Paper Number(s): E4.03

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**ISE4.3** 

IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE UNIVERSITY OF LONDON

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING **EXAMINATIONS 2002** 

MSc and EEE/ISE PART IV: M.Eng. and ACGI

### MOBILE RADIO COMMUNICATION

Wednesday, 8 May 10:00 am

There are FOUR questions on this paper.

Answer THREE questions.

Time allowed: 3:00 hours

**Corrected Copy** 

### Examiners responsible:

First Marker(s):

Gurcan, M.K.

Second Marker(s): Ward, D.B.

Special instructions for invigilator: None

Information for candidates: None.

- Assume that a signal-to-noise ratio of 15 dB is required for the satisfactory down-[2] 1. a) link channel performance of a cellular system that has 6 co-channel cells in the first tier. What is the frequency re-use factor and cluster size that should be used for maximum capacity if the path loss is due to the inverse fourth power loss? A mobile is located 5 km away from a base station and uses a vertical  $\lambda/4$ b) monopole antenna with a gain of 2.55 dB to receive cellular radio signals. The E field at 1 km from the transmitter is measured to be  $10^{-3}$  V/m. The carrier frequency used for the system is 900 MHz. Find the length and the effective area,  $A_e$ , of the receiving antenna. i)
  - [2]
  - Find the received power at the mobile using a 2-ray ground reflection model [3] ii) assuming the height of the transmitting antenna is 50 m and the receiving antenna is 1.5 m above ground.
  - Using Figure 1.1, compute the diffraction loss for the three cases shown in Figure c) 1.2. For all the cases assume that  $\lambda = 1/3$  m,  $d_1 = 1$  km,  $d_2 = 1$  km. Also assume that the obstacle height for each case is
    - [2] i) h = 25 m,
    - [1] ii) h=0 m,
    - [1] h = -25 m.
    - For each of these cases, identify the Fresnel zone within which the tip of the [1] obstruction lies.
  - Consider a transmitter which radiates a sinusoidal carrier frequency of 1850 MHz. d) For a vehicle moving at 60 mph, compute the received carrier frequency if the = 26.82 m5-1 mobile is moving
    - [2] directly towards the transmitter, i)
    - [1] directly away from the transmitter, ii)
    - in a direction which is perpendicular to the direction of arrival of the [1] iii) transmitted signal.
  - Find the average fade duration for a threshold level  $R_0 = 0.707$  when the Doppler [4] e) frequency is 20 Hz. Assume that for a binary digital modulation with data rate of 50 bps, a bit error occurs whenever any portion of a bit encounters a fade for which  $R_0 < 0.1$ . Calculate the average number of bit errors.

In Rn 406/7

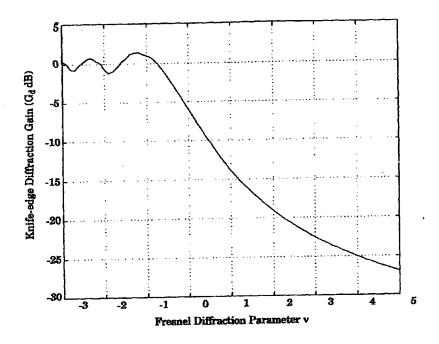


Figure 1.1 Diffraction loss diagram

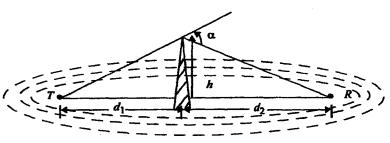


Figure 1.2, case 1.

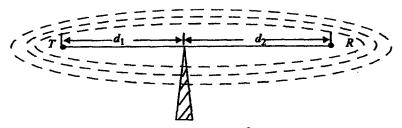


Figure 1.2, case 2.

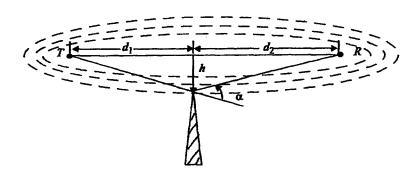


Figure 1.2, Case 3.

In a mobile radio data transmission system, each cell radius is designed to be 500 2. a) metres. The calls originating from the users in each radio cell divide into four groups. Average bit rates for the four groups are: 10, 12.5, 17.5 and 20 kbit/s. Packets are of equal size of 1250 bits. There are 40741 mobile users in an area of 2 km<sup>2</sup> and 90 percent of the mobile users are active during any period of one hour. What is the call arrival rate,  $\lambda$ , per second? i) [2] What is the average number of packets an active user transmits over an hour ii) [1] period? The call arrival process described in part a) identifies the call arrivals for a deferredb) first transmission Aloha system. The packets are transmitted over a link with data rate of 200 kbs. The number of backlogged users is  $n_k = 30$ and the retransmission probability is  $q_r = 1/30$ . Compute the offered load, g, for the system and the corresponding throughput [2] i) [1] the call arrival rate,  $\lambda_T$ , per slot ii) [2] the drift, dn, for the real number of backlogged users. iii) The joint drift equation dj = dn - g ds is used to stabilise the Aloha system given in c) part b). In the joint drift equation, the term ds is the estimated drift equation for the estimated number of backlogged users with the control parameters  $(u_0, u_1, u_c)$ . If  $u_1 = u_c = 0.4$ find the control parameter  $u_0$  which will provide a unique settling point at [3] i) g=1[3] calculate the estimated drift (ds), the real drift (dn) and also the joint drift ii) (dj) at the offered load value of g = 2. For a deferred-first transmission Aloha system d) state three criteria that can be used to stabilise the system using the joint drift [2] i) equation [2] find the limiting values of dj(G) for G = 0 and  $G = \infty$ ii)

describe how the roots of dj = 0 are used to determine the settling points for

iii)

the Aloha system.

