The University of Texas at Austin
Dept. of Electrical and Computer Engineering
Midterm #2

Prof. Brian L. Evans

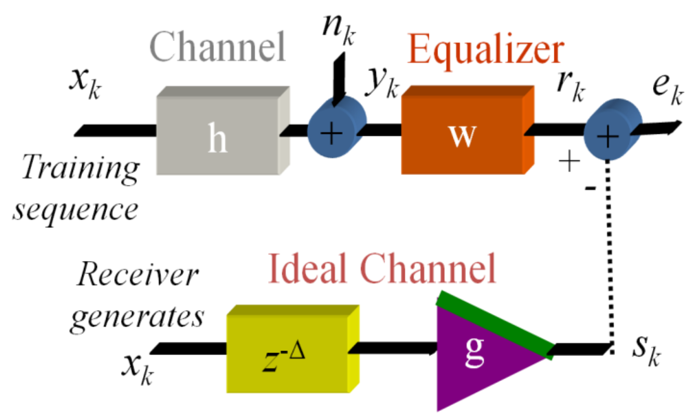
Date: May 2, 2014 Course: EE 445S

Name: ____
Last, First

- The exam is scheduled to last 50 minutes.
- Open books and open notes. You may refer to your homework assignments and the homework solution sets. You may not share materials with other students.
- Calculators are allowed.
- You may use any standalone computer system, i.e. one that is not connected to a network. **Disable all wireless access from your standalone computer system**.
- Please turn off all cell phones and other personal communication devices.
- All work should be performed on the quiz itself. If more space is needed, then use the backs of the pages.
- **Fully justify your answers unless instructed otherwise**. When justifying your answers, you may refer to the Johnson, Sethares & Klein textbook, the Welch, Wright and Morrow lab book, course reader, and course handouts. Please be sure to reference the page/slide number and quote the particular content you are using in your justification.

Problem	**Point Value**	**Your score**	**Topic**
1	27		Channel Equalization
2	27		Communication Performance
3	24		Multicarrier Communications
4	22		Potpourri
Total	100		

Problem 2.1. *Channel Equalization*. *27 points*.



In the discrete-time system on the right, the equalizer operates at the sampling rate.

The equalizer is a finite impulse response (FIR) filter with two real coefficients w_0 and w_1:

$r[k] = w_0\, y[k] + w_1\, y[k\text{-}1]$

Channel model is an FIR filter with impulse response h in cascade with additive spectrally flat noise n_k.

(a) What training sequence would you use? Why? *6 points.*

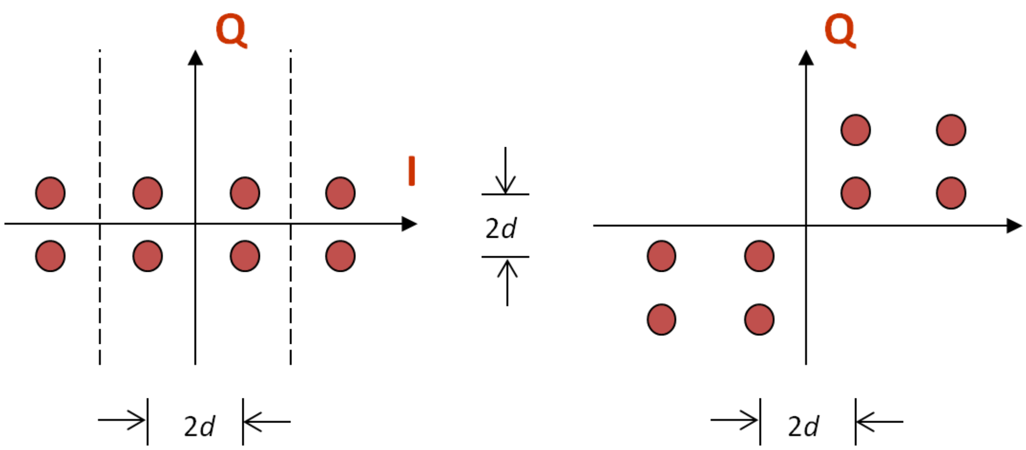
(b) Using your training sequence in part (a), describe how you would estimate the delay parameter Δ in the ideal channel model. *6 points.*

