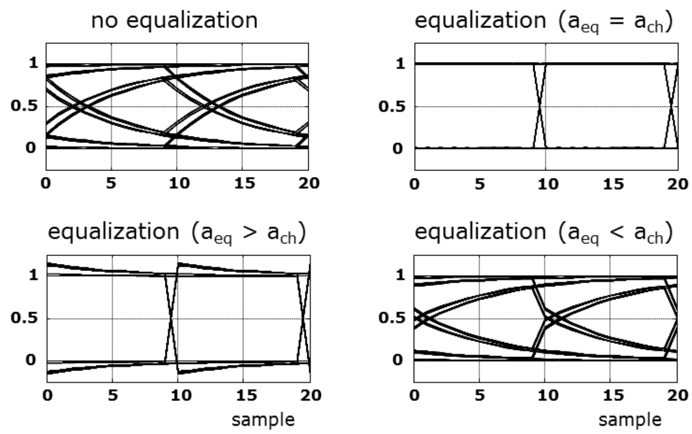
LAB 3 - TASK 3 (1 point possible)

In Part I of this course, we introduced the concept of an equalizer to compensate for the effects of the channel. Because the channel was bandlimited, it introduced intersymbol interference. This caused the eye diagram to close. The equalizer "undid" the effect of the channel, and resulted in a more open eye. Recall that the equalizer depended upon an estimate of the exponential parameter a of the channel. If the estimate is correct, the effects of the channel can be cancelled exactly, resulting in an open and square eye. However, if the estimate is incorrect (too high or too low), then the eye is not exactly square, as shown in the figure below. We implemented the equalizer in Lab 6 of Part I.

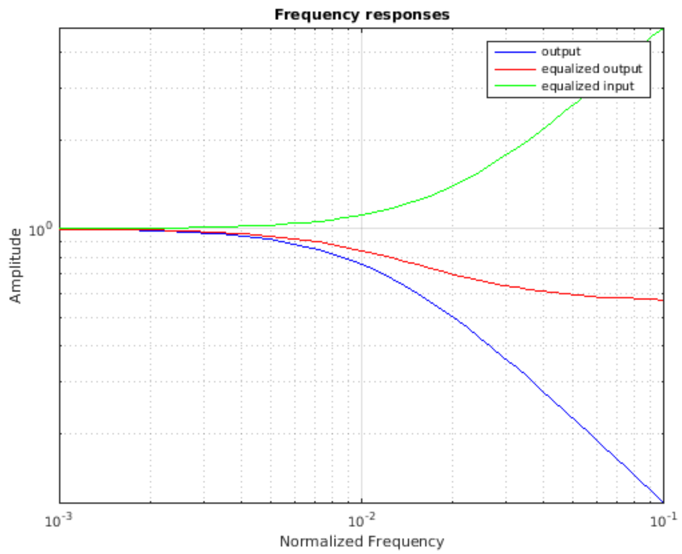


While in the previous part of this course we studied the channel and the equalizer in the time domain, here we study them in the frequency domain. In this lab, we will re-examine the operation of the equalizer. Be reminded that we had to characterize the relationship between the channel input and output and then we designed the equalizer. As a result, we reduced the intersymbol interterference and showed the results using the eye diagram. In this task, we will study the effect of equalization on the channel using the frequency response. We will compare the amplitudes of the frequency responses of the channel with and without equalization. We will also measure the amplitude of the frequency response of the equalizer itself.

```
% Exponential factor controlling step response of channel
ach = 0.93;
% Exponential factor controlling the equalizer. This is the
% equalizer's estimate of the a of the channel.  Ideally, this
% should equal ach, but in practice, there is often mismatch.
aeq = 0.88;

nsamp = 1200;
n=0:(nsamp-1);

flist = logspace(-3,-1);
h_rx = zeros(1,length(flist));
h_eq_rx = zeros(1,length(flist));
h_eq_tx = zeros(1,length(flist));

for i=1:length(flist)
```

Unanswered

Figure 1



eq_rx =

Columns 1 through 17

0.0700 0.6125 0.6396 0.6647 0.6881 0.7098 0.7300 0.7487 0.7660 0.7821 0.7970 0.8109

Columns 18 through 34

0.8747 0.8826 0.8900 0.8967 0.9029 0.9086 0.9138 0.9186 0.9229 0.9269 0.9305 0.9337

