Project - 100 points (MCOM 2025 - ECE 343)

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April 17, 2025

1 (CO2, CO3, CO4) Simulator for OFDM

In this project you will develop a simulator for a wireless communication system with frequency selective fading. Using your computer record your voice and get the corresponding bits. Then, pass these bits through the transmitter, channel, and the receiver. At the output of the receiver, you will get back the bits. Reconstruct the audio signal and play it to see if it matches what you recorded. You can assume that the modulation scheme used is 64-QAM. On top of that, the communication system uses OFDM. For the purpose of the project, all processing corresponding to wireless communication must be done in the low pass equivalent form.

You need to submit the following:

1. The developed simulator. The simulator should have the capabilities:
   (a) First, the simulator should record your voice for 10 seconds and load the corresponding bits on MATLAB
   (b) Then, the simulator should perform 64-QAM modulation, followed by ODFM modulation.
   (c) While creating the constellation diagram for 64-QAM, you need the energy for the point closest to the origin. The whole constellation diagram would scale up accordingly. The energy of the closest constellation point, E_{min}, should be asked to the user. If not provided use, $E_{min} = 10^{-15}$.
   (d) Then, the simulator passes the complex baseband symbols through the channel. The simulator must simulate the channel for every run as described in the following:
      i. For channel simulation, the simulator should ask the user the number of multipath channels and the corresponding delays. If no values are provided by the user, use four paths in the multipath channel with delays 0 μs, 5 μs, 10 μs, and 15 μs, respectively.
      ii. Compute the amplitudes of the paths as described in MATLAB Fading Channels. In the above link, look at the top part and use the sum of sinusoids technique. For simplicity, assume that the maximum Doppler shift is zero. Take the number of sinusoids to be 48. Do not use MATLAB in-built functions like comm.RayleighChannel; otherwise your score will be 0.
      iii. Using the path amplitudes and delays of the different paths, compute the channel coefficients at the sampling instants as described in MATLAB Fading Channels. For this implementation assume N_1 and N_2 to 0 and 15 respectively. The simulator should ask user for the sampling frequency. If not provided by the user, use 1 MHz. [*What are we doing in this part? The multipaths arrive at time instants that are not sampling instants. So, to convolve a discrete-time input signal with the multipath channel we need the channel coefficients at the sampling instants. This is done via interpolation and the interpolation formula is already given in the above link.*]
   (e) Simulator performs all the necessary demodulation on the channel output and reconstructs the audio signal from bits and plays it.
   (f) Simulator must also perform necessary OFDM equalization.
   (g) For every run, the simulator must report the bit error rate and symbol error rate. After simulating the channel, the simulator should plot the multipath channel and the coefficients in sampling instant in dbW. The simulator must provide scatter plots for the generated QAM symbols, the received symbols, and the symbols after all receiver side processing.

2. The simulator should take into account the noise. It should ask the user for noise PSD and use the default value if not provided by the user.

3. There must be a clear readme file explaining how to run the simulator, what must be fed as input, what output to expect. Without readme, the code will not be evaluated. Code must be developed in MATLAB.

4. Code must be properly commented.

5. In the report, provide a block diagram for the developed simulator and thoroughly explain each and every block using mathematical notations and equations. The report must also have examples outputs for different inputs.

6. Once the simulator is developed, play with the sampling rate and comment in the report regarding your observations. Also, write about what you learned in the project.

7. **Bonus question:** Add the capability in your simulator to not use OFDM and demonstrate the benefit of using OFDM. (10 points)