Name KEY

ECE 5960 Final Exam 2003

You may use your portfolio and a calculator.

Part 1: Replaces Midterm I
Problem 1 and 2
Part 2: Replaces Midterm II
Problem 3 and 4
Part 3: Everyone must do this part.
Problem 5 and 6.

Good luck, do well! Have a good summer!

PLEASE REMEMBER:

1) Turn any ungraded portfolios, labs, etc. into the ECE office after the final (or before 5 pm Friday).
2) Please check the web for any mis-recorded scores, and turn in the appropriate assignments to the ECE office with a NOTE.
3) If you would like your portfolio / assignments / exams to be returned through your mailbox across from the ECE office, please sign here ____________________
(I can't guarantee we can do this yet, but we are requesting permission to return homework this way.)
(Otherwise, please pick them up from Lance in the TA room beginning the Monday after finals.)

Part 1: Problem 1 (Replaces Midterm I)

A hexagonal cell in a 19-cell cluster has a radius of 1 km. ~~The cluster~~ a cell is divided into 3 sectors. Each sector is allocated a 200 MHz band, and each channel is 1 MHz wide. The average user makes three 5-minute calls an hour.

(a) How many erlangs should be allocated for each USER?
(b) How many users can the CLUSTER support with a 5% probability of delay?
(c) What is the probability that the call will be delayed more than 3 minutes?

a) $A_u = \lambda H = \left(\frac{5 \text{ min}}{60 \text{ min/hr}}\right) 3 \text{ calls/hour} = .25 \text{ Erlangs}$

b) $\frac{200 \text{ MHz}}{1 \text{ MHz/channel}} = 200 \text{ channels}$

Each user needs 2 channels for a duplex system.

100 duplex channels = 83 Erlangs from Erlange C chart at .05 GOS.

Total users = $19 \text{ cells} * \frac{3 \text{ sectors}}{\text{cell}} *$ ~~200 channels~~ $* \frac{83 \text{ Erlangs}}{.25 \text{ Erlangs/User}}$

$= 19 \times 3 \times \frac{83}{.25} = 18{,}924$ users

Eqn 3.18

c) $P_d = Pr[\text{delay} > 0] \exp\left(\frac{-(C-A)t}{H}\right) = .05 \exp\left(-\frac{(100-83)3}{5}\right) = 1.86 \times 10^{-6}$

Part 2: Problem 2 (Replaces Midterm I)
Given the following, determine the power that the base station should transmit in order to have a balanced system:

Base Station Transmit Power = .631 Watts

Given:

Mobile power	= 0.6 Watts = 10 Log(.6) = -2.2dB = 27.8dBm
Gain of mobile antenna	= 3 dBd = 5.15 dBi
Gain of base station antenna	= 7 dBi
Loss in the head	= 3 dB
Loss in base station cables	= 25% = 10 Log (1-.25) =
Voltage reflection coefficient at mobile	= 0.8 = 10 Log (1-(.8)^2) =
Polarization loss	= typical for non-line-of-sight 3dB
Temperature	= 294 kelvin
Required S/N	= 13 dB
Bandwidth	= 0.1 MHz
Noise Figure	= 4 dB

Assume no additional interference

~~Receiver Sensitivity~~

Noise at Receivers = $F * T * k * Bw$

$$= 10^{\frac{4dB}{10}} * 294k * 1.38 * 10^{-23} J/k \times .1 \times 10^{+6} Hz$$

$$= 1.02 \times 10^{-15} W = -149.9 dB \approx -120 dBm$$

Loss in base station cables = $10 \log(1-.25) = -1.25$ dB

& Voltage reflection coefficient at mobile = $10 \log(1-(.8)^2) = -4.44$ dB

The required SNR is 13dB, so each receiver must receive (-120dBm $+ 13$ dB $= -107$dBm).

