University of Victoria

Final Examination - April 12, 1997
Electrical Engineering 456 S01
Mobile Communications

<u>Duration: 3 Hours</u>

TO BE ANSWERED IN BOOKLETS

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<u>CAREFULLY READ THE FOLLOWING INSTRUCTIONS:</u>

1. Answer all questions in the exam booklet.
2. Use at least three significant digits in all intermediate calculations.
3. Marks will be deducted for poor presentation or lack of clarity.
4. The number of marks allocated to each question appears in parentheses before the question. The total number of marks is 60.
5. Clearly indicated all required numerical answers by a double underline or an enclosing box.
6. Pencil is preferred but neat pen work is allowed. Erase thoroughly but carefully.
7. Calculators may be used.
8. Textbooks and notes may be used for reference during the examination.
9. The use of personal communications services (PCS) during the examination is prohibited.

STUDENTS MUST COUNT THE NUMBER OF PAGES IN THIS EXAMINATION PAPER BEFORE BEGINNING TO WRITE AND REPORT ANY DISCREPANCY IMMEDIATELY TO THE INVIGILATOR.

THIS QUESTION PAPER HAS 3 PAGES.

1. (2) We require a 15 dB carrier to co-channel interference ratio in a cellular system using hexagonal cells. Assuming $\alpha = 3.5$:
   a) Find the re-use distance (co-channel re-use ratio).
   b) Find the minimum acceptable cluster size.

2. (2) Explain why channel sharing and channel borrowing are not used in current AMPS systems

3. (2) Although field component diversity can yield zero envelope cross-covariance with zero antenna separation, explain why it is not normally used with personal communications systems.

4. (2) Why is amplitude-shift keying not used in mobile communications systems? What type of modulation scheme works better and why?

5. (2) What is sectorization and what are the benefits of sectorization?

6. (2) Explain the difference between a waveform coder and a vocoder.

7. (2) Explain the difference between hard handoff and soft handoff. Give a brief system example for each.

8. (6) For a cellular radio system in a Canadian suburban environment with the following parameters:

Base station antenna height	100 m	Base station power	10 W
Distance to mobile	5 km	Mobile antenna height	2 m
Carrier frequency	800 MHz	Channel bandwidth	30 kHz
Mobile velocity	80 km/hr	α	3.8
rms received envelope level	0 dB	Delay spread	2 μs

   a) Find the propagation path loss in dB using Okumura's model. Show all steps.
   b) Find the received power in Watts and in dBm (decibels referenced to 1 mW) if the distance to the mobile is 10 km.

9. (6) Given the parameters in question #4:
   a) Compute the probability that the signal level is below -20 dB
   b) Compute the level-crossing rate at -20 dB
   c) Compute the average duration of fades at -20 dB

10. (3) Given the parameters in question #4:
   a) A multiple transmission scheme can be used to reduce BER. Find the minimum temporal separation between re-transmissions such that the envelope correlation between these transmissions is less than 0.2
   b) Instead of multiple transmission, spatial diversity can be used to reduce BER. Use the answer from part (a) to find the antenna separation that is required to ensure that the envelope correlation is less than 0.2.

11. (2) Find the diffraction loss in dB for a 1 GHz signal if the distance between the base and the mobile is 6 km and an obstruction which protrudes 20 m above the direct path is 1 km from the base.

12. (1) Which of the six types of microscopic diversity do not require an increase in transmission bandwidth?

13. (6) For a mobile radio system receiving coherent PSK with an average SNR per bit of 15 dB, compute the probability of a word error for an 8-bit data word for each of the following cases:
   a) no diversity or error correction
   b) two-out-of-three multiple transmission
   c) three-branch spatial diversity using maximal ratio combining

14. (8) The generator matrix **G** and parity check matrix **H** for the (7,4) Hamming code (having d=3) are given by

$$G = \begin{bmatrix} 1&1&0&1&0&0&0 \\ 0&1&1&0&1&0&0 \\ 1&1&1&0&0&1&0 \\ 1&0&1&0&0&0&1 \end{bmatrix} \qquad H = \begin{bmatrix} 1&0&0&1&0&1&1 \\ 0&1&0&1&1&1&0 \\ 0&0&1&0&1&1&1 \end{bmatrix}$$

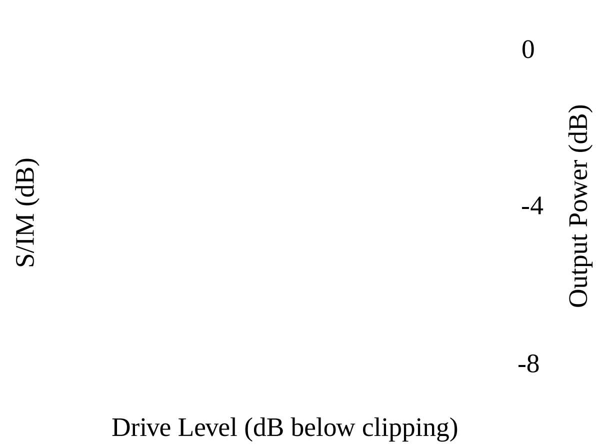
   a) Generate the codeword for the data word 1011
   b) Create a bit error in the rightmost bit position and find the syndrome.
   c) If the all of the possible syndromes and error vectors were available, explain how to find the corrected codeword.
   d) For this code, find the word error rate for a mobile channel using non-coherent FSK and an average SNR per bit of 20 dB.

15. (2) Assuming two users, find the maximum NEFER that can be tolerated in a FDMA system if the frequency separation is 3 channels, the receiver filter slope is 12 dB/oct, and the minimum allowed carrier-to-interference ratio is 18 dB.

16. (5) Consider a TDMA system where the required guard time is 20 μs, the die-out time is 1 μs, and the number of preamble and postamble bits is 40. The channel bandwidth and channel bit rate are both 30 kbps. If each user requires at least 6 kbps of data and the frame time cannot exceed 100 ms:
   a) Find the maximum number of users that can be supported and the resulting data rate per user
   b) Compute the system efficiency

17. (5) Consider a DS-CDMA system where the baseband signal has a bandwidth of 10 kHz and a SNR of 15 dB.
   a) Find the required spread bandwidth such that the spread signal is 5 dB below the noise floor.
   b) Assuming equal power for all users, find the maximum number of users if the minimun acceptable <u>despread</u> S/(I+N) is 10 dB
   c) If there are only two users, find the maximum NEFER that can be tolerated. Find the resulting ratio of distances if $\alpha = 4$

18. (2) The dashed curve below shows signal level to IM distortion as a function of the amplifier drive level. The solid curve shows the output power as a function of drive level. If the output level is currently -2 dB find the improvement in IM distortion that is obtained by reducing the output power by 3 dB



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