[2]

- Assume a mobile travelling at a velocity of 10 m/s receives two multipath components at a carrier frequency of 1000 MHz. The first component is assumed to arrive at  $\tau = 0$  with an initial phase of zero degrees and a power of -70 dBm (which is equal to 100 pW). The second component is 3 dB weaker than the first component and is assumed to arrive at  $\tau = 1$  µs with the initial phase of zero degrees. The mobile moves directly towards the direction of arrival of the first component and directly away from the direction of arrival of the second component. For a narrow band system, consider the observation interval  $0 \le t \le 0.5 \,\mu$ s and
  - i) compute the instantaneous power at the times  $0\mu$  s,  $0.1\mu$  s,  $0.2\mu$  s,  $0.3\mu$  s,  $0.4\mu$  s,  $0.5\mu$  s
  - ii) calculate the average power received over the observation interval [2]
  - iii) compare average narrowband and wideband received powers over the [2] interval.
  - Assume that in a small scale propagation measurement system, the time between samples is equal to  $T_c/2$ , where  $T_c$  is the coherence time. Determine the sampling interval required to make the measurements when it is assumed that consecutive samples are highly correlated in time.
    - i) How many samples will be required over 10 m travel distance if f = 1900 [2] MHz and v = 50 m/s?
    - ii) How long would it take to make these measurements assuming they could be made in real time from a moving vehicle?
    - iii) What is the Doppler spread  $B_D$  for the channel? [1]
  - c) A minimum-mean-square-error decision-feedback-equaliser has the mean square [4] error between the desired and equalised signals as follows

$$\varepsilon^{2} \approx \frac{1.3(N+1)}{1 + (Nh_{0}^{2} + (N-1)h_{1}^{2} + (N-2)h_{2}^{2})X_{R}}$$

where  $X_R$  is the signal-to-noise-ratio (SNR) at the input of the equaliser and the feed-forward filter is of length N+1. The channel impulse response coefficients are specified by  $\mathbf{H} = \begin{bmatrix} h_0 & h_1 & h_2 \end{bmatrix}^T$ . Find the equaliser gain for large values of  $X_R$ .

- d) In connection with the Global Systems Mobile (GSM) radio system, explain
  - i) the framing structure for the traffic channels [3]
  - ii) how the network switching subsystem is organized. [2]

ii) the uplink multiplexing over the DPDCH channel.  c) the system architecture, paying particular attention to  i) the user equipment  ii) the UTRAN system  iii) the core network.  d) the UMTS interfaces, paying particular attention to  i) the Cu interface  ii) the Uu interface  iii) the Iu interface  iv) the Iur interface  v) the Iur interface.  []  the UMTS traffic classes, paying particular attention to  i) the conversational class  ii) the streaming class  iii) the interactive class  []	4)	a)	In connection with the transitional 2.5 G radio systems, explain how the HSCSD,	[4]
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	Examinations : M.	Examinations : Mobile radio Communication
	MODEL ANSWER	MODEL ANSWER and MARKING SCHEME
First	First Examiner: Dr. M. Gurcan	Paper Code E4.03, AS5, SO10, ISE4.3
Secor	Second Marker: Dr. D. Ward	Question 1-9/Page 1. out of 30
Ques	Question labels in left margin	Marks allocations in right margin
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	Since this SNR is required sNR of 15d	Since this SNR is greater than minimum required SNR of 15 dB, clutur size of N=7 dB be used
	- 1111	
から	T-R separation is 5km E field at a distance of 1 km = 10 <sup>-3</sup> Frequacy of operation, f= 900 MHz.	T-R separation is 5km  E field at a distance of 1 km = 10 <sup>-3</sup> V/m.  Frequacy of operation, f= 900 MHz.
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(i)	Gain of the antenna	a G= 4KAR = 2.55 dB=1.8

First Examiner: Dr. M. Gurcan	Ħ	
Second Marker : Dr. D. Ward	Question 1 b Page 2 out of 30	
Question labels in left margin	Marks allocations in right margin	
Ac = (a. 32 -	Ac= G. 72 1.8 x (0.333) = 0.0159	
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= 113.	= 113.1×10 V/m	
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= (H3.1	= (113.1×10 b) x 0.0159	
P (1) = 2.695 × 10	\$2.695 × 10 W	

