NOISE AND BIT ERRORS

SECTION 4 QUESTION 1 (2/2 points)

Suppose that you are transmitting information over a channel and you increase the power used in transmission so that the difference between **r_max** and **r_min** increases from 1.5V to 2V. Assuming the noise power in the received signal remains the same, how does the signal to noise ratio change?

Please select the correct answer.

- It remains the same.
- It increases by 1.33dB.
- It increases by 1.78dB.
- It increases by 2.50dB. ✔
- Not enough information is given to determine how much the SNR changes.

Show Answer *You have used 1 of 1 submissions*

SECTION 4 QUESTION 2 (2 points possible)

Which of the following statments are true (may be more than one)? Assuming other factors remain the same, the bit error rate of a channel will decrease as

Please select the answer that matches.

- [ ] The distance between the transmitter and receiver increases.
- [ ] The signal to noise ratio increases. ✔
- [ ] The noise power increases.
- [x] The power in the transmitted signal increases. ✔
- [ ] The bit rate increases.

Hide Answer *You have used 1 of 1 submissions*

SECTION 4 INTRODUCTION

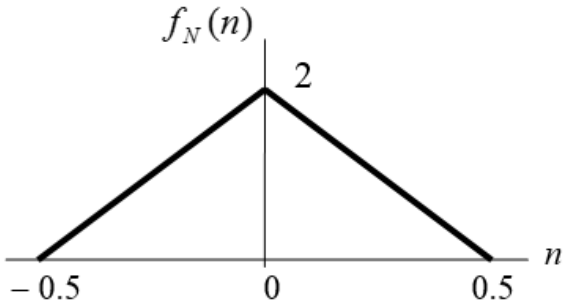
Consider a binary channel with the following properties:

1. The input bit IN is equally likely to be 0 or 1.

2. The output of the channel before thresholding is given by $y = r + n$, where

$$r = \begin{cases} 0 & \text{if IN} = 0 \\ r_{max} & \text{if IN} = 1 \end{cases}$$

and the noise n is a random variable with the following probability density function.



3. Output bit decisions are made by comparing y with a threshold T, i.e.

$$\text{OUT} = \begin{cases} 0 & \text{if } y < T \\ 1 & \text{if } y \geq T \end{cases}$$

4. For the threshold chosen, it turns out that

- The probability of error when input is 0: $P_{e0} = 0.02$
- The probability of error when input is 1: $P_{e1} = 0.08$

Note that the threshold T was not chosen optimally to minimize the bit error rate.

SECTION 4 QUESTION 3 PART A (2/2 points)

What is the bit error rate of this channel?

Please key in the numerical value of your answer in the box provided below.

0.05

0.05

Show Answer *You have used 1 of 1 submissions*

SECTION 4 QUESTION 3 PART B (2/2 points)

Suppose that (IN=0) is twice as likely as (IN=1), what is the bit error rate?

Please key in the numerical value of your answer in the box provided below.

Help

0.0398

0.0398

Show Answer *You have used 1 of 1 submissions*

SECTION 4 QUESTION 3 PART C (2 points possible)

What was the value of the threshold T?

Please key in the numerical value of your answer in the box provided below.

0.25

0.25

Answer: 0.4

Hide Answer *You have used 1 of 1 submissions*

SECTION 4 QUESTION 3 PART D (2 points possible)

What was the value of $r_{\max}$?

Please key in the numerical value of your answer in the box provided below.

0.5

0.5

Answer: 0.7

Hide Answer *You have used 1 of 1 submissions*

SECTION 4 MATLAB QUESTION

In this MATLAB question, you will use MATLAB to analyze the output of a communication channel in order to estimate important parameters for bit detection, and to estimate the bit error rate.

Help

The initial code in the code window will generates a random 1280 bit sequence and then frames it by adding one start bit with value 1 and one stop bit with value 0. It then converts the framed bit sequence into a waveform at 20 samples per bit, adds a 1500 sample long training sequence (500 0s followed by 500 1s and another 500 0s). It transmits the this waveform through a noisy channel, and stores the result in **rx_wave**. Note that because the framed bit sequence occurs immediately after the training sequence, the beginning of the start bit is always at sample 1501.