Columns 35 through 51

0.9469 0.9483 0.9494 0.9503 0.9511 0.9516 0.9520 0.9523 0.9523 0.9523 0.9521 0.9518

Columns 52 through 68

0.9475 0.9465 0.9453 0.9441 0.9428 0.9414 0.9399 0.9384 0.9368 0.9351 0.9334 0.9316

Columns 69 through 85

0.9196 0.9174 0.9152 0.9129 0.9105 0.9081 0.9057 0.9032 0.9007 0.8981 0.8955 0.8928

Columns 86 through 102

0.8760 0.8731 0.8701 0.8671 0.8640 0.8609 0.8578 0.8546 0.8514 0.8481 0.8449 0.8416

Columns 103 through 119

0.8209 0.8174 0.8138 0.8102 0.8065 0.8028 0.7991 0.7953 0.7916 0.7877 0.7839 0.7800

Columns 120 through 136

0.7561 0.7520 0.7478 0.7437 0.7395 0.7353 0.7310 0.7268 0.7225 0.7181 0.7138 0.7094

Columns 137 through 153

0.6825 0.6779 0.6733 0.6686 0.6640 0.6593 0.6546 0.6498 0.6450 0.6403 0.6354 0.6306

Columns 154 through 170

0.6010 0.5960 0.5910 0.5859 0.5808 0.5757 0.5706 0.5654 0.5603 0.5551 0.5499 0.5446

Columns 171 through 187

0.5127 0.5073 0.5019 0.4965 0.4911 0.4856 0.4801 0.4746 0.4691 0.4636 0.4580 0.4524

Columns 188 through 204

0.4186 0.4129 0.4072 0.4015 0.3957 0.3899 0.3842 0.3784 0.3726 0.3668 0.3609 0.3551

Columns 205 through 221

0.3197 0.3137 0.3078 0.3018 0.2958 0.2898 0.2838 0.2778 0.2718 0.2658 0.2597 0.2537

Columns 222 through 238

0.2171 0.2110 0.2049 0.1987 0.1926 0.1864 0.1803 0.1741 0.1679 0.1618 0.1556 0.1494

Columns 239 through 255

0.1121 0.1059 0.0996 0.0934 0.0872 0.0809 0.0747 0.0684 0.0622 0.0559 0.0496 0.0434

Columns 256 through 272

0.0058 -0.0005 -0.0067 -0.0130 -0.0193 -0.0255 -0.0318 -0.0381 -0.0443 -0.0506 -0.0568 -0.0631

Columns 273 through 289

-0.1006 -0.1068 -0.1130 -0.1193 -0.1255 -0.1317 -0.1379 -0.1441 -0.1503 -0.1565 -0.1627 -0.1689

Columns 290 through 306

-0.2058 -0.2119 -0.2181 -0.2242 -0.2303 -0.2364 -0.2424 -0.2485 -0.2546 -0.2606 -0.2667 -0.2727

Columns 307 through 323

-0.3087 -0.3146 -0.3206 -0.3265 -0.3324 -0.3383 -0.3442 -0.3501 -0.3560 -0.3618 -0.3676 -0.3735

Columns 324 through 340

-0.4080 -0.4138 -0.4195 -0.4251 -0.4308 -0.4364 -0.4421 -0.4477 -0.4533 -0.4588 -0.4644 -0.4699

Columns 341 through 357

-0.5028 -0.5082 -0.5135 -0.5189 -0.5243 -0.5296 -0.5349 -0.5402 -0.5454 -0.5506 -0.5559 -0.5611

Columns 358 through 374

-0.5917 -0.5968 -0.6018 -0.6068 -0.6117 -0.6167 -0.6216 -0.6265 -0.6313 -0.6362 -0.6410 -0.6458

Columns 375 through 391

-0.6740 -0.6786 -0.6832 -0.6877 -0.6922 -0.6967 -0.7012 -0.7057 -0.7101 -0.7145 -0.7188 -0.7232

Columns 392 through 408

-0.7485 -0.7527 -0.7568 -0.7608 -0.7649 -0.7689 -0.7728 -0.7768 -0.7807 -0.7846 -0.7885 -0.7923

Columns 409 through 425

-0.8146 -0.8182 -0.8217 -0.8253 -0.8288 -0.8322 -0.8357 -0.8391 -0.8425 -0.8458 -0.8491 -0.8524