Examinations: Mobile radio Communication MODEL ANSWER and MARKING SCHEME

Paper Code E4.03, ASS, SO10, ISE4.3  Question 1-C Page 3 out of 30  Marks allocations in right margin  Marks allocations in right margin  (4,142) = $25\sqrt{2(1000+1000)} = 2.7g$ 1 the lass is obtained to be  2 $\times 1000 \times 1000$ 1 the fits we need to compute in which the tip  4 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 3 $\times 1000 \times 1000$ 4 $\times 1000 \times 1000$ 3 $\times 1000 \times 1000$ 4 $\times 1000 \times 1000$ 5 $\times 1000 \times 1000$ 6 $\times 1000 \times 1000$ 7 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 3 $\times 1000 \times 1000$ 4 $\times 1000 \times 1000$ 5 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 3 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 3 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 3 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 3 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 3 $\times 1000 \times 1000$ 4 $\times 1000 \times 1000$ 5 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 3 $\times 1000 \times 1000$ 5 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 3 $\times 1000 \times 1000$ 4 $\times 1000 \times 1000$ 5 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 1 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 2 $\times 1000 \times 1000$ 3 $\times 1000 \times 1000$ 4 $\times 1000 \times 1000$ 5 $\times 1000 \times 1000$ 5 $\times 1000 \times 1000$ 7 $\times 1000 \times 1000$ 1 $\times 10$	Examinations: MODEL ANSWE	Examinations: Mobile radio Communication MODEL ANSWER and MARKING SCHEME		
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Marks allocations in right margin $ \frac{1}{2} \left( \frac{1}{2} \right) = 25 \sqrt{\frac{2}{1000 + 1000}} = 27p $ A d <sub>1</sub> d <sub>2</sub> A d <sub>2</sub> A d <sub>1</sub> d <sub>2</sub> A d <sub>2</sub> A d <sub>1</sub> d <sub>2</sub> A d <sub>2</sub> A d <sub>1</sub> d <sub>2</sub> A d <sub>3</sub> A d <sub>1</sub> d <sub>2</sub> A d <sub>2</sub> A d <sub>3</sub> A d <sub>1</sub> d <sub>2</sub> A d <sub>2</sub> A d <sub>3</sub> A d <sub>1</sub> d <sub>2</sub> A d <sub>3</sub> A d <sub>1</sub> d <sub>2</sub> A d <sub>2</sub> A d <sub>2</sub> A d <sub>3</sub> A d <sub>1</sub> A d <sub>2</sub> A d <sub>2</sub> A d <sub>2</sub> A d <sub>3</sub> A d <sub>1</sub> A d <sub>2</sub> A d <sub>3</sub> A d <sub>1</sub> A d <sub>2</sub> A d <sub>2</sub> A d <sub>2</sub> A d <sub>3</sub> A d <sub>1</sub> A d <sub>2</sub> A d <sub>2</sub> A d <sub>3</sub> A d <sub>1</sub> A d <sub>2</sub> A d <sub>2</sub> A d <sub>3</sub> A d <sub>2</sub> A d <sub>3</sub> A d <sub>1</sub> A d <sub>2</sub> A d <sub>2</sub> A d <sub>3</sub> A d <sub>1</sub> A d <sub>2</sub> A d <sub>2</sub> A d <sub>2</sub> A d <sub>3</sub> A d <sub>1</sub> A d <sub>2</sub> A d <sub>3</sub> A d <sub>1</sub> A d <sub>2</sub> A d <sub>2</sub> A d <sub>1</sub> A d <sub>2</sub> A d <sub>1</sub> A d <sub>2</sub> A d <sub>1</sub> A d <sub>2</sub> A d <sub>2</sub> A d <sub>2</sub> A d <sub>1</sub> A d <sub>2</sub> A d <sub>1</sub> A d <sub>2</sub> A d <sub>3</sub> A d <sub>2</sub> A d <sub>3</sub> A d <sub></sub>	ker : Dr. D. Ward			Sec
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	Examinations : Mobi	Examinations : Mobile radio Communication
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econd M	second Marker : Dr. D. Ward	Question  - C Page 4 out of 30
uestion	Question labels in left margin	Marks allocations in right margin
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DEL ANSWER and MA	
First Examiner: Dr. M. Gurcan Paper Code E4.03, ASS, SO10, ISE4.3 Second Marker: Dr. D. Ward Onestin 1- Page 4. out of	ISE4.3
	ht margin
Therefore the freshel parameter V=0  From figure 1, the differential bass is obtained as 608.  For this case, since h=0, we have b=0, and the tip of the obstruction lies in the middle of the first freshel zone.  The middle of the differential loss is as the middle of the differential loss is as yoperoximately equal to 1ds.  Since the dissolute value of the height h, is the same as port (a), the excess part lasth & and hence n will also be the same. The tip of the obstruction blocks the first three freshel zones, the differential size are resided zones, the differential size of size the same of sight.	٥ ١ ١ ١ ١ ١

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econ	Second Marker: Dr. D. Ward	Question 1-4 Page 5 out of 50
)uesi	Question labels in left margin	Marks allocations in right margin
	$f_{c} = 1850 \text{ MHz}$ wowelength $\lambda = \frac{6}{f_{c}} = \frac{3 \times 10}{1850 \times 10^{6}} = 0.162 \text{ m}$ Yehicle speed, $v = 60 \text{ mph} = 26.82 \text{ m/s}$	3×10 1850×10 1850×10 mph = 26.82 m/s
(·)	the vehicle is moving The Doppler shift is frequency is given by	directly tow positive and
(i)	f=fe+fe= 1850×10+ 26.62 The vehicle is moving direct the transmitter. The Doppler shift is regartic	f=fc+fc= 1850×10+ 16.62 = 1850.00016miz The venicle is moving directly away from the transmitter. The Doppler shift is regarive. The received
αij	r- 0	frequency is given by  frequency is given by  frequency is given by  frequency = 1850 × 10 - 26.82 - 1849.997834 MMz  The vehicle is moving perpendicular to the  ongle of arrival of the transmitted spinal.
	In this case Organo Doppler shift. The received signical significations of the transmitted significations of the transmitted significations.	In this case O=90°, coso=0 and there is no Doppler shift. The received signal frequency is the same as the transmitted frequency of 1850 MHz.

