

ELEX 7860 : Wireless System Design
Term 201310

FINAL EXAMINATION

1:00 – 4:00 PM

May 23, 2013

This exam has six (6) questions. The marks for each question are as indicated. There are a total of 26 marks. Answer all questions. Write your answers in the exam book provided. Show your work. You may answer the questions in any order. Books, notes and calculators are allowed. You may keep this exam paper.

Show your work.

Question 1 (4 marks)

A geostationary TV broadcast satellite operates at a frequency of 12 GHz with a slant range (distance from satellite to receive antenna) of 36000 km.

- (a) What is the path loss in dB?
- (b) The transmit antenna gain is 36 dBi and the transmit power is 4 W. What is the transmit EIRP in dBm?
- (c) The receiver has a noise bandwidth of 4 MHz, a 1 dB noise figure and requires an SNR of 3 dB. What receive antenna gain, in dBi, is required to achieve a 3 dB link margin?
- (d) What is the effective aperture of this receive antenna in m^2 ?

Question 2 (5 marks)

You are designing a wireless communication system to control robotic forklifts in a warehouse. The system operates at 5 GHz. Experiments have shown that propagation between the controller and the forklifts is not direct but instead the signal travels via many paths, each with a different path length.

- (a) What is a reasonable model for the probability distribution of the magnitude (voltage) of the signal over distances of about a metre?
- (b) It is found that the signal level in an aisle is approximately constant and has a mean value of -60 dBm. What is the probability that at any given location in this aisle the signal level is less than -80 dBm? What is the probability that it is *greater* than -54 dBm?
- (c) Assuming the horizontal angle of arrival distribution is uniform and the forklift is moving at a speed of 3 m/s, how many times per second would you expect the signal to drop below -66 dBm? How long would you expect each of these fades to last?

Question 3 (3 marks)

The robotic forklifts in the above question are sent 125-byte command frames. This only happens when they are stationary.

- (a) Assuming independent bit errors, what BER is required to ensure a PER of 1%?

(b) If the communication link uses differential BPSK at a bit rate of 1 Mb/s and the receiver has a noise bandwidth of 1 MHz, what SNR is required to ensure the PER of 1%?

Question 4 (3 marks)

You are setting up a telephone system for an apartment building and need to know what fraction of a “T1” trunk you need to lease. A T1 trunk can carry 24 phone calls.

The building has 100 tenants and during the busiest part of the day the mean call duration is 15 minutes and each tenant makes an average of 0.5 calls/hour. If call duration is exponentially distributed, calls arrivals are independent, and blocked calls are not retried, what is the minimum fraction of a T1 you should order to ensure the grade of service is better than 1%?

Question 5 (6 marks)

(a) Compute the cascade IIP3 and NF for a receiver front-end that consists of an LNA, passive mixer and IF amplifier with the following specifications:

component	gain (dB)	noise figure (dB)	input IP3 (dBm)
LNA	10	3	20
mixer	-6	—	30
IF amplifier	30	6	30

(b) A CB radio with 4 W RF output is required to have an adjacent channel power output that is 32 dB lower than the transmit channel power output. Assuming RF power amplifier (PA) intermodulation distortion is the only significant source of adjacent channel power, what is the required specification for the RF PA output IP3 in dBm?

Question 6 (5 marks)

An FEC block code encoder outputs one of four possible 5-bit codewords:

- 00110
- 01101
- 10010
- 11001

- (a) How many data bits and how many parity bits are transmitted by each codeword?
- (b) If this code was described as an (n, k) code, what are the values of n and k ?
- (c) If the bits 11000 are received, what codeword was most likely transmitted? How many bit errors would be corrected? Show your work.