Columns 426 through 442

-0.8713 -0.8743 -0.8773 -0.8803 -0.8832 -0.8861 -0.8890 -0.8918 -0.8946 -0.8973 -0.9001 -0.9027

Columns 443 through 459

-0.9181 -0.9205 -0.9229 -0.9253 -0.9276 -0.9299 -0.9321 -0.9344 -0.9365 -0.9387 -0.9408 -0.9428

Columns 460 through 476

-0.9544 -0.9562 -0.9580 -0.9597 -0.9614 -0.9631 -0.9647 -0.9663 -0.9678 -0.9693 -0.9708 -0.9722

Columns 477 through 493

-0.9799 -0.9810 -0.9822 -0.9832 -0.9843 -0.9853 -0.9862 -0.9871 -0.9880 -0.9889 -0.9897 -0.9904

Columns 494 through 510

-0.9942 -0.9947 -0.9951 -0.9955 -0.9959 -0.9962 -0.9965 -0.9968 -0.9970 -0.9972 -0.9973 -0.9974

Columns 511 through 527

-0.9971 -0.9970 -0.9967 -0.9965 -0.9962 -0.9959 -0.9955 -0.9951 -0.9946 -0.9941 -0.9936 -0.9930

Columns 528 through 544

-0.9887 -0.9879 -0.9870 -0.9861 -0.9851 -0.9841 -0.9831 -0.9820 -0.9809 -0.9797 -0.9785 -0.9773

Columns 545 through 561

-0.9691 -0.9676 -0.9660 -0.9644 -0.9628 -0.9612 -0.9595 -0.9577 -0.9560 -0.9542 -0.9523 -0.9504

Columns 562 through 578

-0.9383 -0.9362 -0.9340 -0.9318 -0.9295 -0.9273 -0.9249 -0.9226 -0.9202 -0.9177 -0.9152 -0.9127

Columns 579 through 595

-0.8969 -0.8942 -0.8914 -0.8885 -0.8857 -0.8828 -0.8798 -0.8769 -0.8739 -0.8708 -0.8678 -0.8646

Columns 596 through 612

-0.8453 -0.8419 -0.8386 -0.8352 -0.8317 -0.8282 -0.8247 -0.8212 -0.8176 -0.8140 -0.8104 -0.8067

Columns 613 through 629

-0.7840 -0.7801 -0.7762 -0.7722 -0.7683 -0.7643 -0.7602 -0.7561 -0.7520 -0.7479 -0.7437 -0.7396

Columns 630 through 646

-0.7138 -0.7094 -0.7050 -0.7005 -0.6961 -0.6916 -0.6870 -0.6825 -0.6779 -0.6733 -0.6686 -0.6640

Columns 647 through 663

-0.6354 -0.6306 -0.6257 -0.6208 -0.6159 -0.6110 -0.6060 -0.6010 -0.5960 -0.5910 -0.5859 -0.5808

Columns 664 through 680

-0.5499 -0.5446 -0.5394 -0.5341 -0.5288 -0.5234 -0.5181 -0.5127 -0.5073 -0.5019 -0.4965 -0.4911

Columns 681 through 697

-0.4580 -0.4524 -0.4468 -0.4412 -0.4356 -0.4299 -0.4243 -0.4186 -0.4129 -0.4072 -0.4015 -0.3957

Columns 698 through 714

-0.3609 -0.3551 -0.3492 -0.3433 -0.3374 -0.3315 -0.3256 -0.3197 -0.3137 -0.3078 -0.3018 -0.2958

Columns 715 through 731

-0.2597 -0.2537 -0.2476 -0.2415 -0.2354 -0.2293 -0.2232 -0.2171 -0.2110 -0.2049 -0.1987 -0.1926

Columns 732 through 748

-0.1556 -0.1494 -0.1432 -0.1370 -0.1308 -0.1245 -0.1183 -0.1121 -0.1059 -0.0996 -0.0934 -0.0872

Columns 749 through 765

-0.0496 -0.0434 -0.0371 -0.0309 -0.0246 -0.0183 -0.0121 -0.0058 0.0005 0.0067 0.0130 0.0193

Columns 766 through 782

0.0568 0.0631 0.0694 0.0756 0.0819 0.0881 0.0943 0.1006 0.1068 0.1130 0.1193 0.1255

Columns 783 through 799

0.1627 0.1689 0.1750 0.1812 0.1874 0.1935 0.1997 0.2058 0.2119 0.2181 0.2242 0.2303