Examinations: Mobile radio Communication MODEL ANSWER and MARKING SCHEME

		- 0			/<-
Examinations: Mobile radio Communication	MODEL ANSWER and MARKELING SCHEME  can  Paner Code F4.03, AS5, SO10, 1884.3	30	Marks allocations in right margin	The average fade duration can be obtained from $\frac{1}{2}$ = $\frac{\exp\left(\ell^3\right) - 1}{\ell}$ = $\frac{\exp\left(6.707\right)^2 - 1}{\ell}$ = $\frac{\exp\left(6.707\right)^2 - 1}{\ell}$ for $\sqrt{2}\pi$ = $15.3$ ms.  The a darka rate of 50 ms, the bit period is 100s than the bit period, for the given data rate the signal 4 underpose fade duration $\sqrt{2}\pi$ is 100s than the bit period, for the given data rate the signal 4 underpose fact Rayleph fedding.  Ving $\ell = 0.1$ and the fading duration aparts $\sqrt{7}\pi = \frac{\exp\left(\ell^3\right) - 1}{2 \exp\left(\ell^3\right) - 1} = \frac{\exp\left(6.1^3\right) - 1}{2 \exp\left(\ell^3\right) - 1} = \frac{\exp\left(6.1^3\right) - 1}{2 \exp\left(6.1^3\right) - 1} = \frac{\exp\left(6.1^3\right) - 1}{2 \exp\left(6.1^3\right) - 1} = \frac{\exp\left(6.1^3\right) - 1}{2 \exp\left(6.1^3\right)}$ The number of level crossings for $\ell = 0.1$ Where $\ell = \sqrt{2}\pi$ fine $\ell = \exp\left(-\ell^3\right) = 4.96$ crossings A portion of a bit excontors a fuse,	and since avorage fade duration spans only a fraction of a bit duration, the total number of bits in error 15 S per second, resulting in a bit error = \$\frac{5}{50} = 0.1
Examinations: Mo	First Examiner: Dr. M. Gurcan	Second Marker: Dr. D. Ward	Question labels in left margin	The average fade duform  from Exp(e²)-1  for a data rate  ported is 20 ms. si  is 1055 than the bi data rate the signal data rate the signal fading.  Vsing P=0:1 au  Pine number of 1ev  NR = 12π fm (  B bit error is assume a portion of a bit	a fraction of a bit on me ber of bits in a resulting in a bit e

	Examinations : M.	Examinations : Mobile radio Communication
	MODEL ANSWER 8	MODEL ANSWER and MARKING SCHEME
First	First Examiner: Dr. M. Gurcan	Paper Code E4.03, AS5, SO10, ISE4.3
Secon	Second Marker : Dr. D. Ward	Question 2018 Page 7 out of 30
Ques	Question labels in left margin	Marks allocations in right margin
ક	Total data rate = [10+12	Total data rate = [10+125+17.5+20]x10= 60x10 bps
	Number of packets per s	Number of packets per second = 60×103 = 48 packets/s
	over an how inchance =	over an how we have = 48 x3600 = 172800 packets.
	Total number of active users in the rell is	uses in the cell is
	4074/ × 1× (0.5)	40741 x 11 x (0.5) x 0.9 = 14400 USES
	7	
	Number of packets per	Number of packets per user = 172800 = 12 packets/hour.
/		-
۵ ً	Packet rate for the	Packet rate for the link = 200 × 10 = 160 packets
	Call actival tate	064
<u>(5</u>	77 = 48 = 0.3	= 0.3 packets/5lot.
		;
<b>(</b>	9= n g = 1 packet/5.	acte+/5.
•	$5(9=1)=9 \exp(-9)=\exp(-1)=0.36P$	exp(-1) = 0.36P.
1jij	dn = Ar sex	dn = 27 - 3 exp(-9)= 0.3 -0.368=0.068

	Examinations : N	Examinations : Mobile radio Communication
	MODEL ANSWER	MODEL ANSWER and MARKING SCHEME
First	First Examiner: Dr. M. Gurcan	Paper Code E4.03, AS5, SO10, ISE4.3
Secon	Second Marker: Dr. D. Ward	Question 2 C Page 8 out of 30
Quest	Question labels in left margin	Marks allocations in right margin
1,	dj=0=dn-gds	
	= > - 9 exp(-9)-9	= > - 9 exp(-3)-9 [ 40 exp(-3)+4, 9 exp(-9)
	+40 (1-exp(-0	+40 (1-exp(-9)-9 exp(-9)]
	= 0.3 - exp(-1)-	= 0.3 - exp(-1) - [u. exp(-1) + 0.4 exp(-1)
	+0.4 (1-exp	+0.4 (1-exp(-1)-exp(-1))
	40 = exp(1) [0.	40 = exp(1) [ 0.3 - exp (-1) +0.4 exp(-1)-0.4]
	901	= -0.6 - 0.1 exp(1) = -0.8718
	No=-0,8718	
م. ۲	ds= 40.exp(-9)	40.exp(-9) +4, 9 exp(-9)
<u> </u>	-  ) <b>*</b> *+	+4 = (1- 9 exp(-9) - exp(-9))
	×8118x	= -0.8718x exp(-2) + 0.4 x2x exp(-2)
	1) 5.0 +	+ 0.4 (1- exp(-2)-2xexp(-2)]
	= 0.2279	
	dn= 0.3-2.	0.3-2.exp(-9) = 0.0293
	= 26.6 - ND - T. LD	dj= dn-9.45 = 0.0293-2×0.2270
	04765	

