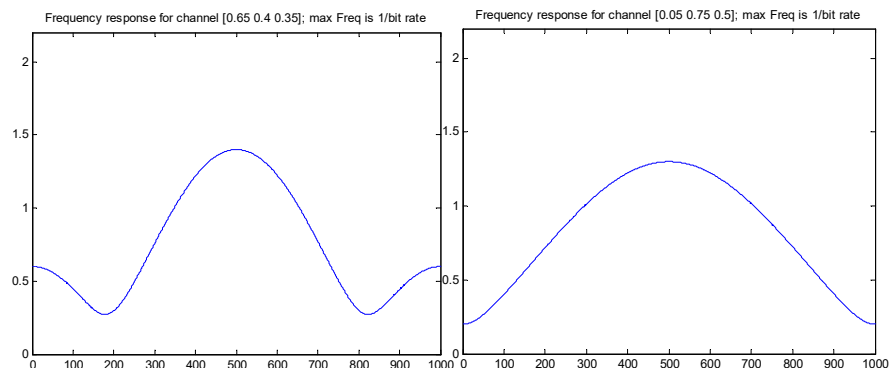


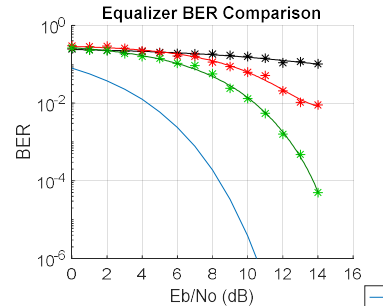
Study questions for Equalization

1. Give two sources of intersymbol interference.
2. Give the definition of the maximum likelihood sequence estimator.
3. In what situation is symbol by symbol detection optimal? In what situation is sequence reception optimal?
4. Give an equation to describe the sequence that maximizes likelihood for a received sequence of $r(kT)$ for $k=1$ to m where m is the memory length of the channel. State the equation in words.
5. Give a major advantage and a major disadvantage when using maximum likelihood sequence estimation.
6. Discuss how maximum likelihood sequence estimation convolutional codes are both similar and different.
7. Can the Viterbi algorithm help combat additive white Gaussian noise? Why or why not?
8. Discuss why intersymbol interference and not additive white Gaussian noise can be corrected with the Viterbi algorithm.
9. Describe how a channel with memory length of one symbol can act like a 4-state finite-state machine.
10. For a channel with memory length of L symbols, and modulation with M points in the constellation, how many states are in the finite state machine describing transmission?
11. Why is knowledge of the channel required for the maximum likelihood sequence estimator? How is the channel information exploited?
12. Discuss how effective the maximum likelihood sequence estimator is in eliminating intersymbol interference for different kinds of channels. For instance, consider the following two channel frequency responses. Which channel would lead to better correction with MLSE?



13. In the following graph, label each of the curves with one of the following labels

- Linear equalizer, ISI present
- Decision feedback equalizer, ISI present
- maximum likelihood sequence estimator, ISI present
- Ideal, AWGN only

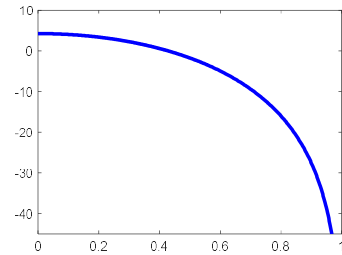
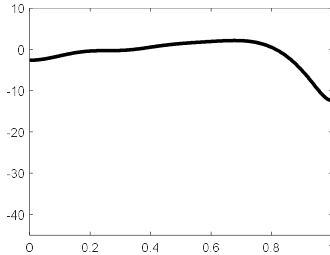
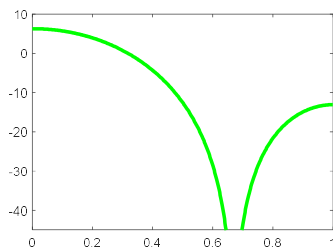


- Consider symbol-by-symbol detection vs. sequence detection. Give an example of an equalizing technique for each type of detection. Which detection/equalizer is more effective? Under what circumstances? At what cost?
- Contrast zero forcing equalizer and the minimum mean square error equalizer. How are they similar? How are they different? When are they equivalent? Which is more effective?
- What kind of equalizer is most appropriate for a static channel? For a channel which is changing in time?
- Describe the channel impulse response for a channel with multiple reflections, i.e., a multipath channel.
- Give a sketch of the impulse response of a multipath channel, and a block diagram of the tap delay line model for that channel.
- Give a block diagram for a linear equalizer. How does the block diagram differ for a zero forcing equalizer versus a minimum mean squared error equalizer?
- Give a block diagram for a linear equalizer. Give the equation for the output of the equalizer as a function of the weight of the linear transversal equalizer.
- Given the following equation that describes the output of an equalizer as a function of received signal following channel effects. Give an equation for the zero forcing requirement.

