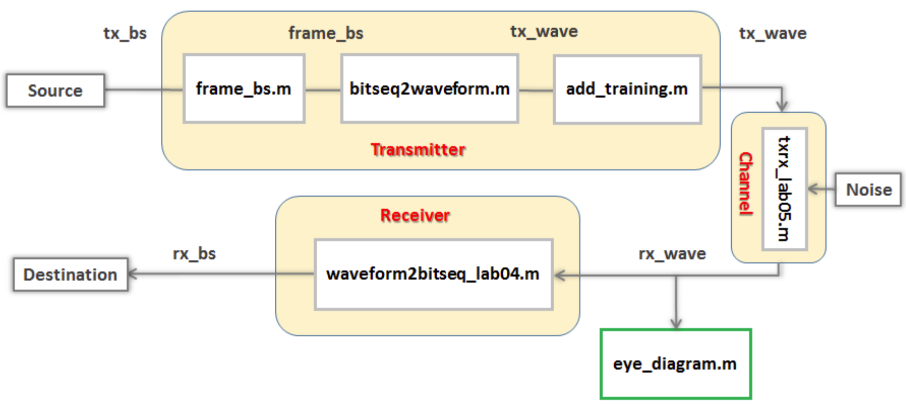
LAB 5 TASK 3 - EFFECT OF SAMPLING POINT (1/1 point)

In this task, you will investigate how changing the sampling point used for making bit decisions affects the BER performance of our communciation system. When doing Lab 3 Task 3, you may have noticed that while the relative spacing between points used for making bit decisions is critical for achieving a low bit error rate, there is more flexibility in choosing their absolute location. We investigate that phenomenon here using the eye diagram.



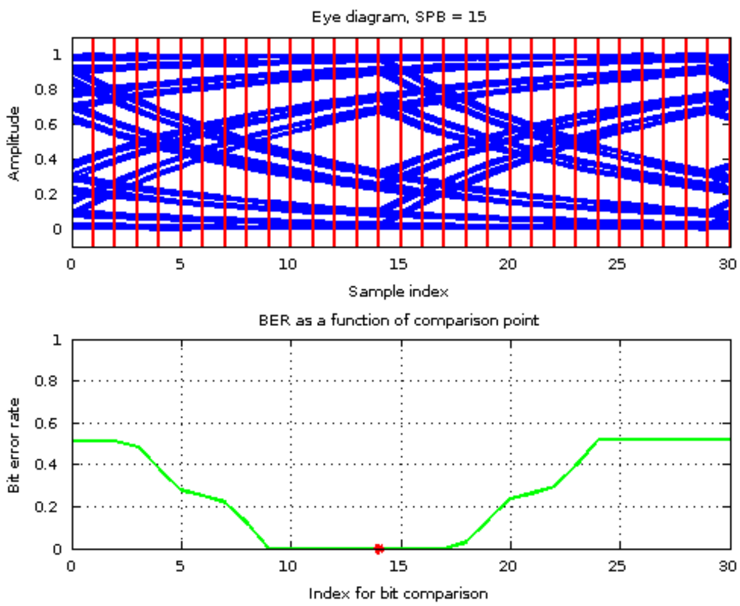

```
tx_bs=rand(1,1280)>0.5;         % generate a random bit sequence
SPB = 15;                       % bit time in samples

% transmit/receive bit sequence
tx_wave = format_bitseq(tx_bs,SPB);  % create waveform following protocol
rx_wave = txrx_lab05(tx_wave);       % simulate channel
threshold = get_threshold(rx_wave);  % set threshold
start_ind = find_start(rx_wave);     % find start bit

% plot eye diagram
subplot(211)
eye_diagram(rx_wave,start_ind,SPB); % plot eye diagram
title(['Eye diagram, SPB = ' num2str(SPB)]);
xlabel('Sample index');
ylabel('Amplitude');
```

Correct

```
num_index = length(ind_list);
for i = 1:num_index,
    sample_ind = start_ind + SPB + ind_list(i) + SPB*[0:1279];
    rx_bs = rx_wave(sample_ind)>threshold;
    BER(i) = compute_BER(tx_bs,rx_bs);  % compute the BER
end
```