	Examinations: Mo MODEL ANSWER an	Examinations : Mobile radio Communication MODEL ANSWER and MARKING SCHEME
First Examiner: Dr. M. Gurcan	M. Gurcan D Ward	Paper Code E4.03, AS5, SO10, ISE4.3 Onestion 2   Page Q out of 30
Question labels in left margin	ft margin	allocations in r
150	dj. dn-gds	
when point.	dj=0 the system so	when dj=0 the system settles at that point. Stability critoria
	dj=o for dj>o for	1=8
	dj< for	.176 7
7	4)= 7 for 0	863
<b>S</b>	K = 15 b	(
	os at coots	\$ 7 X
P	43 Sauble and Laying	100
<i>3</i>	We want one roof	dj (9=1)=0

Examinations: Mobile radio Communication MODEL ANSWER and MARKING SCHEME First Examiner: Dr. M. Gurcan Second Marker: Dr. D. Ward Ouestion 3 a Page	adio Communication ARKING SCHEME Paper Code E4.03, AS5, SO10, ISE4.3 Question 3 a Page 0 out of 30
Question labels in left margin	Marks allocations in right margin

Given v=10 m/s, the time intoval of 0.1 s
corresponds to spatial intervals of 4 m. The
corrier frequency is given to be 1000 mHz,
hence the wowklagth of the signal is

The placed bout instantaneous power can be composted using

Note that -70 dBM = 100 pw. At time t=0, the phases of both multipath components are 0, hence the instantaneous power is equal to

Now, as the mubile moves, the phase of the two multipath components charges in opposite direction.

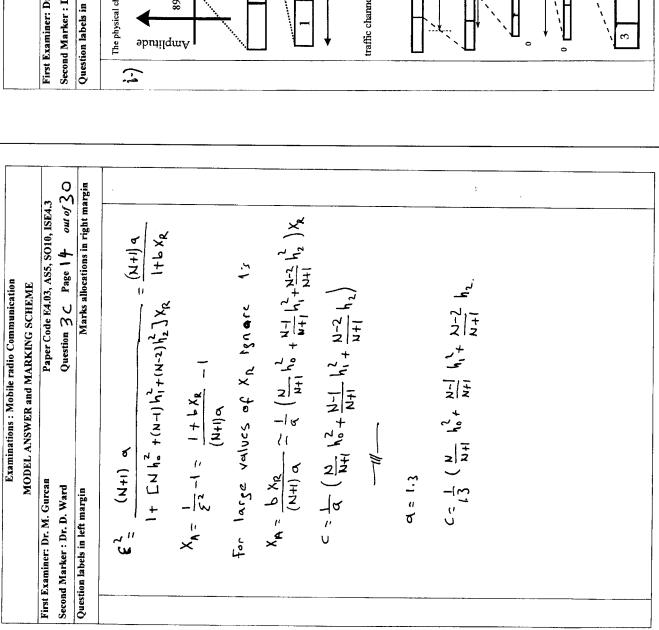
At t=0.1s, the phase of the two multipath components charges in opposite directions.

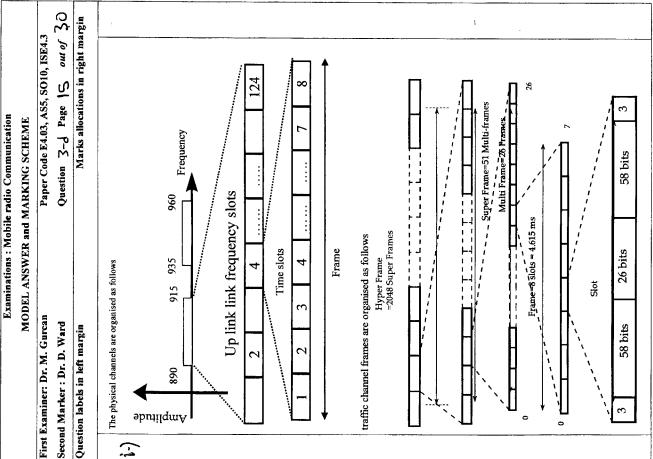
At t=0.1s, the phase of the first component is  $\theta_{i=} \frac{2\pi d}{3} = \frac{2\pi vt}{3} =$ 