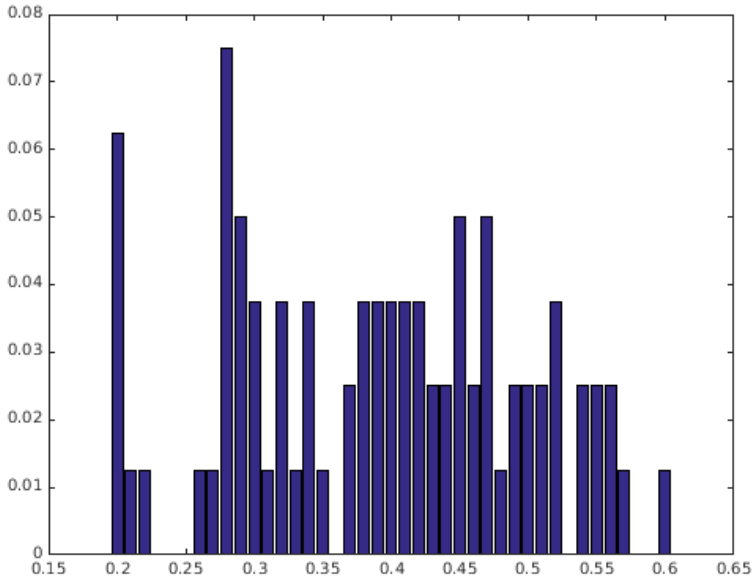
Your job is to use MATLAB to examine the received waveform and estimate the values for the received signal for IN=0 and IN=1 before noise is added (**rx_min** and **rx_max**), and the bit error rate of the channel assuming the threshold is chosen optimally. You are free to do this in any way you like. For example, you might estimate the values of **rx_min** and **rx_max** graphically, by inspecting the empirical histogram of the received signal during the training sequence. An alternative would be to try to estimate the values numerically, by averaging the signal. To estimate the bit error rate, you might try this numerically, using the **compute_BER** function used in the lab, or try to compute it analytically, using parameters estimated from the waveform.

You do not need to submit your coding work. Answer the questions below the code window based on your observations. Because the noise is random, your estimates may vary each time you run the code, so run your code several times before submitting your answer to make sure your estimate is not an outlier.

```
tx_bs = rand(1,1280)>0.5; % generate a random bit sequence
SPB = 20;                 % bit time in samples

tx_bs_frame = frame_bs(tx_bs);              % add start and stop bit and generate framed block
tx_wave = bitseq2waveform(tx_bs_frame,SPB); % create a sample waveform with SPB=20
tx_wave = [zeros(1,500) ones(1,500) zeros(1,500) tx_wave];  % add training sequence

start_ind = 1501; % for convenience the start bit location is fixed

rx_wave = channel_final_04(tx_wave);        % transmit waveform through channel
rx_min = 0;
rx_max = 0;

for i=1:1500
    if (tx_wave(i) == 1) %if IN=1
```

Unanswered

Figure 1



Help

0.3269

0.4780

0.1391

Run Code

SECTION 4 MATLAB QUESTION PART A (1/1 point)

What was the value of $r_{\min}$?

The answer is correct if it is within 0.05 of the expected answer.

Please key in the numerical value of your answer in the box provided below.

0.33

0.33

Show Answer *You have used 1 of 1 submissions*

SECTION 4 MATLAB QUESTION PART B (1/1 point)

What was the value of $r_{\max}$?

The answer is correct if it is within 0.05 of the expected answer.

Please key in the numerical value of your answer in the box provided below.

0.48

0.48

Help

Show Answer *You have used 1 of 1 submissions*

SECTION 4 MATLAB QUESTION PART C (1/1 point)

Empirically estimate the BER acheivable over this channel if the optimal threshold is chosen. Assume that input bits are equally likely to be 0 or 1. Express the BER as a ratio betwen 0 and 1.

The answer is correct if it is within 0.03 of the expected answer.

Please key in the numerical value of your answer as a decimal between 0 and 1 in the box provided below.

0.14

0.14

Show Answer *You have used 1 of 1 submissions*

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