Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2015-16 (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.**

1. **a.** (i) Show that the uplink load factor η_{ul} due to *N* users simultaneously accessing a 3G WCDMA cell all uploading data at an equal bit rate *R* can be written as

$$\eta_{ul} = (1+i)\frac{NE}{E+G_p}$$

(ii) Hence show that at pole capacity

$$NR = \left(R + \frac{W}{E}\right)\frac{1}{(1+i)}$$

(12)

defining all symbols used.

b. If *8* users are all uploading data at 200kbps simultaneously calculate

(i) The uplink load factor
(ii) The cell pole capacity

assuming $E = 3dB$ and there is no interference from users of adjacent cells. **(6)**

c. What is the ratio (total upload data rate) / (cell pole capacity) in part **b.** equal to? **(2)**

2. **a.** A GSM BTS uses a vertically polarised co-linear dipole array with a gain of 12dBi to serve a particular cell in the 900MHz band, with an instantaneous power of 10W for each timeslot burst in use. Estimate the minimum safe distance from the antenna in the direction of the (horizontal) main lobe so that the radiated power density level is within the safety limit of $35Wm^{-2}$, assuming all timeslots are active. **(4)**

b. One of the side lobes of the BTS array has a level of -15dB with respect to the main lobe at an angle of 70^o from the horizontal towards the ground. Assuming the antenna height is 10m, calculate the power density at ground level due to this side lobe. **(3)**

c. Estimate the power density within a bedroom of a house at the same height as the BTS antenna and at a distance of 15m from it. **(2)**

d. Define the near field exposure metric SAR and give the recommended public safety limit on SAR level in human tissue. **(3)**

e. Assuming the relation

$$P_d = \frac{E^2}{754}$$

estimate the SAR induced in a person in the bedroom in part **c.** assuming a tissue conductivity of 1.54S/m and density 1000kg/m^3. **(3)**

f. Using the above data, plus any other relevant information, discuss whether the concerns of residents are scientifically justified when objecting to BTS's being located next to their houses. **(5)**

3. **a.** Describe the following logical control channels in the GSM protocol and the bursts they map on to (including bit sequences):

(i) Frequency Correction Channel (FCCH),

(ii) Synchronisation Channel (SCH),

(iii) Broadcast Control Channel (BCCH),

(iv) Common Control Channels (CCCH). **(10)**

b. Hence sketch typical downlink and uplink control channel multiframes involving the channels in part **a.** **(3)**

c. Assuming an MS keeps sending a random access burst in timeslot 2 of every uplink control frame, what is

(i) the instantaneous RACH bit rate

(ii) the average RACH bit rate? **(4)**

d. Describe the *cell broadcast* message in GSM, and how it differs from SMS. **(3)**

4. **a.** Describe the uplink and downlink DPDCH and DPCCH in the 3G WCDMA protocol. Your answer should include:

(i) Modulation types,
(ii) Bit rates,
(iii) Type of information the bits contain,
(iv) Timeslot bit sequences and frame structures. **(12)**

b. If a spreading factor of 128 is used and data is being transmitted continuously, estimate

(i) The uplink DPDCH symbol rate,

(ii) The uplink DPDCH bit rate,

(iii) The uplink DPDCH user data rate assuming half rate coding,

(iv) The downlink DPCH symbol rate,

(v) The downlink DPCH bit rate,

(vi) The downlink average user data rate assuming half rate coding and that the DPCCH occupies 30% of the DPCH.

(8)

GGC/TOF