Department of Electrical Engineering
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EE 5141 Introduction to Wireless and Cellular Communications
February – May 2021

Computer Assignment Instructions

- Teams of two students
- Submit the following
    - Required plots
    - Include brief explanation of observations, as appropriate
    - Listing of code written by you

- The submitted file should be in .pdf format

- Mention name and roll number of both team members

- Use following naming convention for file you
    - roll_number_assign#.pdf
      (Use roll number of one of the team members)
    - Example: EE19M001_assign1.pdf

- Assignment submission via Moodle
    - Instructions given by TAs
    - Do not send via email

- Honour Code:
    - Add this line to your assignment and an electronic signature
    - We certify that this assignment submission is our own work and not from obtained from any other source

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Computer Assignment #3 (Due date: March 22, 2021)

BER Performance of Differential BPSK (DBPSK) and Differential QPSK (DQPSK)

1. The task is to modify the simulator developed in Assignment 1 to simulate the performance of DBPSK and DQPSK and study the Bit Error Rate (BER) performance using Monte-Carlo simulations.

   (a) Differential BPSK

   Generate a random sequence of about 512 DBPSK symbols and apply pulse shaping with an SRRC pulse (roll off $\alpha = 0.35$), as generated in Task 1. Use the following mapping for the symbols.

Bit (b_n)	0	1
$\Delta\theta_n$	0	π

$$s_n = s_{n-1}\ e^{j\Delta\theta_n}, \text{ n=1,2, … 512 with } s_0 = 1 + j0$$

The symbol rate is 25 Ksymbols/sec

(b) Assume that the received signal is down-sampled to one sample per symbol. Plot the received symbols for the case when $\frac{E_b}{N_0} = 6$ dB.

(c) BER simulation

- Generate AWGN with different variance values
- Pass the desired signal and noise through a matched receive filter (same SRRC filter as used in transmitter)
- Apply differential detection rule
  - ❖ $bit\ [b_n] = \begin{cases} 0\ if\ \ Re\ \{r_n\ \ r_{n-1}^*\} > 0 \\ 1\ if\ Re\ \{r_n\ \ r_{n-1}^*\} \le 0 \end{cases}$
- Compute BER for $\frac{E_b}{N_0}$ in the range [0, 10dB] in steps of 2 dB, using 500 bursts for averaging.

(d) Plot BER versus $\frac{E_b}{N_0}$

(e) In the BER plot, include the analytical computation of the BER for coherent DBPSK given by $BER = \frac{1}{2}\ e^{-\gamma},\ where\ \gamma = SNR.$

(f) Verify that the BER plot (simulations) and the BER curve (analytical computation of BER) are in agreement.

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2. Differential QPSK (DQPSK)

Generate a random sequence of about 512 QPSK symbols (using 1024 random bits) and apply pulse shaping with an SRRC pulse (roll off $\alpha = 0.35$), as generated in Task 1. Use the following mapping for the symbols.

Bits $(b_{n,0}, b_{n,1})$	00	01	10	11
$\Delta\theta$	$\frac{\pi}{4}$	$\frac{3\pi}{4}$	$-\frac{\pi}{4}$	$-\frac{3\pi}{4}$

$s_n = s_{n-1}\, e^{j\Delta\theta_n}$, n=1,2, … 512 with $s_0 = e^{j\frac{\pi}{4}}$

The symbol rate is 25 Ksymbols/sec

(a) Assume that the received signal is down-sampled to one sample per symbol. Plot the received symbols for the case when $\frac{E_b}{N_0} = 6$ dB.

(b) BER simulation

- Generate AWGN with different variance values
- Pass the desired signal and noise through a matched receive filter (same SRRC filter as used in transmitter)
- Apply differential detection rule
  - ❖ $bit\,[b_{n,1}] = \begin{cases} 0 \ if \ Re\ \{r_n\ r_{n-1}^*\} > 0 \\ 1 \ if \ Re\ \{r_n\ r_{n-1}^*\} \le 0 \end{cases}$
  - ❖ $bit\,[b_{n,0}] = \begin{cases} 0 \ if \ Im\ \{r_n\ r_{n-1}^*\} > 0 \\ 1 \ if \ Im\ \{r_n\ r_{n-1}^*\} \le 0 \end{cases}$
- Compute BER for $\frac{E_b}{N_0}$ in the range [0, 10dB] in steps of 2 dB, using 500 bursts for averaging.

(c) Plot BER versus $\frac{E_b}{N_0}$

(d) In the BER plot, include the analytical computation of the BER for coherent DQPSK given by $BER = \frac{1}{2}\left[1 - Q\left(\sqrt{b}, \sqrt{a}\right) + Q\left(\sqrt{a}, \sqrt{b}\right)\right]$ where $a = (2 - \sqrt{2})\frac{E_b}{N_0}$ and $b = (2 + \sqrt{2})\frac{E_b}{N_0}$. $Q(p, q)$ is Marcum Q function (https://en.wikipedia.org/wiki/Marcum_Q-function with M=1)

(e) Verify that the BER plot (simulations) and the BER curve (analytical computation of BER) are in agreement.

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