ECL332 - Communication Lab

Department of Electronics and Communication
College of Engineering Trivandrum

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1 Instructions

1. The programs should be written in Python language only. You can use any of the available python tools for coding.
2. Each section of this document (after the instruction section) shall be written in a separate file.
3. There should be a file header for each program. The file header is a comment section at the start of the file before you write the program. The file header consists of `Description of the program`, `Author` and `Date of program`.
4. The program should be properly commented and meaningful names shall be given to variables and functions.
5. All the programs should be made as modular as possible by implementing necessary functions. There should be function header for each function. Function header is similar to file header except that there will not be Author and Date instead there will be `Description of the function` and `Explanation of the parameters`.
6. The student should print the *Student Name*, *Student Roll No* and *Student Department* at the start of the program.

2 MPSK Modulation and Demodulation

The aim of the experiment is to reconstruct a transmitted image, modulated by MPSK scheme, at the receiver. The 'M' in the M-PSK represents the maximum number of possible symbols (For Example: BPSK: M=2, QPSK: M=4). The maximum likelihood decoder will be used at the receiver to recover the symbols. To model a channel for transmission AWGN noise will be added to transmitted signal before processing at the receiver.

The symbol error rate (SER) vs $\frac{E_s}{N_0}$(in dB) and bit error rate (BER) vs $\frac{E_b}{N_0}$(in dB) will be plotted (where E_s is the symbol energy, E_b is the bit energy and $N_0/2$ is the AWGN noise variance) and will be compared with the theoretical value, .

The MPSK symbols are generated as

$$s_i = \sqrt{E_s}\cos\left[\frac{2\pi(i-1)}{M}\right] + j\sqrt{E_s}\sin\left[\frac{2\pi(i-1)}{M}\right] \quad i = 1, 2, \ldots, M \tag{1}$$

The probability of symbol error is given by

$$P_s = 2Q\left[\sqrt{\frac{2E_s}{N_0}}\sin\left(\frac{\pi}{M}\right)\right] \tag{2}$$

and that of bit error is given by

$$P_b = \frac{2}{\log_2 M} Q\left[\left(\sqrt{\frac{2E_b}{N_0}\log_2 M}\right)\sin\left(\frac{\pi}{M}\right)\right] \tag{3}$$

where E_b is the energy per bit.
The relation between E_s and E_b is given by

$$E_s = E_b \log_2(M) \tag{4}$$

Note that we are a using the baseband transmission for simulation.

Following are the steps to be followed for the simulation experiment.

1. Read the image cameraman.png. You can get the image by clicking here. The image is of size 256×256. Use suitable python package for reading the image (imageio, opencv etc).

2. Convert the pixel values to bits and map to MPSK symbols. Make sure to use same number of bits for all the values. Plot the constellation diagram of the MPSK symbols.

3. Set an SNR value for the transmission and generate a complex Gaussian noise with enough number of samples for the required SNR. Here $\frac{E_s}{N_0}$ can be considered as the SNR. Since each value of SNR is generated by varying the noise power you can take $E_s = 1$.

4. The received signal which is the combination of MPSK symbol and the noise samples shall be passed through an ML decoder to do the demapping. The constellation diagram of the received signal shall be plotted.

5. Convert the demapped symbols to bits and then to pixel values. Also find the SER and BER.

6. Reconstruct the image.

7. Iterate the above steps for SNR (in dB) values from -10 to 10 with increments of 1 and plot the SER and BER separately. Also plot the theoretical SER and BER value for MPSK Modulation. Compare them.

8. Iterate all the above steps for M=2,4,8.