

Department of Electrical Engineering IIT Madras, Chennai 600 036.

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)
 - o Example: EE19M001_assign1.pdf
- Assignment submission via Moodle
 - o Instructions given by TAs
 - o 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	

$$s_n = s_{n-1} e^{j\Delta\theta_n}$$
, 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 $\frac{E_b}{N_o}$ = 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 $\frac{E_{\scriptscriptstyle b}}{N_{\scriptscriptstyle 0}}$
- (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	00	01	10	11
$(b_{n,0},b_{n,1})$				
	π	3π	π	3π
$\Delta heta$	$\overline{4}$	4	$-\frac{1}{4}$	$-{4}$

$$s_n = s_{n-1} e^{j\Delta\theta_n}$$
, 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

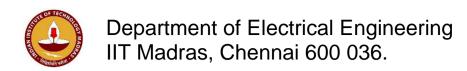
$$\text{\star bit } [b_{n,1}] = \begin{cases} 0 & \text{if } Re \ \{r_n \ r_{n-1}^*\} > 0 \\ 1 & \text{if } Re \ \{r_n \ r_{n-1}^*\} \le 0 \end{cases}$$

$$bit [b_{n,0}] = \begin{cases} 0 & if Im \{r_n \ r_{n-1}^*\} > 0 \\ 1 & if Im \{r_n \ r_{n-1}^*\} \le 0 \end{cases}$$

- 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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