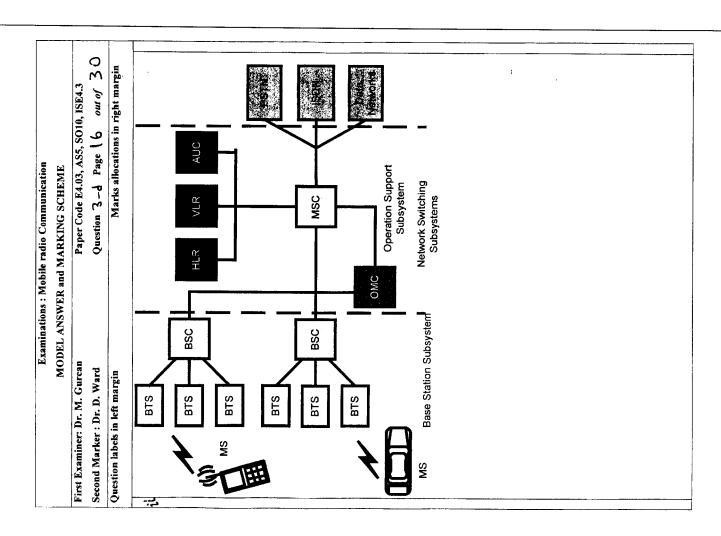
First Examiner: Dr. M. Gurcan Second Marker: Dr. D. Ward Question labels in left margin Question labels in left margin  \[ \therefore \\ \ther
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	Examinations	Examinations : Mobile radio Communication
	MODEL ANSW	MODEL ANSWER and MARKING SCHEME
First F	First Examiner: Dr. M. Gurcan	Paper Code E4.03, ASS, SO10, ISE4.3
Secon	Second Marker: Dr. D. Ward	Question 3 of Page 12 out of 30
Questi	Question labels in left margin	Marks allocations in right margin
	Smilarly at E=0.3	E=0.35, 8=360=0 and 0,=-360=0
	and the Instantan	instantaneous power is equal to
	((t,) =   \subseteq a; exp(j \theta;(t,7))	P(j 0; (t, 7))
	- Noopu x ex	= (V100pw x exp(jo) + (50pw x exp(-jo) = 291pw
	It follows that and	It follows that at t=a45, \r(t) = 78.2pw
(1.3	The average nam	The average narrowboad received power is
	Cqual to 2x 291 + 2x7	al to 2x291 + 2x782 + 2x815 = 150.233pw
	9	•
	The wideboard po	The widebound power is given by
, 72,	E (Py) = 2 92	9; = 100p x+ 50pw=180pw
	As can be seen, the received power are	As can be seen, the narrowbond and widebond received power are virtually identical.
******		

Paper C Question Question Question Sx 1900 x 106 Dx 1900 x 106 Dx 565 Ms Dx 565 Ms	ARKING SCHEME Paper Code E4.03, ASS, SO10, ISE4.3 Question 3-b Page   3 out of 30 Marks allocations in right margin the smalest value of the smalest value of  = 9c   6 K v fc     16 K v fc     17 K v fc     18 K v fc     18 K v fc     19 K v fc     10 K
Paper C  Question  and we use the  fin 16 TV  16 TV  x3 x 108  x3 x 108  x3 x 108  x3 x 108  x4 x 50 x 1900 x 10  b x 3.14 x 50 x 1900 x 10  1 x 5 m s, curresponds  5 m s, curresponds  6 f 50 x 565 ms  1 x 1 cm.  fre number of s  fro m france ditha	Page 13 out of 30  Page 13 out of 30  allocations in right margin  lest value of  vfc  an half Tc  a spatial
Ouestion  ) and we use the  If m  If m  Sx x 10  Sx x 10  Sx x 10  Sx x 14 x 50 x 1900 x 10  If me samples at less  If me samples at less  Sx x s  If me samples at less  1 + 1 cm  The number of s  1 on travel ditha	Page 13 out of 30 allocations in right margin lest value of vfc  an half Tc  a spatial
) and we use the ond we use the off 16 x 1 18 3 x 3 x 108 16 x 3.14 x 50 x 1900 x 106 16 x 3.14 x 50 x 1900 x 106 17 x 2 x 2 1.41 cm. 1.41 cm. 1.41 cm.	allocations in right margin  lest value of  vfc  an half Tc  a spatial
	lest value of vfc.  An half Tc.  a spatial
The standard of somples of samples over a tom travel distance is an example of samples at less than at 282.5 ms, where so	vfc an half Tc a spatin
= $\frac{9 \times 3 \times 10^8}{16 \times 3.14 \times 50 \times 1900 \times 10^6}$ The stand of the samples at less than at 282.5 ms, corresponds to a laternal of $A \times \frac{\sqrt{6}}{2} = \frac{50 \times 565  ms}{2} = 0$ .  Therefore, the number of samples over a to m travel dittance is	an half Tc a spatial
Taking time samples at less than at 282.5 ms, corresponds to a finterval of $Ax = \frac{\sqrt{6}}{2} = \frac{50 \times 565  ms}{2} = 0$ .  Therefore, the number of samples over a to m travel distance is	an half Te a spatial
at 282.5 ms, corresponds to a gaternal of Ax= $\frac{\sqrt{16}}{2} = \frac{50 \times 565  \mu s}{2} = 0$ .  Therefore, the number of samples over a 10 m travel distance is	a spatial
Ax= \(\frac{\gamma}{2} = \frac{50 \times 55 \times = 0.}{2} = 0.  = 1.41 cm.  Therefore, the number of samples over a 10 m travel distance is	_
Therefore, the number of samples	0.014125m
	les required is
Nx = 10 = 10 = 708 samples	amples
ill that taken to make this measurement is equal to 10m = 0.25.	durement is
9	-= 316.66 112.







	Examinations : !	Examinations : Mobile radio Communication
	MODEL ANSWER	MODEL ANSWER and MARKING SCHEME
Ē	First Examiner: Dr. M. Gurcan	Paper Code E4.03, AS5, SO10, ISE4.3
Seco	Second Marker: Dr. D. Ward	Question 4 9, Page 17 out of 30
Que	Question labels in left margin	Marks allocations in right margin
(F)		HSCSD, High speed eirouit switched data
	allows a single my	ed technique that
	Conseautive user tim	CONSERUTIVE VSC time slots in the GIM
	standard . Instead of	standord. Instead of Unithy each user to
	2412 ore specific	only one specific time slot in the GSM
	OMA Standowd HS.	roma standard HISCED will allow individual
	data users to come	data users to committee consecutive time
	orcess on the som return higher spec	rain higher speed data
	relaxes the error a	relaxes the error control cooling along the
	orginally specified	ortsinally specified in the asm standord for
	nata transmission an	increases the available
	application data rate 14.400 bps as	the 14.400 bps as
	Composed to the	Composed to the original 9600 by in
	The asm speaking	the asm specifications. By using up to
	tare consecutive time	slots, HSCSD is able
	To provide a ray	to provide a raw trammation rate up to
	57.6 Kbps to individual users.	istal users.

