Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2014-15 (2.0 hours)

EEE6224 Mobile Networks and Physical Layer Protocols

Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section. Where a symbol or abbreviation is not defined it can be assumed to have its usual meaning, with which candidates should be familiar.**

(10)

1. **a.** Explain OFDM modulation (as used in 4G mobile networks). Your answer should include a basic explanation of how this signal is produced, and schematic diagrams of an OFDM transmitter and receiver.

b. If a baseband OFDM signal is represented by

$$s(t) = \sum_{m=0}^{M-1} F_m e^{j2\pi m\Delta f t}$$

show mathematically how a specific subcarrier F_m may be recovered at the receiver.

(4)

c. An OFDM signal has a baud rate of *15k symbols/s* and a cyclic prefix length of $6.67\mu s$.

(i) What is the maximum path length difference that can be accommodated without any inter-symbol interference? (assume $c = 300m/\mu s$)

(ii) What is the bit rate if there are 100 subcarriers each modulated with 64QAM?

(iii) How does the cyclic prefix affect the capacity of an OFDMA system? **(6)**

2. **a.** What is the TETRA mobile system used for?

(2)

b. By drawing labelled sketches of the burst, frame and multi-frame structures compare the TETRA and GSM protocols. Your answer should include number of bits, timeslots, burst/frame lengths and bit rates where appropriate.

(8)

c. Assuming a TETRA handset transmits in one timeslot per frame on a carrier frequency of 400MHz, and all bits are set to 1, sketch the signal spectral envelope and calculate:

(i) The separation between spectral harmonics;

(ii) The relative magnitude of the 6^{th} harmonic with respect to the carrier;

(iii) The frequencies of the first two spectral envelope nulls;

explaining any Fourier analysis methods used. **(10)**

3. **a.** Explain the terms *softer*, *soft* and *hard* handovers in the context of 2G and 3G mobile networks.

(5)

b. Explain why fast closed loop power control is required in 3G WCDMA cellular mobile networks and how it is implemented.

(5)

c. Estimate the uplink allowed propagation loss for a cell assuming the following:

Mobile transmit power = 0.126W into dipole antenna

Body loss = 3dB

Base station minimum required received power = -120dBm

Base station antenna directivity = 14dBi

Base station feeder loss = 3dB.

Hence calculate the range of the cell. The following formula may be of use:

$L = 137.4 + 35.2 \log_{10} R$.

(8)

d. What other factors may influence the predicted range?

(2)

4. **a.** Explain the Random Access burst in the GSM protocol. Your answer should include a sketch of the frame structure.

(6)

b. If a handset is instructed to use a Time Advance of 41 by the network, estimate the distance of the handset from the BTS and explain the accuracy of this estimate (assume $c = 300m/\mu s$).

(4)

c. A GSM mobile user on a mountain receives a strong BCCH signal from a BTS 50km away, but cannot make a call. Explain why.

(3)

d. Explain how location information about a mobile handset could be obtained using the TA, and compare results with GPS.

(5)

e. Discuss other ways a mobile 'smart-phone' can obtain a user's location (not using GPS).

(2)

GGC/TOF