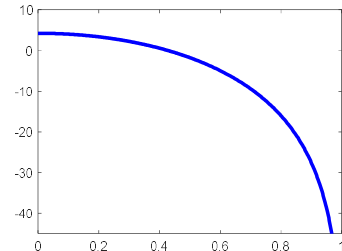
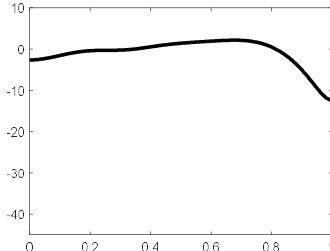
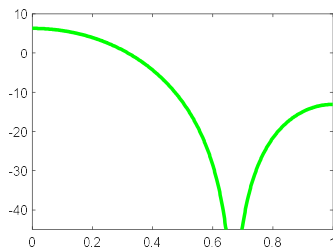
$$\sum_{n=-N}^N \alpha_n p_c[(m-n)T] = P_c A = \begin{bmatrix} \sum_{n=-N}^N \alpha_n p_c[(-N+n)T] \\ \vdots \\ \sum_{n=-N}^N \alpha_n p_c[(m-n)T] \\ \vdots \\ \sum_{n=-N}^N \alpha_n p_c[(N+n)T] \end{bmatrix}$$

- Suppose a multipath channel has one direct line of sight path and 2 delayed reflections. Suppose that the first delay is two symbol intervals, and the second reflection is delayed by 3 symbol intervals. Each delay is referenced to the line of sight path. Give an equation for the channel impulse response. Plot the channel impulse response. What is the memory length of the channel in units of symbol intervals?
- Give two definitions of the zero forcing equalizer, one based on frequency domain concepts, and one based on time domain concepts.

24. Consider one of the following frequency responses for a channel. Sketch the frequency response of the zero forcing equalizer.

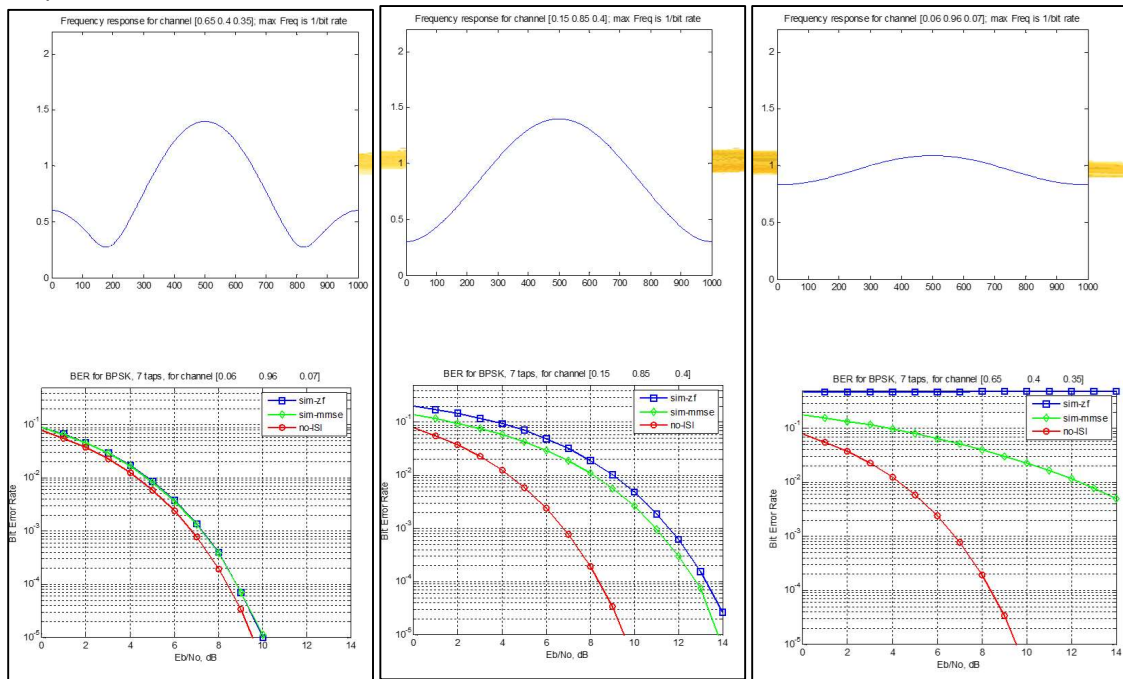


25. What is the major weakness of using a zero forcing equalizer? Is this weakness more apparent for certain channels? Give a sketch of the frequency response for channel for which the zero forcing equalizer will have poor performance.
26. Under which hypothesis is the zero forcing equalizer equivalent to the minimum mean squared error equalizer?
27. Does the zero forcing equalizer exist for all channels? If not, give a sketch of a channel for which a zero forcing equalizer does not exist and explain why the equalizer does not exist for this channel. Same question for the MMSE equalizer.
28. For the following frequency responses for 3 different channels, indicate the best, worst channel in terms of the performance of zero forcing equalizer.



29. What is the order of OFDM processes : Adding cyclic prefix, Decoding, Demodulation, Encoding, FFT, IFFT, Modulation, Removing cyclic prefix
30. Why is the minimum mean squared error equalizer inherently more robust to additive white Gaussian noise than a zero forcing equalizer?
31. Given the equation for the optimality criteria of the MMSE equalizer, explain the role of a training sequence for a minimum mean squared error equalizer. What is the disadvantage of using a training sequence?
32. Consider the plot of the performance of a minimum mean squared error equalizer for 3 different channels. Consider the following three frequency responses for the three channels examined. Label

the performance for each channel.



33. What is the difference between a zero forcing equalizer with knowledge of the channel, and a zero forcing equalizer that is adapted from a training sequence? What are the advantages and disadvantages of each type of zero forcing equalizer?
34. Describe how an adaptive equalizer which is data aided is different from an adaptive equalizer which is decision directed.
35. What is decision directed adaptive filtering? Can it be used for zero forcing? Can it be used for minimum mean squared error equalizing? Give one major advantage and one major disadvantage in using decision-directed adaptation.
36. Why would we move to decision directed adaptation, instead of continuing with training sequence (data aided) adaptation? Why might we hesitate to use decision directed adaptation?
37. How does a decision feedback equalizer differ from a decision directed equalizer? Which is more effective? Which is more complex?
38. Describe the principle of operation of the decision feedback equalizer.