Mid-Term Exam Review

Material Covered

The Mid-Term exam will cover the material in the first two Assignments. This corresponds to lectures notes numbered 1-11 and 14. This corresponds to Chapters 4 through 6 in the text by Rappaport. The main topics are path loss, multipath propagation and modulation.

Possible Question Topics

You should be able to (lecture numbers in parentheses):

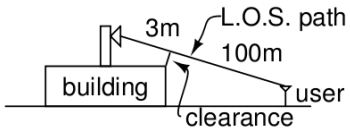
- do computations relating antenna gain, effective aperture, efficiency, and directivity (1)
- compute deterministic path loss using free-space, ground reflection, and knife-edge diffraction models (1, 2, 3)
- compute statistical median path loss using power law and Hata-Okumura models (4)
- compute the probability of an additional path loss due to log-normal fading (11)
- compute signal level probabilities for Rayleigh fading (5)
- locate the location of the n'th Fresnel zone (3)
- determine if propagation paths will result in flat- or frequency-selective fading (5)
- compute level crossing rate and the mean fade duration for Clarke's fading model (5)
- compute information rate, modulation spectral efficiency and power efficiency (6)
- compute bandwidth using various definitions (6)
- compute Shannon capacity for AWGN channels (6)
- compute power spectral density of a deterministic or random signal (7)
- draw constellation diagrams and decision thresholds for square QAM constellations, determine the approximate symbol error rates (8)
- determine if a channel with a given impulse or frequency response meets the Nyquist no-ISI conditions (9)
- explain tradeoffs involving GMSK baseband filter bandwidth, spectra and BER (10)
- compute error rates for the most common types of modulation (14).
- compute link budgets and fade margins using the most common loss/gain items (11)

Sample Questions

These questions, taken from a similar course I taught earlier, do not cover all of the material but are typical of the types of questions that would be asked on an exam.

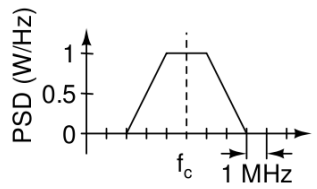
1. A mobile communication system uses a geostationary satellite with a downlink frequency of 1.5 GHz. The satellite transmitter has an output power of 40W and the satellite antenna has a gain of 30 dB. The maximum distance from the satellite the the mobile receiver is 42,000 km. The mobile receiver noise 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?
2. The following diagram shows an antenna mounted on a tower above a building. A line-of- sight path from the antenna to the nearest user passes near the edge of the building. The distance from the antenna to the edge is 3 metres and from the edge to the user is 100m as

shown. The system operates at a frequency of 900 MHz.



3. Compute the median path loss using Hata's path loss model for a distance of 1 km, a frequency of 900 MHz, transmitter and receiver effective antenna heights of 30 metres and 1 metre respectively, for a small city.

4. A radio signal has the following power spectral density:



Compute the bandwidth of the signal using the following definitions:

- absolute bandwidth
- null-to-null bandwidth
- -3 dB bandwidth
- 99% total power bandwidth

5. A cellular radio system with 30 kHz channels provides an SIR of 20 dB at the cell boundary. Assuming methods are employed to eliminate the effects of fading and that the interference can be treated as AWGN, what is the maximum bit rate that could be transmitted error-free over each channel?

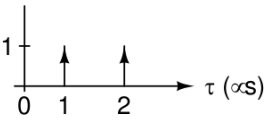
6. Measurements of the signal strength received from an AMPS cellular base station were taken in an urban environment. The measurements were made at 100 different locations, each at a distance of about 1 km from the base station. At each of these locations the signal strength was measured (in μV at 50 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?

7. The following figure shows the power delay profile of a radio channel (x-axis units are microseconds):



   (a) Compute the rms delay spread (in microseconds).

   (b) Would this be considered a frequency-selective channel if the bandwidth of the signal was 4 MHz?

   Hint: the rms delay spread is defined as the standard deviation (square root of the second central moment) of the delay spread: $\sqrt{\int (t-\bar{t})^2 p(t) dt}$.

8. An FM broadcast receiver in a car is tuned to a radio station at a frequency of 100 MHz. The vehicle is traveling at a speed of 30 km/h in an urban area. You can assume there is no direct line of sight to the transmitter and the angle-of-arrival distribution is uniform. The mean (rms) signal level is -70 dBm. The FM receiver output has unacceptable quality (has a low SNR or "fades") when the signal level is below -85 dBm.

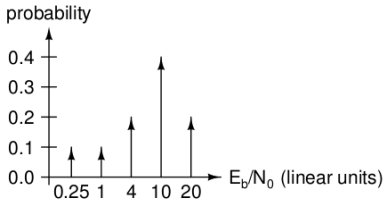
   (a) What fraction of the time is the signal level acceptable?

(b) How often does the signal "fade"?

(c) What is the mean duration of each such fade?

9. 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?

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



11. What is the error rate of DBPSK on an AWGN channel at an $\frac{E_b}{N_0}$ of 12 dB? What is the average BER for the same modulation in a Rayleigh fading channel with the same average $\frac{E_b}{N_0}$?

12. 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?