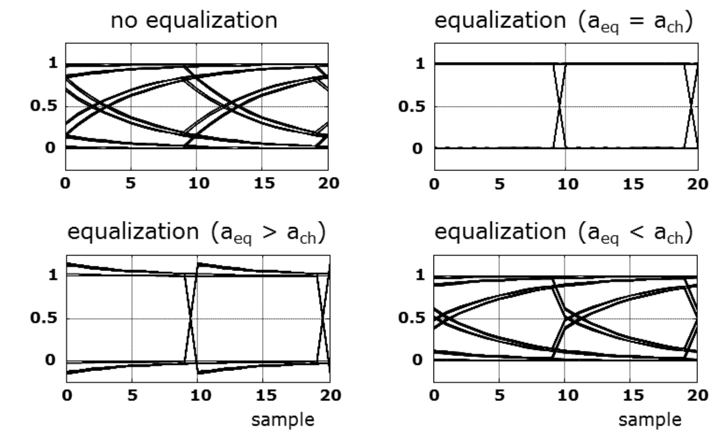
LAB 3 - TASK 3 (1 point possible)

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.

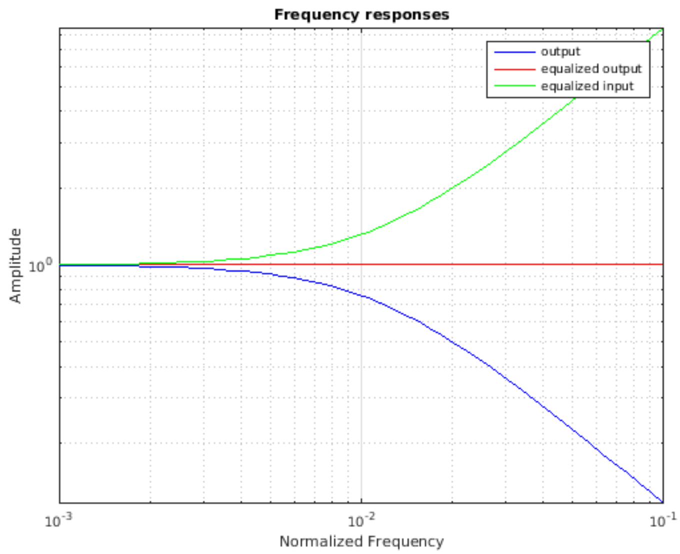


While in the previous part of this course we studied the channel and the equalizer in the time domain, here we study them in the frequency domain. In this lab, we will re-examine the operation of the equalizer. Be reminded that we had to characterize the relationship between the channel input and output and then we designed the equalizer. As a result, we reduced the intersymbol interterfence 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 = 0.93;

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 1.0000 0.9999 0.9998 0.9997 0.9995 0.9993 0.9990 0.9987 0.9984 0.9980 0.9976

Columns 18 through 34

0.9943 0.9936 0.9929 0.9921 0.9913 0.9905 0.9896 0.9887 0.9877 0.9867 0.9856 0.9846

Columns 35 through 51

0.9773 0.9759 0.9745 0.9731 0.9716 0.9701 0.9686 0.9670 0.9654 0.9637 0.9620 0.9603

Columns 52 through 68

0.9491 0.9471 0.9451 0.9430 0.9409 0.9387 0.9365 0.9343 0.9321 0.9298 0.9274 0.9251

Columns 69 through 85

0.9101 0.9075 0.9048 0.9021 0.8994 0.8966 0.8938 0.8910 0.8881 0.8852 0.8823 0.8793

Columns 86 through 102

0.8607 0.8575 0.8543 0.8510 0.8477 0.8443 0.8409 0.8375 0.8341 0.8306 0.8271 0.8235

Columns 103 through 119

0.8016 0.7978 0.7940 0.7902 0.7863 0.7824 0.7785 0.7745 0.7705 0.7665 0.7624 0.7584

Columns 120 through 136

0.7333 0.7290 0.7247 0.7203 0.7159 0.7115 0.7071 0.7026 0.6982 0.6937 0.6891 0.6845

Columns 137 through 153

0.6566 0.6518 0.6471 0.6423 0.6374 0.6326 0.6277 0.6228 0.6179 0.6129 0.6079 0.6029

Columns 154 through 170

0.5724 0.5673 0.5621 0.5569 0.5516 0.5464 0.5411 0.5358 0.5305 0.5252 0.5198 0.5144

