Faculty of Information Engineering and Technology
Dr. Sarah Azzam

# COMM1001: MODULATION AND CODING

## PROJECT

**Deadline:18th May 2024**

**Part I:**

Consider an OFDM communication system whose total system power is P=2 to be distributed over Nc=4 sub-carriers. Given that the ratio between noise power and channel impulse follows $N/|H[i]|^2 = [1.5\ 1\ 0.75\ 0.5]$

**Calculate** the capacity of such OFDM system.

You are required to:

a) Perform hand analysis to calculate the capacity of such OFDM system.

b) Write a code for the water filling algorithm to find the optimal transmit powers that maximize capacity.

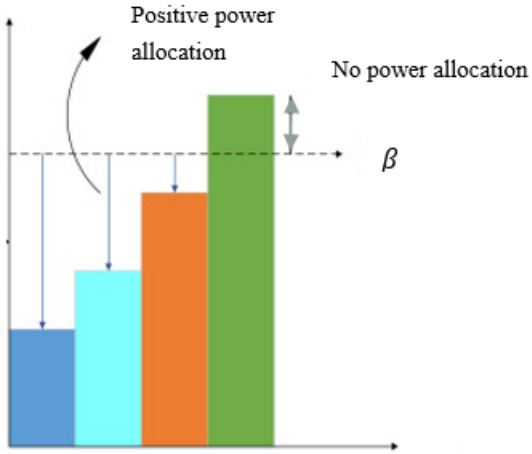


FIGURE 1: WATER FILLING ALGORITHM

You can use any suitable programming language for (b). The code should work for any number of subcarriers, any ratio between noise power and channel impulse $N/|H[i]|^2$and any total transmit power.

**Part II:**

You are required to simulate an OFDM system as follows:

As presented in Figure 2, you should generate Nc QAM symbols, multiply them by the corresponding sub-carrier channel response H[i]. Then AWGN for EACH sub-carrier is added. At the receiver equalization is done followed by QAM demodulation.

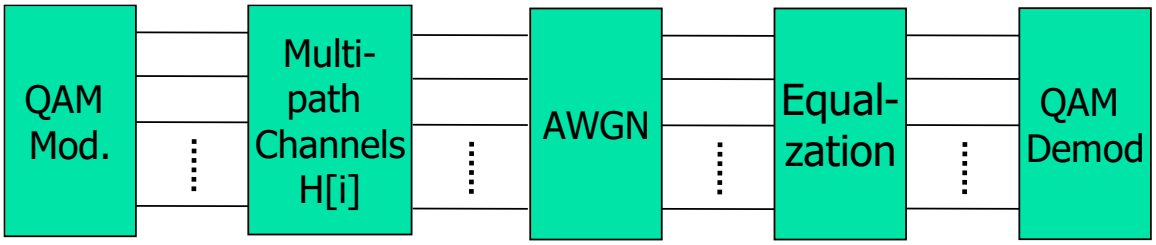


FIGURE 2 OFDM SIMULATION MODEL WITH THE MULTI-PATH CHANNEL DEFINED IN FREQUENCY

For the simulations, you are asked to plot the bit-error rate against the SNR where SNR is the average power used in modulation divided by the average Gaussian noise power.

Notes:

- For QAM simulations use qammod, qamdemod functions in MATLAB. You should support constellations, 4, 16, 64 QAM
- For awgn, use the the normrnd function in MATLAB where the mean should be zero and the variance depends on the Eb/N0 required

All simulations should assume multi-path channel shown in the table below where each resolvable path is a Rayleigh fading channel.

| Resolvable Path | Relative Delay (nsec) | Average Power (Linear) |
|---|---|---|
| 1 | 0 | 0.485 |
| 2 | 310 | 0.3852 |
| 3 | 710 | 0.0611 |
| 4 | 1090 | 0.0485 |
| 5 | 1730 | 0.0153 |
| 6 | 2510 | 0.0049 |

- Assume a bandwidth of 20 MHz with 1024 sub-carriers. Write a MATLAB code for 1,000 OFDM symbols.
- A Rayleigh channel can be generated as follows:

1. The Amplitude by taking the square root of an exponential random variable with mean 1 and multiplying it with the square root of the average power of the corresponding resolvable path

2. The phase is uniformly distributed between 0 and $2\pi$

Deliverables:

You are required to submit a report that includes:

(i) The required written hand analysis in Part I (a).
(ii) Commented codes for Part I (b).
(iii) Display of the results for Part I (b).
(iv) A written section that gives a brief introduction to water filling in OFDM systems.
(v) Commented codes for Part II.
(vi) Figures for BER for Part II.

The Project is ***groups of four***. You should deliver a hard copy of the report in addition to sending an email with the codes and report attached to sarah.mk.azzam@gmail.com maximum by Thursday 18th of May.