Help

Figure 1



BER if comparing at index 14 is 0

BER if comparing at index 0 is 0.51406

BER if comparing at index 1 is 0.51406

BER if comparing at index 2 is 0.51406

BER if comparing at index 3 is 0.48438

BER if comparing at index 4 is 0.37812

BER if comparing at index 5 is 0.27734

BER if comparing at index 6 is 0.25234

BER if comparing at index 7 is 0.21875

BER if comparing at index 8 is 0.11797

BER if comparing at index 9 is 0

BER if comparing at index 10 is 0

BER if comparing at index 11 is 0

BER if comparing at index 12 is 0

BER if comparing at index 13 is 0

BER if comparing at index 14 is 0

BER if comparing at index 15 is 0

BER if comparing at index 16 is 0

BER if comparing at index 17 is 0

BER if comparing at index 18 is 0.029687

BER if comparing at index 19 is 0.13594

BER if comparing at index 20 is 0.23672

BER if comparing at index 21 is 0.2625

BER if comparing at index 22 is 0.29609

BER if comparing at index 23 is 0.39687
BER if comparing at index 24 is 0.51484
BER if comparing at index 25 is 0.51484
BER if comparing at index 26 is 0.51484
BER if comparing at index 27 is 0.51484
BER if comparing at index 28 is 0.51484
BER if comparing at index 29 is 0.51484
BER if comparing at index 30 is 0.51484

INSTRUCTIONS

Let's look at how the initial part of the code works. The code first transmits and receives a random bit stream over our channel using a bit time of **SPB**=15 samples.The code then plots the eye diagram, which is quite open. We explain the remainder of the code below.

Step 1: Run the code as presented

After you click on the **Run Code,** MATLAB will return two subplots in one figure.

The upper subplot shows the eye diagram with a vertical red line at sample 14. This vertical red line indicates the sampling index at which the waveform is being compared to the threshold to make bit decisions. Recall from the lecture video 4.4 A Simple Protocol (/courses/HKUSTx/ELEC1200.1x/3T2014/jump_to_id/c3c907b1597a4cc7948e8f482eb17a4d) that in order to decode the bit stream, we must subsample the waveform at points equally spaced by **SPB** samples and compare the values of the waveform at those points to a threshold to decide whether the corresponding input bit was a 0 or 1. In Lab 3 Task 3, we chose the first sampling point by first detecting the beginning of the start bit as start_ind, and then moving forward by **SPB** samples to skip past the start bit and then by **SPB-1** samples to move to the end of the first bit (**2*SPB-1** samples in total). Subsequent bit decisions are made by skipping forward by **SPB** samples. On the eye diagram shown, these sampling points correspond to the indices 14 and 29 (**SPB-1** and **2*SPB-1**). It is at these points that the eye height is largest, indicating that the waveform is either very far from the threshold, which is 0.5 for this channel.

The lower subplot shows a red asterisk at sample 14 and BER 0, indicating that the BER, if we make bit comparisons at the red line, is zero. Ignore the green line at BER=0 for now.

Step 2: Change the location of the sampling point for bit comparisons

The sample indices at which bit decisions are made is determined by the line

sample_ind = start_ind + SPB + ind1 + SPB*[0:1279];   % choose subsampling points

The variable **ind1** determines how far we move through the first bit before making the bit decision. It is indicated by the red line on the eye diagram. It is set here to **SPB-1**=14, so that bit decisions are made at the end of the bit.

It should be clear from the shape of the eye diagram, that there is considerable lattitude in choosing the sampling point for comparison. For example, change value of **ind1** in the line

ind1 = 14;   % index of eye diagram to perform bit comparisons

to 10 and re-run the code. The location of the red line shifts, indicating that bit decisions are being made at a different point, but the BER stays at zero. However, we cannot move this point by too much. For example, try changing **ind1** to 6. What happens to the BER? Can you explain why?

Interestingly, because the channel changes slowly, we can even choose the sampling point *after* the bit ends and get a low bit error rate (e.g. set **ind1** to 16).

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Step 3: Compute the BER with at many different sampling points

Your task is to compute the BER as the sampling point used to make bit decisions changes from 0 to 2*SPB in steps of one, and to study the resulting plot.

To do this, enter your code below the comment starting with "**% Place your code below that**".

Your code should

1. Estimate the input bit stream by making bit decisions at each of the sampling points on the eye diagram listed in **ind_list**.

2. Compute the corresponding bit error rate and store it in the corresponding element of the vector **BER**.

The remaining code in the window plots your results as a green line. Do not modify this code.

Based on the shape of the curve, how much freedom do you have in choosing the sampling point? What feature of the eye diagram determines the range over which the sampling point can vary without significant degradation in performance. How would the curve and this range change as the bit time changes? Feel free to modify the bit time (**SPB**) in your code to investigate this issue.

Step 4: Submit your work

Once you have completed your work, click on the **Check** button to submit your answer.

After you are done, be sure to answer the question below.

LAB 5 TASK 3 - QUESTION 1 (1 point possible)

As the location of the sample index for bit comparisons (**ind1** in the code above) increases, the bit error rate (BER) __________?

Please select the correct answer.

- Increases
- Decreases
- Remains constant
- Increases first and then decreases
- Decreases first and then increases

Final Check   Save   *You have used 0 of 1 submissions*

Help