General Packet Radio Service is a packet based data network, which is well suffed

GPRS

for non-real time Internet usage including retrieval of email, forces, and asymmetric

Web browsing where fux users downloads

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Examinations	MODEL ANSW	First Examiner: Dr. M. Gurcan	Second Marker: Dr. D. Ward	Question labels in left margin

shoring of individual radio channels and to Slots for "almongs or access to the network. specific users, GPRS supports many more users than HSCSO, but in a bursty manner retains the original modulation formats specified Similar to the cellulur American system, GPRS Intunet. Unlike HSCSD, which dedicates users, GPRS supports multi-user network automatically instructed to tune to dedicated apres radio channels and particular HIME uses a completely redifined air interfere much more data than it uploads on the circuit switched channels to specific in the original 2a TDMA standards, but in order to better handle packet data access. GPRS subscriber units acc

VSU is able to achieve as much as 171.2 kbp When all engite think slots of a gim madio Applications are required to provide their channel are dedicated to GPRS, on Individual own error correction schemes as part of the earred data publicad in GPRS.

Framinations . Makila radio Camminication	MODEL ANSWER and MARKING SCHEME	First Examiner: Dr. M. Gurcan Paper Code E4.03, ASS, SO10, ISE4.3	ker: Dr. D. Ward Question Page 19 out of 30	els in left margin Marks allocations in right margin	(, (, (, (, (, (, (, (, (, (, (, (, (, (
		First Examiner: D	Second Marker: Dr. D. Ward	Question labels in left margin	6

EDGE allows nine different air interface formats 8-PSK which is used in addition to asmis EDGE (Ehanced Data Rates for GSM Evolution) error control protection. Each MCS state Patroduces a new digital Modulation format known as multiple modulation and cooling many use either GMSK (low data late) or schemes (Mcs), with roughly defrees of standord GMSK modulation

8-PSK (high data rate) modulation for network

access depending on the instantgaeous demands of the network and operating conditions. Because

of the higher data rates and relaxed error

control covering in many of the selectable air interface formats, the coverage range is smaller throat in EDGE than in HISDRC or

with marthum error protection and maximum In EDGE packets are transmitted first data rak throughout, and then subsequent transmitted with less error protection and less throughput, until the link has an unacceptable ortege or whow. Rupis feedback petween the base status and sunciber unit then restores the previous acceptable air interface. fackets are from with less effor protection. Then subsequent peachets aske

Examinations: Mobile radio Communication  MODEL ANSWER and MARKING SCHEME First Examiner: Dr. M. Gurcan  Second Marker: Dr. D. Ward  Question labels in left margin  Marks alloca	ARKING SCHEME Paper Code E4.03, ASS, SO10, ISE4.3 Question 4b Page 20 out of 30 Marks allocations in right margin
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Examinations: Mobile radio Communication

Uplink Dedicated change

(h) | 11 | 0

volink dedicated channel stuchre

The uplink channel 'ses I/B multiplexing for user data and physical layer control information. The physical layer control information including data is corred by Dedicated Physical Control Channel (DPDCH) with a fixed spreading factor of 256. The higher leager Phormation, Including vier data, is corried on one or more Dedicated Physical Data channels (DPDCH) with a possible spread factor ranging from 256 down to 4.

The uplink transmission many consist of one or more dedicated physical channely

(TPC) bits and Feedback Information (FBI)

bits, TFCI, Transmission Dower Control

burst durables of 577 MJ. Each slot

has four firelds to be used for pilot

This is rather close to the GSM

duradion of 2560 chips or 666 x1.

The uplink DPCCH uses a slot structure with 15 slots over the 10 ms

radio frame. This results in a slot

IME	Paper Code E4.03, ASS, SO10, ISE4.3	Question 415 Page 21 out of 30	Marks allocations in right margin	oding father	6 40 R20	prically the DPDCH	C DPDC#M.	the Transport	the data	riectly , the	e reliability	on the
MODEL ANSWER and MARKING SCHEME	Paper Code E4	Question 415	Marks	DPDCH with a variable spreading fathor	DPDCH date note many vory or a	with a variable rate service the DEDCH	The DPCCM is transmitted continued in	and rate information is sent with Transport Format Combination Indicate (TECT)	The DPCCH information on the data	If TFCI is not decoded correctly, the	whole data frame is last. The reliability of TFCE is higher than the reliability	of the user data detection on the
MODEL AN	First Examiner: Dr. M. Gurcan	Second Marker: Dr. D. Ward	Question labels in left margin	DPDCH with	D PDCH &	With a variable	The DPCCM :	and rate inform Format Combin	The DpccH rate on the	If TFCI is	whole data to the is	of the vsc
	Firs	Sec	onc									

Examinations: Mobile radio Communication MODEL ANSWER and MARKING SCHEME	rst Examiner: Dr. M. Gurcan Paper Code E4.03, ASS, SO10, ISE4.3	cond Marker: Dr. D. Ward Question 4 Page 22 out of 30	uestion labels in left margin Marks allocations in right margin	First Examiner: Dr. M. Gurcan  Second Marker: Dr. D. Ward  Question labels in left margin  Marks allocat	SS, SO10, ISE4.3  se 22 out of 30  ttions in right margin
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The pilot bits are used for the channel estimation in the receiver, and the T PC bits carry the power control conmands for the downlink power control control. The FRI bits are used when closed loop transmission diversity is used in the down link. The use of FRI bits is covered as pout of physical channel brocedures. The system uses either open loop or closed loop transmit diversities.