Columns 171 through 187

```
  0.4818    0.4762    0.4707    0.4652    0.4596    0.4540    0.4484    0.4428    0.4371    0.4315    0.4258    0.4201

 Columns 188 through 204

  0.3856    0.3798    0.3740    0.3681    0.3623    0.3564    0.3505    0.3446    0.3387    0.3328    0.3269    0.3209

 Columns 205 through 221

  0.2850    0.2790    0.2730    0.2669    0.2608    0.2548    0.2487    0.2426    0.2365    0.2304    0.2243    0.2181

 Columns 222 through 238

  0.1812    0.1750    0.1688    0.1626    0.1564    0.1502    0.1440    0.1378    0.1316    0.1253    0.1191    0.1129

 Columns 239 through 255

  0.0753    0.0691    0.0628    0.0565    0.0502    0.0440    0.0377    0.0314    0.0251    0.0188    0.0126    0.0063

 Columns 256 through 272

 -0.0314   -0.0377   -0.0440   -0.0502   -0.0565   -0.0628   -0.0691   -0.0753   -0.0816   -0.0879   -0.0941   -0.1004

 Columns 273 through 289

 -0.1378   -0.1440   -0.1502   -0.1564   -0.1626   -0.1688   -0.1750   -0.1812   -0.1874   -0.1935   -0.1997   -0.2059

 Columns 290 through 306

 -0.2426   -0.2487   -0.2548   -0.2608   -0.2669   -0.2730   -0.2790   -0.2850   -0.2910   -0.2970   -0.3030   -0.3090

 Columns 307 through 323

 -0.3446   -0.3505   -0.3564   -0.3623   -0.3681   -0.3740   -0.3798   -0.3856   -0.3914   -0.3971   -0.4029   -0.4086

 Columns 324 through 340

 -0.4428   -0.4484   -0.4540   -0.4596   -0.4652   -0.4707   -0.4762   -0.4818   -0.4873   -0.4927   -0.4982   -0.5036

 Columns 341 through 357

 -0.5358   -0.5411   -0.5464   -0.5516   -0.5569   -0.5621   -0.5673   -0.5724   -0.5776   -0.5827   -0.5878   -0.5929

 Columns 358 through 374

 -0.6228   -0.6277   -0.6326   -0.6374   -0.6423   -0.6471   -0.6518   -0.6566   -0.6613   -0.6660   -0.6707   -0.6753

 Columns 375 through 391

 -0.7026   -0.7071   -0.7115   -0.7159   -0.7203   -0.7247   -0.7290   -0.7333   -0.7375   -0.7417   -0.7459   -0.7501

 Columns 392 through 408

 -0.7745   -0.7785   -0.7824   -0.7863   -0.7902   -0.7940   -0.7978   -0.8016   -0.8053   -0.8090   -0.8127   -0.8163

 Columns 409 through 425

 -0.8375   -0.8409   -0.8443   -0.8477   -0.8510   -0.8543   -0.8575   -0.8607   -0.8639   -0.8671   -0.8702   -0.8733

 Columns 426 through 442

 -0.8910   -0.8938   -0.8966   -0.8994   -0.9021   -0.9048   -0.9075   -0.9101   -0.9127   -0.9152   -0.9178   -0.9202

 Columns 443 through 459
```

-0.9343 -0.9365 -0.9387 -0.9409 -0.9430 -0.9451 -0.9471 -0.9491 -0.9511 -0.9530 -0.9549 -0.9567

Columns 460 through 476

-0.9670 -0.9686 -0.9701 -0.9716 -0.9731 -0.9745 -0.9759 -0.9773 -0.9786 -0.9799 -0.9811 -0.9823

Columns 477 through 493

-0.9887 -0.9896 -0.9905 -0.9913 -0.9921 -0.9929 -0.9936 -0.9943 -0.9950 -0.9956 -0.9961 -0.9967

Columns 494 through 510

-0.9990 -0.9993 -0.9995 -0.9997 -0.9998 -0.9999 -1.0000 -1.0000 -1.0000 -0.9999 -0.9998 -0.9997

Columns 511 through 527

-0.9980 -0.9976 -0.9972 -0.9967 -0.9961 -0.9956 -0.9950 -0.9943 -0.9936 -0.9929 -0.9921 -0.9913

Columns 528 through 544

-0.9856 -0.9846 -0.9834 -0.9823 -0.9811 -0.9799 -0.9786 -0.9773 -0.9759 -0.9745 -0.9731 -0.9716

Columns 545 through 561

-0.9620 -0.9603 -0.9585 -0.9567 -0.9549 -0.9530 -0.9511 -0.9491 -0.9471 -0.9451 -0.9430 -0.9409

Columns 562 through 578

-0.9274 -0.9251 -0.9227 -0.9202 -0.9178 -0.9152 -0.9127 -0.9101 -0.9075 -0.9048 -0.9021 -0.8994

Columns 579 through 595

-0.8823 -0.8793 -0.8763 -0.8733 -0.8702 -0.8671 -0.8639 -0.8607 -0.8575 -0.8543 -0.8510 -0.8477

