Assignment 1
EE6143: Advanced Topics in Communications

Due: 11:59 PM, 22 February 2021

1 Problem Statement

In this assignment, you will simulate a bits to bits system in which data is transmitted through an AWGN channel. The goal is to study the variation of bit error rate (BER) with $\frac{E_b}{N_0}$ for different constellations0- 4 QAM, 16 QAM, 64 QAM and 256 QAM. Upon completing the assignment you will be able to generate (and analyse) the waterfall curves discussed in class.

The following gives you a more precise description of what you need to do-

1. Select a range in which the value of N_0 will vary and generate suitably spaced samples in that range for N_0. Varying N_0 for a given signal power is equivalent to varying the signal to noise ratio (SNR) or $\frac{E_b}{N_0}$. Remember that this range needs to be chosen so that a BER of 10^{-3} can be seen for all constellations. This range can also be made specific to different constellations.

2. For each constellation

   - For each value of SNR,
     - Compute the corresponding value of $\frac{E_b}{N_0}$.
     - Randomly generate suitable number of bits. During this process, ensure that all bits are equally likely which in turn ensures that all symbols are equally likely. This will simplify (and is necessary for) your receiver design.
     - Generate and transmit the corresponding QAM symbol through an AWGN channel.
     - Demodulate the received symbol (to bits) and compute the BER. Repeat this procedure over several iterations and compute the average BER at the given SNR for the constellation being considered.

3. Plot the variation of BER with $\frac{E_b}{N_0}$ for all the constellations on the **same graph**. Ensure that the Y axis is logarithmic and that you are plotting $\frac{E_b}{N_0}$ in dB scale (i.e $10log\left(\frac{E_b}{N_0}\right)$ on the X axis.
4. Analyse the results.
5. Plot the **theoretical** BER vs $\frac{E_b}{N_0}$ curves for all the constellations on the same plot and look for any deviation.

2 Submission

The assignment is due by **11:59 PM, 22 February 2021**.

You must submit the following in order for us to evaluate your assignment-

- MATLAB code
  - This should perform the above simulation and produce **only one plot with 8 curves**- theoretical and empirically obtained curves for 4, 16, 64 and 256 QAM constellations- as output.
  - This should be a single .m file with all the necessary functions.
- A report detailing your work, the associated theory and results. LaTeX/markdown reports would be preferred.

3 Things to keep in mind

- This is an individual assignment. Do not plagiarise or copy either the code or the report! If you have discussed with someone else, make sure to mention their names in the code and report.
- The code should have detailed documentation in the form of Docstrings and comments.
- Make sure to remove all debug statements (such as print statements) from the code before you submit. The only output produced by the code when run should be the aforementioned plot. Further, no inputs will be provided to the code you write.
- The plot produced must be formatted correctly-
  - It must have a grid.

  - It must have a legend.
  - It must have a title.
  - The X and Y axes must be labelled.
- Make sure all figures in the report have captions. Further the report should have the appropriate sections, a table with list of figures, a table of contents and a References section.

4 Evaluation

This assignment will be evaluated for 100 points with the following split-

- **Code - 80 points**
  - Documentation - 5 points
  - Completeness - 15 points
  - Plot - 60 points
    * Plot formatting - 5 points
    * Range of $\frac{E_b}{N_0}$ - 5 points
    * Plot correctness - 50 points (6.25 points per curve)
- **Report - 20 points**
  - Presentation - 5 points
  - Theory and analysis - 15 points

5 Useful resources

- **ber_BPSK.m**- The simulation implemented for BPSK. Only refer to this code. **Do not copy from it!**
- Signal Processing and Detection by Prof. John M. Cioffi. Section 1.4.4 contains the derivation of the BER for an M-QAM system.
- MATLAB style guidelines