Is telesed loop diversity scheme, the base station uses two antennass. The FRI chanted is used to send freelback commends to control phase adjustments that are expected to maximix power received by the terminal.

In mode 2, the amplitude is adjusted in addition that to the phase adjustment.

# Upline Multiplexing

In the uplink direction the services overwulfiplexed dynamically so that the data she and is confinuous with the exception of zero rate. The symbols on the DPDCH are sent with equal power level

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Examination	MODEL ANSI	First Examiner: Dr. M. Gurcan	Second Marker: Dr. D. Ward	Question labels in left margin	

for all services. This means in practice fruct the service coding out channel multiplexing in some cones to adjust the relative symbol rates for different services in order to balance the power level requirements for the channel engabols.

The rate matching function in the multiplexing chain can be used for such quality balancing operations between services on a single DPDCH. Fur the uplink DDDCH there do not exist fixed positions for different services but the frame is filled according to the outcome of the rate matching and interleaving operations.

After receiving a transport block from higher layers, the first operation CRC attachnest, After the CRC attachnest the transport blocks are either concernated together or segmented to different cooling blocks. The channel coding is performed on the cooling blocks after the concernation. Of the channel

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is used when the delay budget allows more than 10 ms of interleaving coding the radio franc equalisation blocks when transmitted our more than a single to ms radio frame. is performed to ensure mate data The first and second interlegating can be divided into equal sized

Rate matching is then used to match the number of bits to be transmitted to the number available on a single frame.

The higher layers provide a semi-static porameter, the rate matching attribute, to control the relative matching between different transport channels. Different Mattplexalig. This multiplexing simply divides the douter evenly on the avoilable spikabing multiplexing operation, this is a sonal tradeport channels are multiplexed to pether by the tradeport channel

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External Networks PSTR NOSI GSM Phase 2+ Core Network **UMTS Phase 1 Network** ≷ س.

## Examinations: Mobile radio Communication MODEL ANSWER and MARKING SCHEME

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RNC Functions

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Question 44 Page 26 out of 30 Marks allocations in right margin

**UTRAN: TS 25.401** 

뎔

DRNC

Core Network CN

SRNC

GSM Phase 2 + Core Network **UMTS Phase 1: UTRAN** 

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Marks allocations in right margin

K-W : Cu Interface. This is the electrical interface between the VSIM smartcard and the ME. The interface follows a standard format for smartcards.

which the UE accesses the fixed part of the system, and is therefore probably • Uu Interface. This is the WCDMA radio interface. The Uu is the interface through the most important open interface in UMTS. •Iu Interface. This connects UTRAN to the CN. Similarly to the corresponding interfaces in GSM

-Iur Interface. The open Iur interface allows soft handover between RNCs from different manufacturers

• Iub Interface. The Jub connects a Node Band an RNC. UMTS is the first commercial mobile telephony system where the Controller-Base Station interface is standardised as a fully open interface



1 The conversational class

The best-known application of this class is speech service over circuit-switched bearers.

With Internet and multimedia, a number of new applications will require this type, for I example voice over IP and video telephony. This is the only type of the four where the required characteristics are strictly imposed by human perception

The end-to-end delay is low and the traffic is symmetric or nearly symmetric.

The maximum end-to-end delay is given by the human perception of video and audio conversation the end-to-end delay has to be less than 400 ms.

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om of 30 Marks allocations in right margin Paper Code E4.03, AS5, SO10, ISE4.3 Question Le Page 29

Question labels in left margin

The Streaming Class

Second Marker: Dr. D. Ward

Multimedia streaming is a technique for transferring data such that it can be

processed as a steady and continuous stream.

With the growth of the Internet because most users do not have fast enough access to I download large multimedia files quickly. With streaming, the client browser or plug-in can start displaying the data before the entire file has been transmitted. For streaming to work, the client side receiving the data must be able to collect the data and send it as a steady stream to the application that is processing the data and converting it to sound or pictures

Streaming applications are very asymmetric and therefore typically withstand more delay than more symmetric conversational services. They tolerate more jitter in transmission. Jitter can be easily smoothed out by buffering



Background Class

Data traffic of applications such as e-mail delivery, SMS, downloading of databases and reception of measurement records can be delivered background since such applications do not require immediate action.

The delay may be seconds, tens or seconds or even minutes.

Background traffic is one of the classical data communication schemes that is broadly characterised by the fact that the destination is not expecting the data within a certain

It is thus more or less insensitive to delivery time

Data to be transmitted has to be received error free.

The electronic postcard is one example of new applications that are gradually becoming more and more common.

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Examinati	MODEL AN	t Examiner: Dr. M. Gurcan

Question 46 Page 30 out of 30 Marks allocations in right margin

### Sil Interactive Class

Second Marker: Dr. D. Ward Question labels in left margin Interactive class is used when the end-user, either a machine or a human, is on line

requesting data from remote equipment.

Examples of human interaction with the remote equipment are

-Web browsing,

-database retrieval, and

-server access

Examples of machine interaction with remote equipment are

-polling for measurement records and

-automatic database enquiries (tele-machines).