Columns 596 through 612

-0.8271 -0.8235 -0.8200 -0.8163 -0.8127 -0.8090 -0.8053 -0.8016 -0.7978 -0.7940 -0.7902 -0.7863

Columns 613 through 629

-0.7624 -0.7584 -0.7543 -0.7501 -0.7459 -0.7417 -0.7375 -0.7333 -0.7290 -0.7247 -0.7203 -0.7159

Columns 630 through 646

-0.6891 -0.6845 -0.6800 -0.6753 -0.6707 -0.6660 -0.6613 -0.6566 -0.6518 -0.6471 -0.6423 -0.6374

Columns 647 through 663

-0.6079 -0.6029 -0.5979 -0.5929 -0.5878 -0.5827 -0.5776 -0.5724 -0.5673 -0.5621 -0.5569 -0.5516

Columns 664 through 680

-0.5198 -0.5144 -0.5090 -0.5036 -0.4982 -0.4927 -0.4873 -0.4818 -0.4762 -0.4707 -0.4652 -0.4596

Columns 681 through 697

-0.4258 -0.4201 -0.4144 -0.4086 -0.4029 -0.3971 -0.3914 -0.3856 -0.3798 -0.3740 -0.3681 -0.3623

Columns 698 through 714

-0.3269 -0.3209 -0.3150 -0.3090 -0.3030 -0.2970 -0.2910 -0.2850 -0.2790 -0.2730 -0.2669 -0.2608

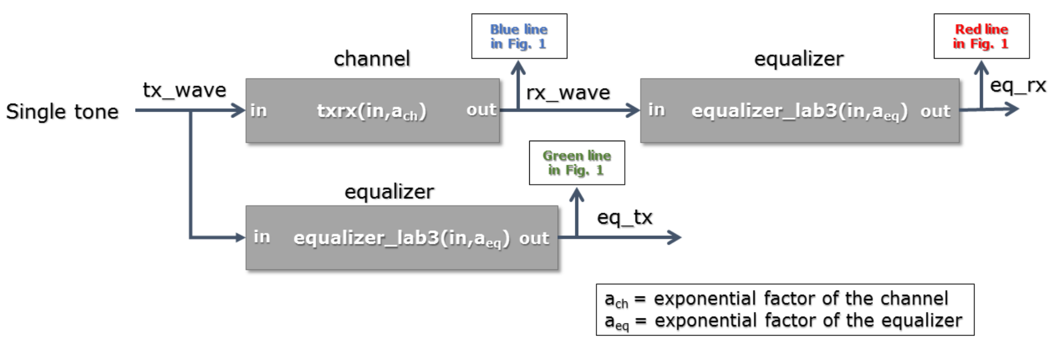
Columns 715 through 731

```
 -0.2243  -0.2181  -0.2120  -0.2059  -0.1997  -0.1935  -0.1874  -0.1812  -0.1750  -0.1688  -0.1626  -0.1564

Columns 732 through 748

 -0.1191  -0.1129  -0.1066  -0.1004  -0.0941  -0.0879  -0.0816  -0.0753  -0.0691  -0.0628  -0.0565  -0.0502

Columns 749 through 765

 -0.0126  -0.0063  -0.0000   0.0063   0.0126   0.0188   0.0251   0.0314   0.0377   0.0440   0.0502   0.0565

Columns 766 through 782

  0.0941   0.1004   0.1066   0.1129   0.1191   0.1253   0.1316   0.1378   0.1440   0.1502   0.1564   0.1626

Columns 783 through 799

  0.1997   0.2059   0.2120   0.2181   0.2243   0.2304   0.2365   0.2426   0.2487   0.2548   0.2608   0.2669

Columns 800 through 816

  0.3030   0.3090   0.3150   0.3209   0.3269   0.3328   0.3387   0.3446   0.3505   0.3564   0.3623   0.3681

Columns 817 through 833

  0.4029   0.4086   0.4144   0.4201   0.4258   0.4315   0.4371   0.4428   0.4484   0.4540   0.4596   0.4652

Columns 834 through 850

  0.4982   0.5036   0.5090   0.5144   0.5198   0.5252   0.5305   0.5358   0.5411   0.5464   0.5516   0.5569

Columns 851 through 867

  0.5878   0.5929   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. ✔
- [x] High frequencies are amplified by too little after equalization. ✔
- [ ] The equalizer perfectly cancels the effect of the channel.

✖

You have used 3 of 3 submissions

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

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.
- [x] The frequency response of the channel after equalization is flat (constant). ✔
- [ ] High frequencies are not amplified enough after equalization.
- [x] The equalizer perfectly cancels the effect of the channel. ✔

✔

You have used 1 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 ✔

EXPLANATION

The frequency respone rises for high frequencies. Thus, high frequencies pass through with more amplification than low frequencies.

You have used 1 of 1 submissions