Part 2: Problem 3 (Replaces Midterm II)

BE SURE TO SHOW YOUR WORK:

Suppose that you have a spectrum analyzer and signal generator, and you measure the following values:

Transmitter and Receiver 1 meter apart: Po (average) = 1 Watt

Transmitter and Receiver 10 meters apart: (measurements 1" apart)

Power = [-25, -28, -15, -17, -18, -16, -29, -17, -19, -16] dBm

(assume that this data is statistically significant)

Both antennas are vertically polarized.

(a) What is the approximate frequency that is being transmitted?
(b) What is the approximate depth of the fade? (ie. What "fade margin" should be included in a link budget?)
(c) Plot the probability density function for the above data. Use "bins" at -30, -25, -20, -15 dBm
(d) Plot the cumulative distribution function for the above data.
(e) Explain in DETAIL (give formulas, but you do not need to calculate them) how to determine if this data is line-of-sight or not-line-of-sight from the data measured.

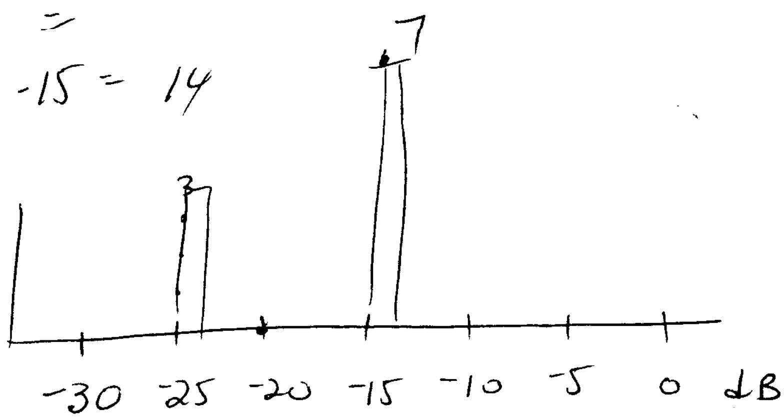
(a) Nulls: 6" apart $= \lambda/2 = c/2F$

$$F = \frac{3e8}{2\,(6'')\left(\frac{2.54\,cm}{in}\right)\left(\frac{m}{cm\,100}\right)}\ Hz$$

=

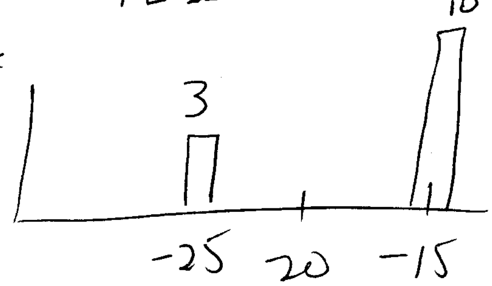
(b) 29 - 15 = 14

(c) PDF



$P \le -25$

(d) CDF



(e) Plot the Rician CDF:

on top of the existing data

find Best fit value of K

IF K = 0, you are NLOS

> 0 you are LOS

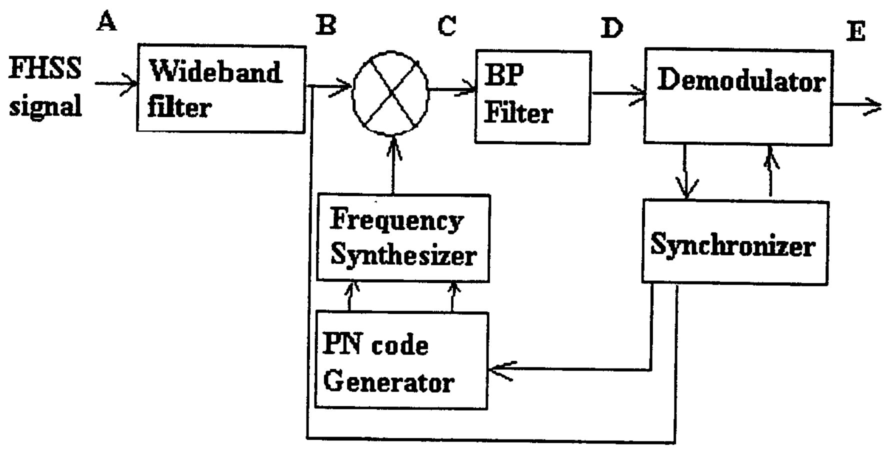
$\gg 0$ very LOS

Part 2: Problem 4:

A FHSS receiver is shown below. For the data = [1 0 1 1] and the PN code: [0 0 1 0 1] (repeated infinitely), sketch the TIME domain signal at points A,B,C,D,E for four CHIP periods. The following table is used to determine the frequency hopping: (Hint: Use a BPSK signal that is frequency hopped depending on the PN code. Assume "fast hopping".)

Chips	Frequency
0 0	100 MHz
0 1	200 MHz
1 0	400 MHz
1 1	800 MHz

(** These frequencies are not normally used in FHSS systems but are visually easy to grade. WRITE IN the frequency at each point.)



Part 3: Problem 5: (Everyone must do this problem) 80 points

Given the following, determine the allowable path loss: (Note, these parameters are same as those given in Problem 1, except for the CDMA application)

Path Loss = ________________ dB

Given:

Mobile power	= 0.6 Watts
Gain of mobile antenna	= 3 dBd
Gain of base station antenna	= 7 dBi
Loss in the head	= 3 dB
Loss in base station cables	= 25%
Voltage reflection coefficient at mobile	= 0.8
Polarization loss	= typical for non-line-of-sight
Temperature	= 294 kelvin
Required Eb/It	= 13 dB
Number of mobiles	= 100
Voice factor	= 0.4
Power control factor	= 0.93
Bandwidth	= 0.1 MHz
Data rate	= 1Mbit / second
Chip rate	= 10 Mbit/second
Noise Figure	= 4 dB
Frequency Reuse Factor	= .6

$$\frac{E_b}{I_t} = \frac{G_p S}{N_o BW + (m-1) v_f S P_f}$$

↑ neglect ? no

$$\left(10^{13/10}\right) = \frac{(10m/1m)\ S}{(1.38e^{-28})(294)(.1m) + (99)(.4)\ S\ (.93)}$$

$$\left[(10^{1.3})(99)(.4)(.93) - 10\right] S = -10^{1.3}\ (1.38e^{-23})(294)(.1M)$$

$725\ S = 8e^{-15}$

$S = 1.12e^{-17}$

$= -169$ dB

Part 3: Problem 6: (Everyone must do this problem) 20 points

Assume that the Path Loss obtained in Problem 5 is 100 dB (it isn't really).

(a) For a log-distance loss model, with loss coefficient = 2.5 , how large can the cell radius be without sectoring?
(b) How large can the cell radius be, if it is divided into 3 sectors? (Assume Po = 1 dB)

(a) $P_r = P_o + 10\, n \log\left(\frac{d}{d_o}\right)$

$100\ dB = 1\ dB + 10\,(2.5) \log\left(\frac{d}{d_o}\right)$

↑ d_o = 1 meter

$d = 10^{\frac{99}{25}} \cong 10\ Km$

(b) I will accept a few variations of this

① Assume PL stays the same. Then the radius stays the same.

② Assume $\frac{E_b}{I_t} = \frac{\gamma_f S G_p}{(M-1)\gamma_f S + f M S \gamma_f} \cong 3 \times$

~1/3 of previous value

$10 \log(3) = 4.77\ dB$

So $PL \cong 100 + 4.77\ dB$

$d = 10^{\frac{104.77 - 1}{25}} = 14.15\ km$

Name ____________________________________

Problem 1 __________ / 50 points

Problem 2 __________ / 50 points

Problem 3 __________ / 50 points

Problem 4 __________ / 50 points

Problem 5 __________ / ~~50~~ 80 points

Problem 6 __________ / ~~50~~ 20 points