the 2 projects will take zero.
3- You should deliver the full Matlab code for all parts
4- Late submission is not accepted.

The requirements of the project are described in the following sections.

# 1. Single Carrier System

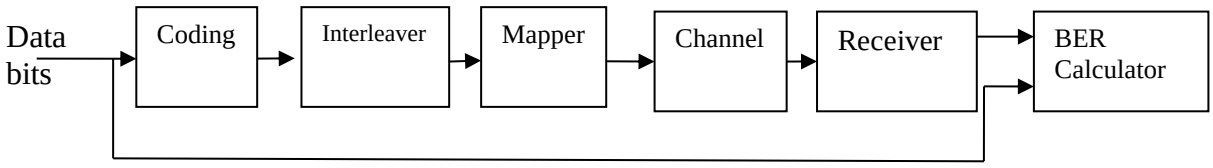



Figure 1 Single carrier communication system.

## *1.1 Coding*

Two cases are considered, no coding or rate 1/3 repetition code.

## *1.2 Interleaver*

The Interleaver size is 4 by 4.

## *1.3 The Mapper*

The mapper takes the I/P data bits and produces the symbols to be transmitted on the channel. The modulation schemes under consideration are the QPSK and the 16QAM systems. Figure 2 shows the constellations.

## *1.4 The channel*

The channel that will be simulated is the flat Rayleigh fading channel. For this channel model, the received signals *y(n)* is given by

$$y(n)=R(n)x(n)+v(n)$$

where *x(n)* is the transmitted signal, *v(n)* is the AWGN, and *R(n)* is the Rayleigh fading envelope. R(n) can be generated using the equation

$$R(n) = \left(\sqrt{v_1^2(n) + v_2^2(n)}\right)/\sqrt{2}$$

Where *v(n)* is AWGN. Note that *R(n)* in this case has power=1.

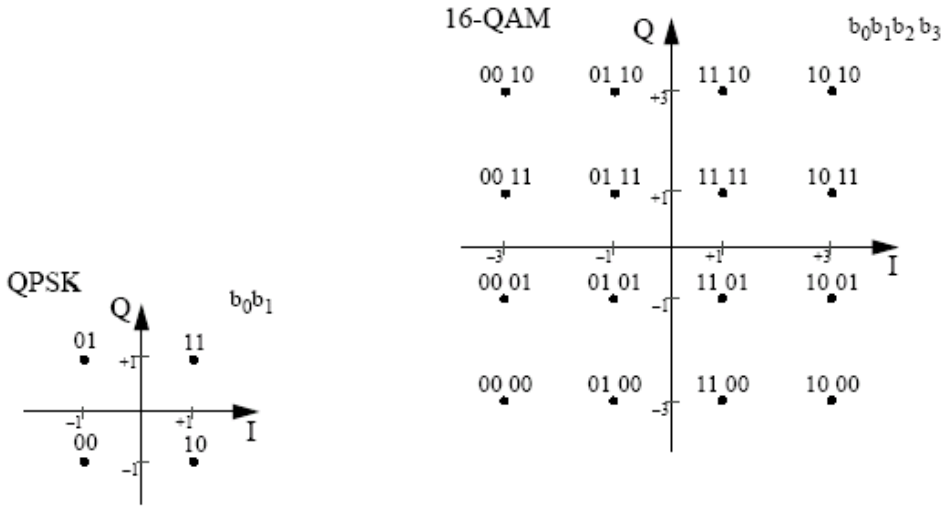



Figure 2 QPSK and 16-QAM constellations

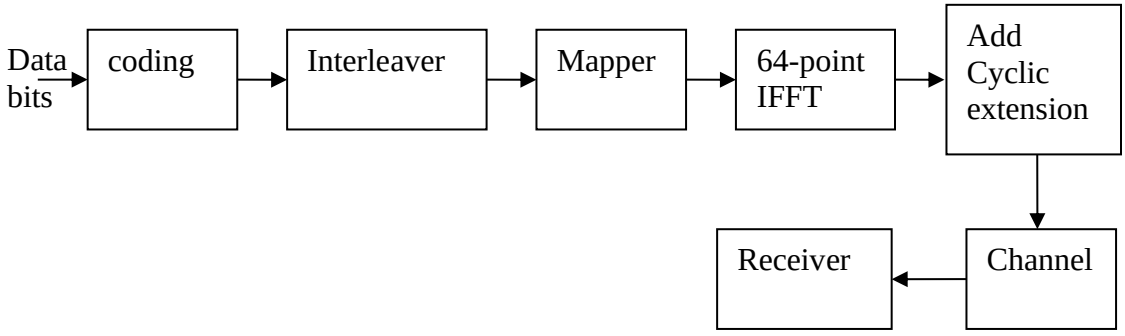
### *1.5 The receiver*

The simple receiver in the model under consideration will take the output of the channel and decide on the symbol transmitted. The output bit stream of the receiver is compared to the input bit stream and the BER is calculated.

### *1.6 Mandatory Tasks*

It is required to plot curves for the BER Vs Eb/No. Note that for the fading channel, Eb/No will be average Eb/No, as the fading magnitude will vary from one sample to the other.
The other requirement is to evaluate the performance using repetition code. This is done by transmitting every "1" as three "1's" and every "0" as three "0's". Draw BER curves in case of Rayleigh fading. Two figures are needed, one for QPSK (coding and no coding) and one for 16 QAM (coding and no coding).

## 2 OFDM system simulation



## 2.1 Coding

Two cases are considered, no coding or rate 1/3 repetition code. Note that you have to adjust the number of input bits per OFDM symbol when using repetition code. For example if you use QPSK, only 21 data bits will be used per OFDM symbol, a zero is added to the encoded data to have 64 bits at the input of the mapper before the IFFT block.

## 2.2 Interleaver

For QPSK, the size of the interleaver is 8 by 16.
For 16QAM, the interleaver size is 16 by 16.

## 2.3 Mapper

The mappers used are the same as those used in the single carrier system in section 1.1

## 2.4 IFFT

Use a size 64 IFFT block. In Matlab use the command "ifft"

## 2.5 Cyclic Extension

16 samples cyclic prefix is to be added.

## 2.6 Channel

Two channel models should be considered
**a- AWGN channel:** Same as single carrier system
**b- Frequency selective Fading channel:** assume a 2-path fading channel h=[0.4 0 0.26 0 0 0.4 0 0.6 0 0.5];
**Receiver**
Design a receiver to receive the signal described above in the two cases of AWGN and fading channels. Assume perfect channel knowledge at receiver.

## 2.7 Requirements

Same as in the single carrier system for the two channel models and for the coding/no-coding scenarios. Four figures will be needed.

## 2.8 Water-filling

Consider an OFDM system with 16 subcarriers. The signal is to be transmitted through the channel h=[0.4 0 0.26 0 0 0.4 0 0.6 0 0.5];
Consider a system with SNR gap =2 and the noise per subcarrier=1.
The total power available is 200, use Matlab to calculate the power allocation per subcarrier to maximize the transmission rate.
The deliverable should be the full Matlab code and the intermediate and final results of running the code.