Columns 800 through 816

0.2667 0.2727 0.2787 0.2848 0.2908 0.2967 0.3027 0.3087 0.3146 0.3206 0.3265 0.3324

Columns 817 through 833

0.3676 0.3735 0.3793 0.3850 0.3908 0.3966 0.4023 0.4080 0.4138 0.4195 0.4251 0.4308

Columns 834 through 850

0.4644 0.4699 0.4755 0.4810 0.4864 0.4919 0.4973 0.5028 0.5082 0.5135 0.5189 0.5243

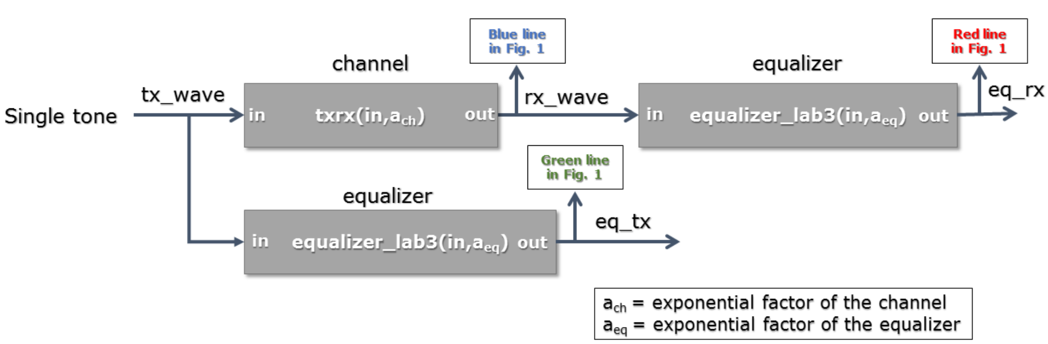
Columns 851 through 867

0.5559 0.5611 0...

Run Code

INSTRUCTIONS

The MATLAB code above should transmit cosine waves of different frequencies (**tx_wave**) through the channel and record the output both with (**eq_rx**) and without equalization (**rx_wave**). It should also send the input signal **tx_wave** directly through the equalizer so that we can measure its frequency response (**eq_tx**). The connections among these signals are shown in the figure below.



Finally, the code should plot the frequency responses of the channel, the equalized channel and the equalizer on a single graph.

Your first task in this lab is to revise the code in order to obtain the peak to peak response of the above mentioned signals, and store them inside the variables, **h_tx**, **h_rx**, **h_eq_rx**, **h_eq_tx**, respectively. The basic structure of this code is very similar to that you have seen in Task 2. You should make similar modifications, as well as make sure that the signals **eq_rx** and **eq_tx** are computed correctly. The equalizer is implemented using the MATLAB function **out = equalizer_lab3(in,aeq)** where **in** is the input waveform (either the input or output of the channel), **aeq** is the equalizer's estimate of the exponential parameter of the channel (**ach**), and **out** stores the output waveform from the equalizer. The values of **ach** and **aeq** should be the same, but in many practical situations they are different, because the equalizer does not have a perfect model of the channel.

When modifying the code, do not modify the variables **ach**, **aeq**, **nsamp** and **flist**. Remember that when you study the peak to peak response you need to remove the transient response of the signal. For this lab, you can safely assume that the transient response ends before the first 200 samples.

Once you have successfully checked your work, experiment with the code by modifying the parameter **aeq** of the equalizer and use the insight gained to answer the questions below. You have an unlimited number of submissions on this task.

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

Suppose that the aeq < ach. Which of the following is/are true?

- [ ] The equalizer thinks the step response of the channel rises more slowly than it actually does.
- [ ] The equalizer thinks the step response of the channel rises faster than it actually does.
- [ ] High frequencies are amplified by too little after equalization.
- [ ] The equalizer perfectly cancels the effect of the channel.

?

You have used 0 of 3 submissions

LAB 3 - TASK 3 QUESTION 2 (1 point possible)

Suppose that the aeq = ach. Which of the following is/are true?

- [ ] The equalizer thinks the step response of the channel rises more slowly than it actually does.
- [ ] The frequency response of the channel after equalization is flat (constant).
- [ ] High frequencies are not amplified enough after equalization.
- [ ] The equalizer perfectly cancels the effect of the channel.

?

You have used 0 of 3 submissions

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

What type of filter is the equalizer?

- Low Pass
- Band Pass
- High Pass

?

You have used 0 of 1 submissions