THE UNIVERSITY OF BRITISH COLUMBIA
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
EECE 563 : Wireless Communication Systems
1999/2000 Winter Session, Term 2

FINAL EXAMINATION
3:30 AM – 6:30 PM
April 17, 2000

This exam has ten (10) questions on four (4) pages. The marks for each question are as indicated. There are a total of 65 marks. Answer all questions. Write all answers in the exam book provided. Show your work. You may answer the questions in any order. Books, notes and calculators are allowed. Show your work. You may keep this exam paper.

Question 1 (8 marks)

The government regulations for a certain type of unlicensed radio device operating at a frequency of 3 GHz specify that the maximum field strength that may be produced by the transmitter, measured at distance of 3m, is 500 mV/m.

(a) Assuming that the largest antenna dimension is approximately 1/2 wavelength, is this measurement being made in the far field of the antenna?

(b) What is the corresponding maximum power density?

(c) Assuming a lossless isotropic source, what is the maximum allowable transmitted power?

(d) If we now assume the transmitting antenna has a gain of 6 dBi, what is the maximum allowable transmitter power?

Question 2 (8 marks)

A mobile communication system uses a geostationary satellite with a downlink frequency of 1.5 GHz. The satellite transmitter has an output power of 40W and the satellite antenna has a gain of 30 dB. The maximum distance from the satellite the the mobile receiver is 42,000 km. The mobile receiver noise figure is 2 dB and the system requires an SNR of 8 dB to operate properly. What is the minimum antenna gain required at the mobile receiver?

Question 3 (5 marks)

Measurements of the signal strength received from an AMPS cellular base station were taken in an urban environment. The measurements were made at 100 different locations, each at a distance of about 1 km from the base station. At each of these locations the signal strength was measured (in μV) at 50 points spaced 1 cm apart. The 50 measurements taken at each location were then averaged and the result was converted to dBm. The mean of these dBm signal levels was -85 dBm. 16 of these values were above (higher power than) -75 dBm.

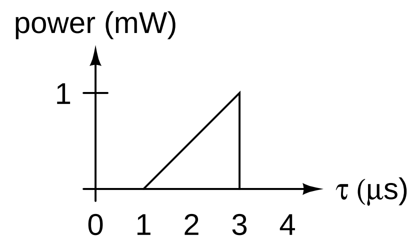
(a) What probability distribution would you expect to see within each set of 50 measurements if the measurements are expressed in μV?

(b) What probability distribution would you expect for the 100 averaged measurements if the average values are expressed in dBm?

(c) How many of the 100 values would you predict would be above -65 dBm?

Question 4 (4 marks)

The following diagram shows the power delay profile of a radio channel.



The delay spread for a continuous (rather than discrete) delay profile is defined as the second central moment of the power delay profile and is computed using integrals rather than sums. What is the delay spread of this channel?

Hints: $\sigma_x = \sqrt{\overline{x^2} - (\overline{x})^2}$, $\overline{x} = \int xp(x)dx$, *and* $\overline{x^2} = \int x^2 p(x)dx$ *if* $\int p(x)dx = 1$.

Question 5 (4 marks)

A cellular carrier uses 900 MHz AMPS cellular phones that experience "fading" when the SNR is less than 13 dB. The carrier has determined that its customers do not find the fading of speech signals objectionable as long as fades do not happen more often than once per second.

The carrier's service area is in an urban area and the maximum expected vehicle speed is 100 km/h. What minimum SNR would the carrier have to provide over the service area so that the fading of speech signals was not objectionable?

Question 6 (4 marks)

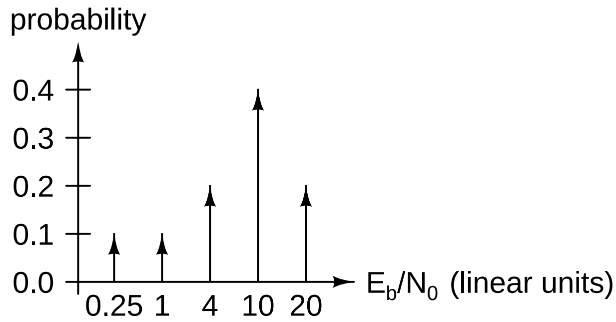
An FM receiver operating above threshold has an IF bandwidth of approximately 30 kHz. The maximum baseband (speech signal) frequency is 3 kHz.

(a) What is the modulation index?

(b) If the IF SNR is 15 dB, what is the approximate audio output SNR?

Question 7 (4 marks)

A digital communication system using DPSK modulation operates over a slowly-fading channel. The following diagram shows the probability density function of the E_b/N_0 as seen at the receiver. What is average BER of this communication system?



Question 8 (10 marks)

Copy the following table into your answer book (omit the second column). Enter T or F in each blank square in the table according to whether that statement is (T)rue or (F)alse for that particular wireless standard. For this question you need not explain your answers.

Part	Statement	AMPS	GSM	IS-95 CDMA
1	mobile transmitter power control affects intra-cell interference			
2	mobile transmitter power control affects inter-cell interference			
3	standard makes provision for an equalizer			
4	uses RAKE receiver			
5	uses speech coding			
6	provides privacy through encryption			
7	transmitter is on continuously during a call			

Question 9 (12 marks)

For each acronym or term in column "A" select the best matching entry in column "B". Write your answers in numerical order and show the number and the selected letter unambiguously. Make sure your answer is unambiguous. There is exactly one best match in column B for each entry column A. No marks will be deducted for incorrect answers. For this question you need not explain your answer.

A		B	
1	PSTN	A	local telephone system operator
2	CO	B	controls base stations
3	LEC	C	uses random retransmission delay
4	T1	E	AMPS-compatible
5	CCS	E	wide-area packet protocol
6	MSC	F	the building housing a telephone switch
7	HLR	G	standard phone network
8	CDPD	H	speech channel multiplex
9	ARDIS	I	WLAN
10	GPRS	J	stores subscriber billing information
11	Aloha	K	inter-switch packet protocol
12	802.11	L	GSM packet radio protocol

Question 10 (6 marks)

You are designing a radio paging system. The system is to use existing transmitter sites and propagation measurements have already established that your system will need to cope with a path loss of 150 dB. You've come up with a preliminary design that includes the following components:

- a transmitter with an output power of 100W
- a transmitter antenna gain of 6 dBi
- feedline losses of 2 dB
- a modulation scheme that requires an IF bandwidth of 20 kHz and an SNR of 10 dB
- a receiver with a noise figure of 6 dB

What is the current link margin?