(c) For an adaptive FIR equalizer, derive the update equation for w_1 for the objective function $J(e[k]) = e^2[k]$. *9 points.*

(d) Derive the values of the step size parameter μ that guarantees convergence of the adaptive algorithm? *6 points.*

Problem 2.2 *Communication Performance. 27 points.*

Consider the two 8-QAM constellations below. Constellation spacing is $2d$.



Energy in pulse shape is 1. Symbol time T_{sym} is 1s. The constellation on the left includes the decision regions with boundaries shown by the I axis, Q axis and dashed lines.

	Left Constellation	Right Constellation
(a) Peak power	$10\,d^2$	
(b) Average power	$6\,d^2$	
(c) Number of type I regions	0	
(d) Number of type II regions	4	
(e) Number of type III regions	4	

Draw the decision regions for the right constellation on top of the right constellation. *3 points*.

Fill in each entry (a)-(e) for the right constellation. Each entry is worth *3 points*.

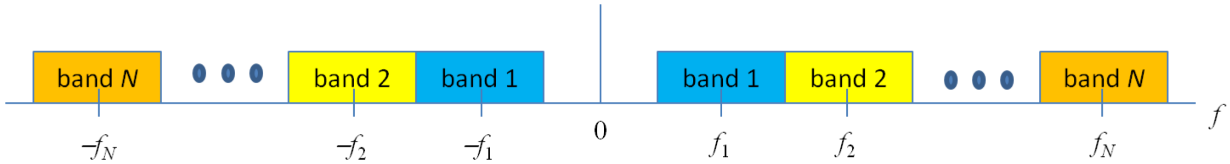
Which of the two constellations would you advocate using? Why? *9 points*.

Problem 2.3. *Multicarrier Communications*. *24 points*.

Multicarrier communications uses multiple carrier frequencies to transmit information in parallel.

Examples include IEEE 802.11a/g Wi-Fi, cellular LTE, DSL, and powerline communication systems.

In multicarrier communications, the transmission bandwidth W is divided into N equally spaced bands, shown below as band 1, band 2, …, band N. A separate modulated signal is placed in each band.



The center frequency for each band is given as $f_1, f_2, \ldots, f_N$.

(a) Would you advocate for using pulse amplitude modulation (PAM) or quadrature amplitude modulation (QAM) in each band? Why? *6 points*.

(b) For each band, we can adapt the constellation size based on the signal-to-noise ratio (SNR) in that band. Based on your choice of modulation in (a), give a formula to determine the number of bits in a band based on the SNR measured in that band. *6 points*.

(c) For part (b), the SNR measurement for a particular band would be taken in the receiver at the equalizer output. From the block diagram of the channel equalizer in problem 2.1 on this test, give a formula to estimate the SNR at the equalizer output $r[k]$ for a given training signal $x[k]$. *9 points*.

(d) If $f_1 = W / N$, give a formula for f_2 and f_N in terms of W and N. *3 points*.

Problem 2.4. *Potpourri*. *22 points*.

Please determine whether the following claims are true or false. If you believe the claim to be false, then provide a **counterexample**. If you believe the claim to be true, then give **supporting evidence** that may include formulas and graphs as appropriate. If you give a true or false answer without any justification, then you will be awarded **zero points** for that answer. If you answer by simply rephrasing the claim, you will be awarded **zero points** for that answer.

(a) Adding noise to a system always reduces signal quality. *8 points*.

(b) Additive noise in a system is always spectrally flat. *7 points*.

(c) The noise floor in a discrete-time digital system is always due to thermal noise. *7 points*.